Document I-1

Document Title: H. J. E. Reid, Director, Langley Memorial Aeronautical Laboratory to National Advisory Committee for Aeronautics, "Research on Space Flight and Associated Problems," 5 August 1952.

Source: National Archives and Record Administration, Fort Worth, Texas.

As World War II was in its final stages, the National Advisory Committee for Aeronautics (NACA) inaugurated sophisticated studies of high-speed upper atmosphere flight that had significant ramifications for the development of human spaceflight. The Langley Memorial Aeronautical Laboratory (LMAL), now the Langley Research Center, in Hampton, Virginia, led this effort. In early 1945, NACA asked Congress for a supplemental appropriation to fund the activation of the Pilotless Aircraft Research Division (PARD), and a short time later NACA opened the Auxiliary Flight Research Station (AFRS) to launch rockets on Wallops Island, Virginia. On 4 July 1945, PARD launched its first test vehicle, a small two-stage, solid-fuel rocket to check out the installation's instrumentation. The group soon began serious work to learn about the aerodynamics of spaceflight. By 1952 Langley's involvement in rocketry and spaceflight research had transformed the Laboratory into one of the world's leading facilities involved in this entirely new field of flight research. This memorandum sought to capitalize on the work of the PARD and to advance the state of the technology by establishing a formal panel to plan for future research.

Langley Field, Va.
August 5, 1952

From Langley
To: NACA
Ref: NACA Letter, July 10, 1952 MBApep Enc.
Subject: Research on space flight and associated problems

1. The Langley laboratory has carefully considered the subject proposed in letter of reference regarding research on space flight and associated problems. It was recommended that the laboratory assign a three-man group to study and prepare a report covering the various phases of a proposed program that would carry out the intent of the resolution of letter of reference. In order to effect NACA coordination of the program proposed by this study, it is further recommended that a review board with representatives of the 3 laboratories and the NACA High-Speed Flight Research Station at Edwards be appointed.

2. If this plan is approved, the Langley laboratory would appoint to the study group Messrs. C. E. Brown, C. H. Zimmerman, and W. J. O'Sullivan. The recommended members of the review board from Langley and Edwards are Messrs. Hartley A. Soulé and Walter C. Williams, respectively.

3. Results of some preliminary work relative to this subject are already available as a result of consideration given to this matter at Langley and Edwards.

H. J. E. Reid
Director

Document I-2

Document Title: H. Julian Allen and A. J. Eggers, Jr., NACA, "Research Memorandum: A Study of the Motion and Aerodynamic Heating of Missiles Entering the Earth's Atmosphere at High Supersonic Speeds," 25 August 1953.

Source: Folder 18674, NASA Historical Reference Collection, NASA History Division, NASA Headquarters, Washington, DC.

In the later 1940s aerodynamicists began research on the best means of reentry to Earth from space, where the high speeds caused atmospheric heating in excess of 1,800°F. These investigations found that a blunt-nose body experienced much less heating than a pointed body, which would burn up before reaching Earth's surface. The blunt reentry body, discovered in 1951 by H. Julian Allen, an engineer with NACA's Ames Research Center, created a stronger shock wave at the nose of the vehicle and dumped a good deal of the reentry heat into the airflow, making less heat available to heat the reentry vehicle itself. Allen's work led to the design of wide-body bases for spacecraft, giving the capsules their characteristic "teardrop" shape, and to the use of the ablative heat shields that protected the Mercury, Gemini, and Apollo astronauts as their space capsules reentered Earth's atmosphere. This document represents one of Allen's earliest contributions to understanding the reentry problem. Coupled with his later contributions, as well as with the research of others including his early collaborator Alfred Eggers, Allen's research made possible human spaceflight in the 1960s.

NACA

RESEARCH MEMORANDUM

A STUDY OF THE MOTION AND AERODYNAMIC HEATING OF MISSILES ENTERING THE EARTH'S ATMOSPHERE AT HIGH SUPERSONIC SPEEDS

By H. Julian Allen and A. J. Eggers, Jr.

Ames Aeronautical Laboratory

Moffett Field, Calif.

August 25, 1953

SUMMARY

A simplified analysis is made of the velocity and deceleration history of missiles entering the earth's atmosphere at high supersonic speeds. It is found that, in general, the gravity force is negligible compared to the aerodynamic drag force and, hence, that the trajectory is essentially a straight line. A constant drag coefficient and an exponential variation of density with altitude are assumed and generalized curves for the variation of missile speed and deceleration with altitude are obtained. A curious finding is that the maximum deceleration is independent of physical characteristics of a missile (e.g., mass, size, and drag coefficient) and

is determined only by entry speed and flight-path angle, provided this deceleration occurs before impact. This provision is satisfied by missiles presently of more usual interest.

The results of the motion analysis are employed to determine means available to the designer for minimizing aerodynamic heating. Emphasis is placed upon the convective-heating problem including not only the total heat transfer but also the maximum average and local rates of heat transfer but also the maximum average and local rates of heat transfer per unit area. It is found that if a missile is so heavy as to be retarded only slightly by aerodynamic drag, irrespective of the magnitude of the drag force, then convective heating is minimized by minimizing the total shear force acting on the body. This condition is achieved by employing shapes with a low pressure drag. On the other hand, if a missile is so light as to be decelerated to relatively low speeds, even if acted upon by low drag forces, then convective heating is minimized by employing shapes with a high pressure drag, thereby maximizing the amount of heat delivered to the atmosphere and minimizing the amount delivered to the body in the deceleration process. Blunt shapes appear superior to slender shapes from the standpoint of having lower maximum convective heat-transfer rates in the region of the nose. The maximum average heat-transfer rate per unit area can be reduced by [2] employing either slender or blunt shapes rather than shapes of intermediate slenderness. Generally, the blunt shape with high pressure drag would appear to offer considerable promise of minimizing the heat transfer to missiles of the sizes, weights, and speeds presently of interest.

Document I-3

Document Title: Adelbert O. Tischler, Head, Rocket Combustion Section, NACA, Memorandum for Associate Director, NACA, "Minimum Man-In-Space Proposals Presented at WADC, 29 January 1958 to 1 February 1958," 10 April 1958.

Source: Folder 18674, NASA Historical Reference Collection, NASA History Division, NASA Headquarters, Washington DC.

Document I-4

Document Title: Paul E. Purser, Aeronautical Research Engineer, NACA, Memorandum for Mr. Gilruth, "Langley Manned-Satellite Program," 11 April 1958.

Source: Folder 18674, NASA Historical Reference Collection, NASA History Division, NASA Headquarters, Washington, DC.

The spring of 1958 brought to the fore a range of possibilities for advocates of an aggressive spaceflight effort in the U.S. The Soviet successes with Sputniks I and II in the fall of 1957, coupled with the spectacular failure of a televised Vanguard launch on 6 December 1957, ensured that national leaders were under the gun to take positive action. Accordingly, this situation led directly to several efforts aimed at "catching up" to the Soviet Union's space *achievements. These included: a) a full-scale review of both the civil and military programs of the U.S. (scientific satellite efforts and ballistic missile development); b) establishment of a Presidential science advisor in the White House who had responsibility for overseeing the activities of the Federal government in science and technology; c) creation of the Advanced Research Projects Agency in the Department of Defense, and the consolidation of several space activities under centralized management by that agency; d) the proposed establishment of a new space agency, NASA, based on NACA to manage civil space operations; and e) passage of the National Defense Education Act to provide federal funding for education in the scientific and technical disciplines. As this was taking place, NACA leaders studied the possibility of launching a human into space. These documents represent the deliberations taking place during this time that explored how initial human spaceflight might be accomplished and suggest the wide variety of concepts being examined. In Document I-3, WADC is the abbreviation for the Wright Air Development Center, Wright-Patterson Field, Dayton, Ohio.*

Document I-3

[CONFIDENTIAL] [DECLASSIFIED]
NACA - Lewis

Cleveland, Ohio
April 10, 1958

MEMORANDUM For Associate Director

Subject: Minimum man-in-space proposals presented at WADC, January 29, 1958 to February 1, 1958

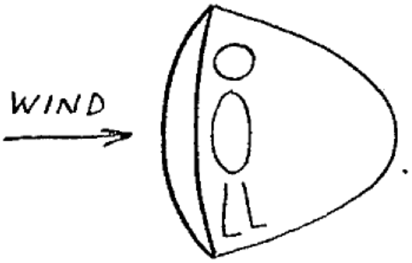
1. The purpose of a series of meetings at WADC under the Chairmanship of Mr. E. Barton Bell was to hear proposals from various contractors on the quickest way to put man in space.

2. Proposals fell into two rough categories: (a) a blunt-nose cone or near-spherical zero-lift high-drag vehicle of a ton to a ton-and-a-half weight, and (b) a hypersonic glider of the ROBO or Dyna-Soar type. The first category of vehicles used existing ICBM vehicles as boosters; the second used more complex and arbitrary multiplex arrangements of existing large-thrust rocket engines. A number of contractors looked at the zero-lift high-drag minimum weight vehicle as the obvious expedient for beating the Russians and the Army into space. Others, notably Bell, Northrup, and Republic Aviation, set this idea aside as a stunt and consequently these contractors stressed the more elaborate recoverable hypersonic glider vehicle as the practical approach to the problems of flight in space. In the following paragraphs the no-lift minimum weight vehicles are reviewed first without regard for order of presentation and the hypersonic glider vehicles follow. An effort is made to summarize the pertinent gross features of each proposed vehicle at the head of each review and some of the details are discussed thereafter.

3. The proposal configurations were patterned directly after concepts developed by Allen, Eggers, et al of NACA-Ames and the background of data obtained through NACA research was impressively apparent throughout the proposals. Therefore, before going into the individual proposals it seems worthwhile to review briefly the suggestions made by NACA people. This review is covered in the next three paragraphs.

4. Mr. John Becker of NACA-Langley discussed two separate minimum man-in-space proposals. The first of these was a no-lift configuration as diagrammed.

[2]



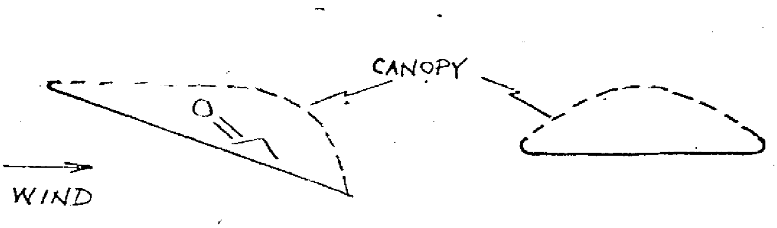
$W_g < 3000$ pounds
$W/S = 35$ pounds per square foot

This discussion considered only vehicles which fly within the atmosphere at perigee so that a small impulse applied anywhere along the flight path will initiate reentry. With zero-lift the drag deceleration will reach a maximum of about 8.5 g's with greater than 5 g's for 20 seconds. Small controls (flaps like air brakes) at the edge of the dish can be used to change angle of attack and thereby produce lift; this will reduce maximum g's to 4.5. The heating rate will approach a maximum of 100-150 Btu per square foot per second. This heat can best be absorbed in a Berylium heat sink between 1/2 and 1-inch thick. The vehicle ultimately requires descent by parachute - this rules out landing in predesignated pin-point areas.

Boost with the ballistic-nose-cone-type vehicle can be accomplished with Atlas. During boost the heat shield is behind the pilot (passenger). Upon injection into orbit the vehicle must be reversed. This requires attitude controls that work in space. Reentry also requires a well-controlled gimbaled retrorocket of nominal impulse and weight (<100 pounds).

Langley is presently making a structural analysis and investigating aerodynamic behavior in hypersonic tunnel.

5. The second proposal was a lift flat-bottomed wing device to enter the atmosphere at an angle of 25° ($C_L = 0.6$).



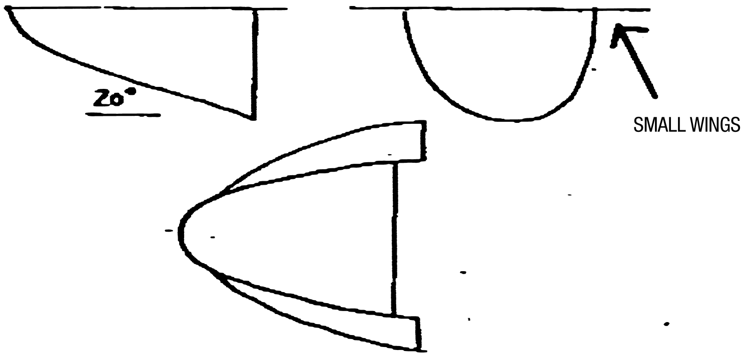
[3]

Blunt leading edge radius was given as 3 inches with W/S = 20 pounds per square foot. The heat transfer rate on the bottom was estimated at less than 12 Btu per square foot per second and the airframe can radiate all heat. Temperature of the skin would reach a maximum of 2000° F at the leading edge. This device would have less than 1 g deceleration at all times during reentry (except possibly at the earth's surface). Range can be controlled somewhat by varying angle of attack (L/D = 3.5 to 1.0).

The weight of this aerodynamic-ski would be less than 5000 pounds, possibly considerably less.

One of the problems of both the NACA devices will be control of velocity and angle at injection into orbit. Present ICBM quality guidance is not good enough. A retrorocket to slow ski down by 200 feet per second at 300,000 feet perigee altitude will lower perigee by 50,000 feet. This will initiate reentry.

6. Mr. Clarence Syvertson of Ames outlined certain configurations that are being studied there. These assume an initial circular orbit at 500,000 feet. If at this altitude the velocity is reduced by 2 percent the altitude will be lowered by 220,000 feet.



$W_g < 5000$ pounds

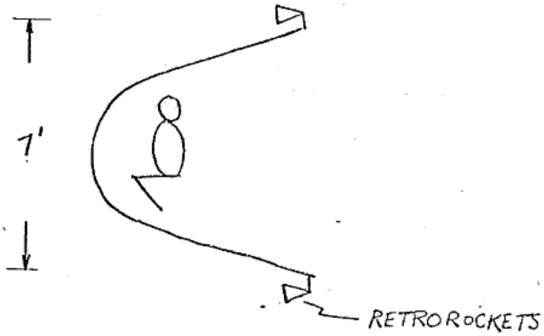
The C_L for the above configuration is 0.6. The maximum deceleration is always less than 1 g. Hypersonic wind tunnel studies of this configuration have shown a serious aerodynamic center shift at transonic speeds. This A.C. shift [4] amounts to about 30 percent of the body length. Two suggested solutions are to use thicker wings or no wings at all. Drag-brake-like controls surfaces (about 5 in number) around the periphery of the configuration are being studied.

Essentially this device is one half of an ICBM reentry body. The controllable lift provides control over range. A former idea for parachute landing is being abandoned.

AUTONEUTRONICS

Initial presentation by Mr. Krause who discussed an elaborate scheme of experiments to be accomplished with rocket-propelled vehicles along with an extended series of engine-vehicle assemblies to carry out the program. Even the manned satellite concept was regarded as the end experiment of a series starting with protozoa and bacteria and building up through invertebrates, vertebrates, and finally, man. Only the manned space vehicle is outlined below. The space program discussed is reviewed in the discussion section.

Vehicle: One man zero-lift nose-cone.



[5]

Weight: Payload 855 pounds:

Man	175 pounds
Oxygen and purifier	85 pounds
Water	20 pounds
Food	10 pounds
Clothing	110 pounds
Temperature controls	130 pounds
Attitudecontrols	85 pounds
Communication	85 pounds
Navigation	45 pounds
Experiments	65 pounds
Telemetering	—
Total payload	**855 pounds**

Beryllium ablation shield	850 pounds
Parachute	100 pounds
Recovery (?) system	50 pounds
Retrorocket	250 pounds
Structure	300 pounds
Instruments	70 pounds
Capsule	70 pounds
Total weight	**2545 pounds**

Boosters: Atlas and Rustler ($F_2 - NH_3$)

Schedule: Manned earth satellite late in 1963 (with 3300 pound payload and Atlas-Rustler booster.)

Costs \$80 x 10^6.

[6]

Discussion

Concerning the high lift/drag glider configurations as opposed to the high drag zero-lift ballistic reentry concepts Mr. Krause presented the following arguments:

The high L/D configuration entail:

(a) Unsolved aerodynamic and structural problems
(b) Development of new test methods
(c) Major test facilities
(d) Material development
(e) Long development schedule
(f) Structural fabrication problems

The high drag configurations entail:

(a) Nominal test facilities
(b) Development of heat sink materials
(c) Short development schedule
(d) Simple fabrication
(e) Aerodynamic data available

A high altitude research program involves:

(a) Procuring scientific data
(b) Studying environmental effects
(c) Testing components
(d) Developing recovery techniques
(e) Biomedical experiments
(g) Manned flight

The high altitude research and test work can be accomplished with: Thor, Polaris, Atlas, Titan, or special vehicles.

Satellite program mast include:

(a) Study of physical environment
(b) Precision experiments
(c) Reconnaissance

[7]

Satellite flights can be accomplished with the Thor-Hustler, Thor-Rustler, Atlas-Hustler, and Fitan-Rustler. Both the Fitan and the Rustler will use fluorine as oxidant

Lunar flight program might include

(a) Navigation in precision orbit
(b) Lunar impact
(c) Instrument landing

For lunar flight, vehicles might be the Thor-Rustler-Vanguard 3rd stage, Atlas-Rustler, and Fitan-Rustler.

The vehicle development chart for these programs proceeds: (a) Thor-Hustler, (b) Thor-Rustler, (3) Atlas-Rustler, and (4) Fitan-Rustler.

For the earth satellite program estimated payload weights for several configurations were calculated:

Configuration	Payload, pounds	Initial W_0, pounds
Th-6V	201	
Th-6V-V	335	
Th-H	377	112,499
Th-R	858	113,169
A-H	3272	
A-R	3848	
F-R	5459	

The schedule was for four earth-satellite flights in twelve months, first recovery 18-20 months, biomedical experiments 22-25 months. Rustler (F_2-N_2H_4) was predicted to be ready in the twenty-first month (extremely optimistic). This would raise payload over 500 pounds within two years.

The purpose of the series of biomedical experiments is to establish survival limits and determine nervous system behavior. Protozoa-bacteria experiments were to be done with Thor-Hustler, Rhesus monkey experiments with Thor-Rustler, chimpanzee experiments with Atlas-Rustler, and manned flight also with the Atlas-Rustler. The Thor-Hustler program is expected to cost $50 x 10^6, boosters and range free, the Thor-Rustler program an additional $30 x 10^6.

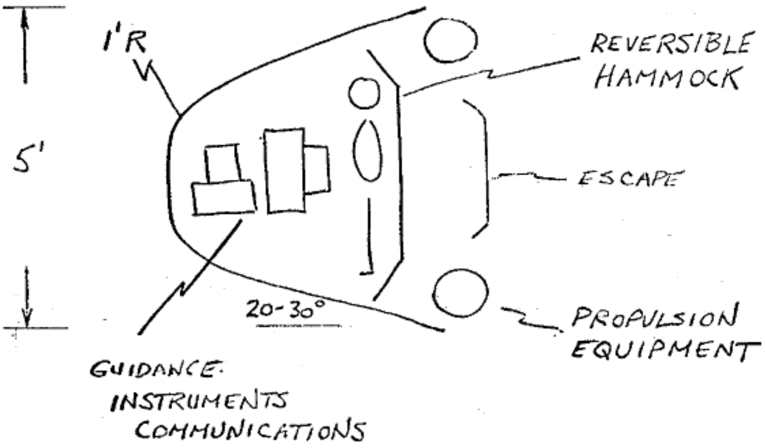
[8]

MARTIN

Introductions by Mr. Bunker, President, and Mr. Merrill, Vice President at the Denver facility. Outline of proposal by Mr. George Trimble, Vice President of engineering. Details by Mr. Demeret, head of the astronautics section(?), Denver.

Pertinent Features

Vehicle: One-man zero-lift body illustrated below. Later vehicles planned to have lift and controls. Later vehicle weights up to 40,000 – 60,000 pounds.



Weight: 3500 Pounds total; ablation shield (phenolic resin), 650 pounds; instruments, 150 pounds.

Boosters: Titan.

Time and altitude: 24-hour trip; 150 - 200 miles at perigee.

[9]

Reentry methods: Retrorocket (-500 feet per second) applied at apogee; ballistic reentry, $W/C_DA = 100 – 150$, maximum g's = 7.5 at 3° reentry angle; maximum temperature = not stated; maximum heat transfer = 5 – 6 Btu per square inch per second; ablation cooling.

Recovery and landing: Parachute within +/- 50 miles.

Tracking: ICBM inertial. Minitrack to provide altitude and position data.

Safety feature: Retrorocket used to separate vehicle from booster if booster fails.

Schedule: Manned flight by mid-1960.

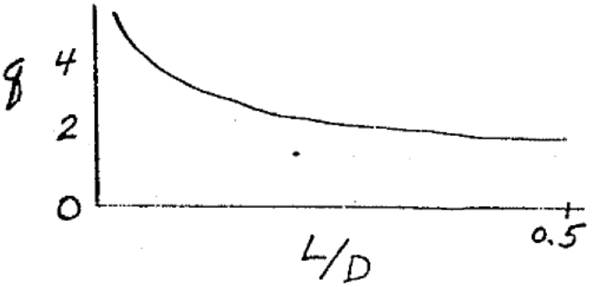
Cost: Not stated.

Discussion

Present ICBM guidance okay for attitude reference for ten days. Integrating accelerometer will gage retrorocket within +/- 10 feet per second. Propose H_2O_2 retrorocket with hot-gas vernier control system for attitude stabilization. Present Titan system fails to lift 3500 pound payload into orbit by 500 feet per second. (Can carry about 2900 pounds into orbit.) Twenty percent additional payload capacity is foreseeable growth by 1960.

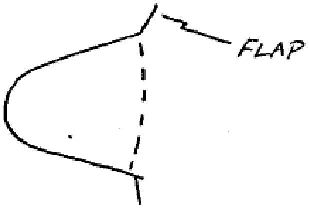
No specific design proposed for controlled flight. A second proposal to carry 16,000 pound third stage with a -5000 feet per second retrorocket (weighing 10,000 pounds) was suggested - but not detailed - to avoid heating problem.

Maximum heat transfer can be reduced by same lift.



[10]

Martin suggested use of control flaps on reentry vehicle to produce angle of attack and lift.



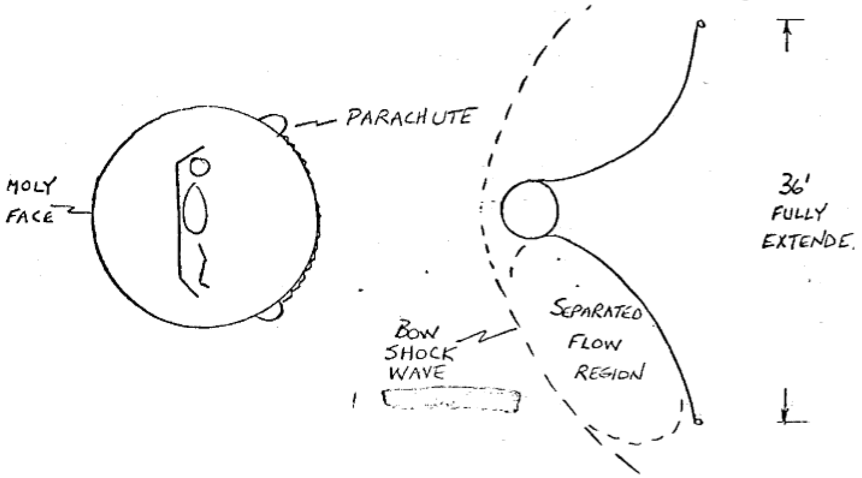
The Martin proposal impressed me as the most thoroughly worked out proposal.

AVCO

Presentation principally by Dr. Arthur Kantrowitz, Director of Research. AVCO has twice previously proposed the following. (The last time in November, 1957.)

Pertinent Features

Vehicle: Eight-foot spherical vessel, zero lift. Parachute equipped to provide drag for reentry.



[11]

Weight: 1500 pounds

Capsule	220 pounds
Internal structure	114 pounds
Survival equipment	126 pounds
Parachute	330 pounds
Other	85 pounds
Escape rocket	240 pounds
Man and clothing	150 pounds
	1265 pounds
Contingency	235 pounds
Total Weight	**1500 pounds**

Boosters: Titan (or Atlas) as is. Maximum g's = 11 (second stage).

Time and altitude: Orbit at 110 - 120 miles (circular). Time arbitrarily variable. With parachute furled as many as 40 orbits are possible. Propose a three-day flight.

Reentry method: Thirty-six foot diameter stainless steel parachute creates drag to cause descent in one half orbit. Control of parachute used both to adjust orbit and to control landing point. Grazing angle (1/4°) reentry; maximum g's @ 250,000 feet; maximum temperature, 1800° F; maximum temperature of parachute, 1140°F; maximum heat transfer (?) @ 270,000 feet.

Recovery and landing: Parachute also used to land capsule; landing area about size of Kansas. Landing velocity, 35 feet per second. Fall requires one half hour.

Tracking: Existing minitrack systems. Man is strictly passenger – no control.

Controls: Air-jets to kill angular momentum (attitude)- Liquid paddles to maintain attitude. Parachute extension controllable by expansion of bellows ring at rim; changes drag by 50 x. Used to correct orbit. ICBM-quality guidance good for 0.8°, want 0.25°.

[12] [illustration deleted here]

Safety features: Solid rocket provided for safety escape if boosters fail; otherwise fires along with second stage. Safety rocket separates from capsule after firing.

Schedule:

	58	59	60	61
Research	————			
Model tests	———			
Capsule tests	——			
Parachute tests	————	————		
Escape system		————		
Balloon flights		————	— [59-60]	
Satellite launch				————
Animals				———
Man				-

Cost: $40 x 10^6$ plus $12 x 10^6$ for flight vehicles excluding launchers.

Discussion

Dr. Kantrowitz looks at this proposal as the quickest way to manned satellite. This he regards as no stunt. A permanent orbit at 110 - 120 miles can be established with a solar propulsion device capable of overcoming the 5 grams drag force. The vehicle described may also offer a means for escape from a disabled large-scale vehicle.

[13]

The g factors and capsule atmosphere (60 percent oxygen, remainder N_2, He at .5 atmosphere pressure) are based on WADC Aeromedical group data. Certain upper atmosphere data on which the calculations are based are in doubt but better data will certainly be available before manned flight schedule.

The stainless steel parachute lies in a region of secondary flow (this is the reason for the shuttlecock shape) and will be subjected to peak temperatures of

1140° F, in contrast to the 1800° F peak at the sphere nose. The capsule will be above 200° F skin temperature for about 20 minutes. With the planned insulated wall construction the amount of heat transferred into the sphere will amount to about 1500 Btu (heat of fusion of a 10 pound block of ice) and is nearly negligible. Construction of the pressure vessel capsule is 0.020-inch stainless steel, insulation thermoflex with 0.001-inch stainless steel radiation shield; the nose is coated with 0.010-inch molybdenum skin.

The parachute has inflatable stainless steel bellows around the rim (about 3-inch diameter) and is made of 400 mesh stainless fabric covered with shim- stock "shingles"; total fabric weight about 60 pounds. Unfurling this chute increases the drag of the vehicle about 50 times. The chute can be opened and collapsed several times provided the bellows expansion doesn't exceed two times its length.

There was some discussion of magneto-hydrodynamic propulsion and means of projecting the shock location away from the vehicle using magnetic fields. This was not part of the proposal.

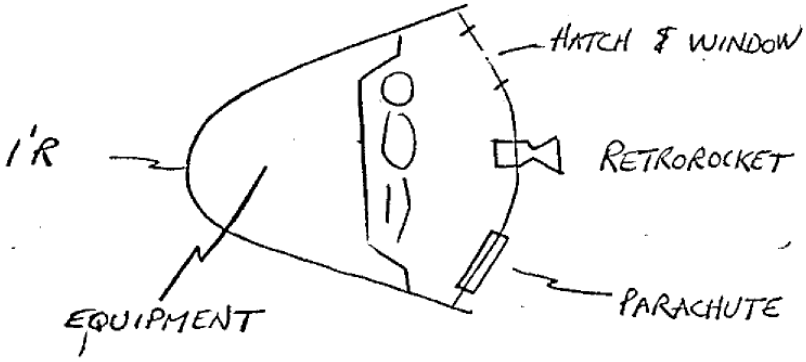
This presentation impressed me as having the most thorough correlation with available scientific and aerodynamic data.

LOCKHEED

Proposal presented by Dr. Perkins, Development Planning.

Pertinent Features

Weight: Capsule	600 pounds, includes	150 pound man
	Ablating material	600 pounds
	Retrorocket	100 pounds
	Parachute	200 pounds
Total weight	**1500 pounds**	



Boosters: Atlas and Bell Hustler. Hustler fires for 80 seconds between 620 -700 seconds flight time to inject into orbit. Maximum g's 6.6 (first stage). Specific impulse = 280 pounds per second per pound required of Hustler.

Time and Altitude. Six hours; perigee 150 miles; apogee 300 miles.

Reentry method: Retrorocket (-225 feet per second. One mile altitude at perigee roughly equals 1.5 feet per second, Retrorocket weighs less than 5 percent of vehicle.)

$W/C_O A = 0.01$

Maximum g's, 7.5 at 1° reentry angle

Maximum temperature, not stated

Maximum heat transfer, not stated

Vehicle subsonic at 60,000 feet; 600 feet per second at 40,000 feet.
Cooling by ablation material.

[15]

Recovery and landing: Cloth parachute to recover entire capsule. Landing area 20 miles by 400 miles along path. Errors of 150 miles due to lack of knowledge of air density between 125,000 and 250,000 feet. Lockheed proposes water recovery.

Tracking: 108 mc minitrack plus two way voice. Flywheel attitude control. Either gimbal or jet-vanes on retrorocket.

Safety features: Overrides on man's limited control functions. Hustler is fired to escape if Atlas booster fails. If Hustler fails man has had it.

Schedule: Preliminary experimental flights (Thor with 300 pound payload) in late 1958. Experimental centrifuge and vacuum chamber testing in mid-1958. Manned flight in late 1959.

Cost: $\$10 \times 10^6 < \text{cost} < \$100 \times 10^6$

Discussion

X-17 tests (28 out of 38 successful) have confirmed hot shot and shock tube high speed data. Lockheed Missile Systems Division (MSD) has three-inch shock tube which uses l-inch model.

Beryllium is better than copper for ablation cooling material. Vehicle has no cosmic or meteor protection.

Lockheed feels lift reentry is best in long run.

CONVAIR

Introduction by Mr. William H. Patterson of Convair Astronautics. Extended discussion by Mr. Krafft A. Ehricke. Much of Ehricke's discussion was concerned with an extensive program of populating the solar system with reconnaissance, radio relay, etc., systems. Pulling that part of the presentation which applies to the minimum man-in-space concept from my notes is difficult. The program reviewed by Mr. Ehricke is contained in the Convair Astronautics report entitled: "A Satellite and Space Development Program", December, 1957 (Copy No. 185 is charged to the Lewis Laboratory Library.).

Some notes on the minimum man-in-space device are outlined in the following.

[16]

Pertinent Features

Vehicle: 60-inch sphere.

Weight: Man plus 1000 pounds, 500 pound heat-sink.

Boosters: Atlas Series D plus third stage. It is conceivable that the third stage need not be used – will require 5 specific impulse units improvement in present rocket performance.

Time and altitude: Time not noted. Altitude – 300 miles.

Reentry method: Retrorocket. Reentry angle, 2^{O} maximum, $C_{O}A/W = .05$ to .08. Maximum g's = 8, greater than 6 g for 60 seconds.

Schedule: First flight (unmanned), February, 1959. Man in satellite orbit, April, 1961. Vehicle production schedule, one per month. Atlas D vehicle will not be fired before May, 1959.

McDONNELL

Introduction by Dr. Wokansky, coordinator of research. Presentation by Mr. Michael Weeks, Chief, preliminary design. McDonnell Aircraft presentation was an obvious bid for the "payload package" without the propulsion problem. Details were given in the McDonnell report to WADC.

Pertinent Features

Vehicle: One-man capsule. Data below are for a nose-cone device. Winged vehicle was considered possible in 30 months.

Weight:

Crew	270 pounds
Seat	50 pounds
Oxygen (3 hours)	70 pounds
Pressurization	134 pounds

Canopy	135 pounds
Structure	345 pounds

[17]

(Weight – continued.)

Stabilization	202 pounds
Retrorocket	90 pounds
Electronic	400 pounds
	1693 pounds
Landing chute	135 pounds
Heat problem	450 pounds
Incidentals	122 pounds
	2400 = 25 percent

Boosters: Atlas and Polaris. Peak g's (Polaris) about 7.

Time and Attitude: One orbit (1.5 hours); apogee not noted; reentry initiated at $300{,}000^{+}$ feet.

Reentry method: Retrorocket (-143 feet per second). Ballistic reentry WC_D/M= .5 to 1; maximum g's 10 (1°) to 13 (4°), above 7 g's for 50 seconds, above 5 g's for 100 seconds; maximum temperature, 1200° F one foot behind leading edge (?); heat sink (not ablative) cooling.

Recovery and landing: Ejection seat with parachute.

Safety features: Polaris fired if Atlas fails. Ejection seat throws pilot clear.

Tracking: Ground control system for control of vehicle.

Schedule: Manned capsule flight 20-25 months.

Costs: Not stated.

GOODYEAR

After introduction by Mr. Baldwin, Mr. Darrell Romick described Phase 1 of a long-range (six to eight years) program to provide an operational satellite platform. The initial program was to conduct reentry tests (30 pound payload) [18] with Jupiter launcher; with primate (150 - 300 pound payload) with a Thor or Jupiter; manned spherical ball (1500 - 2000 pound payload) with Atlas or Titan. Only the features of the minimum man proposal are given here.

Pertinent Features

Vehicle: One-man 7-foot spherical vessel.

Weight: 1700 pounds; structure, 1050 pounds.

Boosters: Atlas or Titan first stage. Five third stage Vanguards or eight Irises (made by Goodyear Aircraft Corporation) for second stage. Maximum g's 5 to 7.

Time and Altitude:

Perigee = 110-115 miles; and Apogee = 600 - 800 miles.

Reentry method: External retrorocket (H_2O_2 -polyethylene, -800 feet per second, with tankage jettisoned before reentry.) $W/C_D\ A = 0.028$; maximum g's 7.5, greater than 4 for five minutes; maximum temperature, 3200^{O} F, temperature greater than 2000° F for five minutes; maximum heat transfer not stated. Ablative cooling using Goodyear Aircraft Corporation-developed material.

Recovery and landing: Parachute for entire capsule deployed at 15,000 feet, with velocity 300 feet per second. Water landing in Western Pacific Ocean. Velocity at impact – 28 feet per second.

Control features: Extendable skirt for attitude control. Peripheral jet nozzles for attitude stabilization with retrorocket.

Tracking: Minitrack and defense radar.

Schedule: First firing - 23 months; manned flight - 26 months.

Cost: $\$100 \text{ x } 10^{6}$.

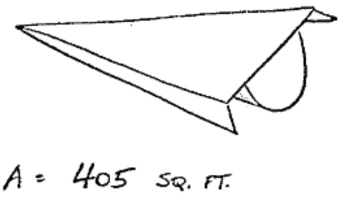
[19]

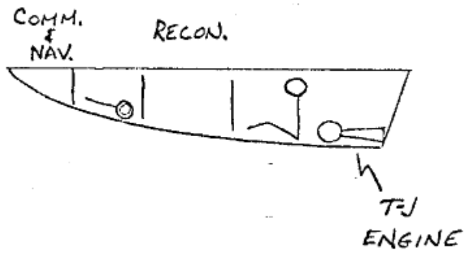
NORTHRUP

Northrup's presentation stressed the previously presented Dyna-soar proposal along with the military advantages and capabilities of the reconnaissance-bomber glider vehicle. Their man-in-space proposal is essentially an adaptation of this vehicle.

Pertinent Features

Vehicle: A glider as outlined below:





Weight: 10,500 pounds including 400 pounds fuel and a J-83 turbojet engine for final maneuver and landing.

Boosters: Three stages not detailed. The boost requirements vary in carrying out the separate steps in the development program. For the satellite flight the three stages of boost would each require a mass ratio of 3.6 with oxygen - JP-4. Initial gross weight, about 600,000 pounds. Maximum g's - 3.

Range and Altitude- 22,000 miles. Total time 70 minutes, attitude and speed variable with time, maximum altitude 200,000 feet.

[20]

Reentry: By increasing drag as glider descends. Maximum temperatures 3450° F at leading edge; 2150° F on lower surface, 1000° F on upper surface. 100 pounds liquid coolant and radiation cooling.

Recovery and landing: Conventional glide landing.

Tracking: Self-contained navigational system claimed to have 2 miles C.E.P.

Schedule: First glider vehicle 1960, boost flight tests at 4000 - 5000 mile range 1961, near-orbital manned flight - 1964.

Cost: 22 test vehicles.

Year	Megadollars	Year	Megadollars
1958	0.5	1962	92
1959	26.5	1963	59
1960	57	1964	29
1961	116		
Total	**380**		

Discussion

The test sequence for the various stages of vehicle development would be: (1) air launch from a carrier aircraft, (2) unmanned version for boost development testing, and (3) manned tests. Several technologies are needed, particularly the development of reliable boost rockets. Results of the x-15 high-speed flights and development of stellar-sight guidance equipment are also required.

Development of this vehicle brings with it the possibility of bombing or reconnaissance missions. These Northrup has detailed in the "Dyna-soar" proposals. Much of the allotted discussion time was spent in reviewing these weapon system capabilities.

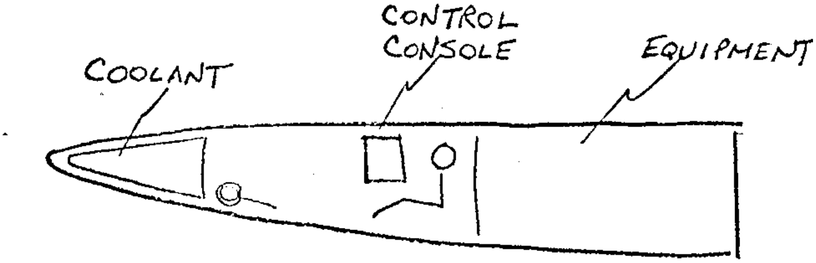
[21]

Bell

Introduction by Dr. Dornberger. Presentation by Mr. Casey Forest. Dr. Dornber[g]er discussed briefly a 3000 pound eight-foot sphere with retrorocket and maximum stagnation temperature of 3500^{O} F; maximum deceleration - 8 g's. Although it could be accomplished one and one half years sooner, he dismissed the sphere as having no growth potential. Bell's proposal therefore hinged strongly on their ROBO concept. The glide vehicle is outlined in the following.

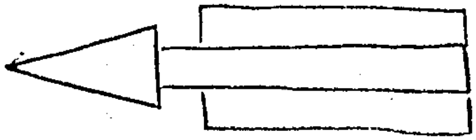
Pertinent Features

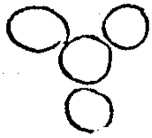
Vehicle: Glider.



Weight: 18,800 pounds.

Boosters. Several assembled configurations were discussed. The one favored was a three-stage clustered configuration with three Titans, one Titan, One F_2-NH_3 rocket, as diagrammed below:





Initial gross weight would be 747,000 Pounds; Φ 1 = 521,300 pounds, Φ 2 = 175,300 pounds, Φ 3 = 31,300 pounds, airplane - 18,800 pounds, research equipment 1500 pounds. Total propellants would be 659,500 pounds. Maximum acceleration - 4 g's.

[22]

Time and altitude: 127 minutes duration. Boost for seven minutes. Altitude at end of boost - 260,000 feet. Follow maximum L/D (Breguet) path.

Recovery and landing: Conventional man-controlled glider landing.

Navigation: Self-contained.

Schedule: Five years. Flight in 1963.

Cost: \$889 x 10^6 including everything. Maximum cost in 1961 - \$240 x 10^6.

Discussion

A short term (10 hour) satellite glider was also mentioned.

Bell has had a contract for development of a F_2-NH_3 rocket; they are willing to incorporate a $F_2N_2H_4$ rocket in the manned glider as the third stage of boost. In their ROBO studies and F_2NH_3 development work Bell claims to have \$2.5 x 10^6 effort, with the USAF also spending \$2.5 x 10^6.

A system development team has been in existence for more than a year. This team is organized as follows:

Airplane	Bell Aircraft
Electronics	Bendix Aviation
Navigation	Minneapolis-Honeywell
Boost	——
Ground and Supplies	——
Special Radar	Goodyear Aircraft

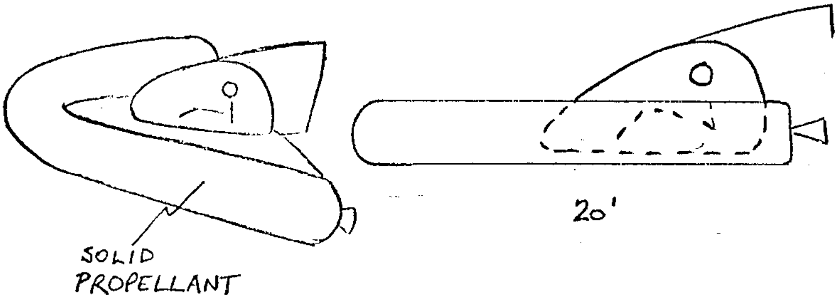
REPUBLIC

Introduction by Dr. Alexander Kartveli, Vice-President of Research and Development. The Republic proposal was based on the hypersonic glider concept of Dr. Antonio Ferri.

[23]

Pertinent Features

Vehicle: A blunt leading-edge sled with solid propellant rockets housed in the edges, Surface = 120 square feet. W/S = 25 pounds per square foot. C_L = .7.



Weight:

Propulsion	1000 pounds

Electrical	375 pounds
H_2O_2 control	175 pounds

Weight Total 3895 pounds (includes other factors)

Boosters: Atlas or Titan with modified propellants.

Time and altitude: 24 hours. Perigee 550,000 feet, reentry altitude – 300,000 feet.

Reentry method: Two retrorockets (-65 feet per second) applied at apogee. This reduces perigee to 300,000 feet. At this altitude produce negative lift (0.0005 g) by flying airplane inverted to prevent increasing altitude. Reaches M = 2 at 80,000 feet. Angle of attack on reentry about 40°. L/D = 1. Maximum temperature 2500° F.

Recovery and landing: Ejection seat for pilot and survival kit. Vehicle destroyed.

[24]

Safety features: H_2-O_2 attitude controls. Three aerodynamic control surfaces.

Guidance and tracking: Inertial guidance with short term rate gyros, accurate within 20 - 25 miles in position. Also UHF communication and beacon transponder.

Schedule: 18 months. Lead item claimed to be inertial guidance system.

Cost: Not estimated.

Discussion

The performance estimates of the booster units are summarized in the following:

	Stage 1	Stage 2	Stage 3
Wo	198,700	74,000	15,000
W_{Bo}	78,600	16,890	4,000
F	304,000	72,200	16,000
IS	230	250	265

CONCLUSION

This was the first round of proposals. Mr. Bell and WADC people expected to review these critically (they solicited comments from the NACA representatives before breakup of the group). A second round of the favored proposals was in the latter part of February and was planned to yield a proposal for WADC to submit to the Pentagon.

[signed]

Adelbert O. Tischler
Head, Rocket Combustion Section

WTO
MG
GM
AOT:jcs

Document I-4

[confidential] [declassified]
NACA- Langley
April 11, 1958

MEMORANDUM For Mr. Gilruth
Subject: Langley manned-satellite program

1. Langley has been working for several months on the general problems of manned-satellite vehicles. General studies have led to the choice of a basic drag-reentry capsule as the most logical first vehicle. Following this choice several more specific studies were undertaken at Langley. The overall program into which these specific studies fit are:

1) Reduced-scale recoverable satellite
2) Wind-tunnel and flight model studies of capsules and vertical flight vehicles
3) Laboratory studies (models, analyses, mock-ups) of structures, loads,stability and control, etc.
4) Full-scale vertical flight
5) Full-scale orbiting flight

Studies in item 1 above are summarized on the attached sheet 1 [not included]. Studies in items 2 and 3 are summarized in sheets 2 to 7 [not included]. All of these studies are pointed directly toward items 4 and 5.

2. In addition to the above studies the following are underway:

a) The Langley Instrument Research Division is studying attitude-control systems for the vertical flight capsule. Some hardware is already on order.

b) The Langley Theoretical Mechanics Division is studying orbits and general space-mechanics problems of satellite flight.

c) The human-factors problems of vertical-flight and satellite reentry capsules have been discussed with personnel of the Naval Medical Acceleration

Laboratory, Johnsville, PA. Copies of typical vertical reentry histories of V, g, h, and oscillation have been sent to NMAL for their further study.

[Signed]
Paul E. Purser
Aeronautical Research Engineer

Document I-5

Document Title: Maurice H. Stans, Director, Bureau of the Budget, Memorandum for the President, "Responsibility for 'Space' Programs," 10 May 1958.

Source: Folder 18674, NASA Historical Reference Collection, NASA History Division, NASA Headquarters, Washington DC.

Document I-6

Document Title: Maxime A. Faget, NACA, Memorandum for Dr. Dryden, 5 June 1958.

Source: Folder 18674, NASA Historical Reference Collection, NASA History Division, NASA Headquarters, Washington DC.

Document I-7

Document Title: Clotaire Wood, Headquarters, NACA, Memorandum for Files, "Tableing [*sic*] of Proposed Memorandum of Understanding Between Air Force and NACA For a Joint Project For a Recoverable Manned Satellite Test Vehicle," 20 May 1958, with attached Memorandum, "Principles for the Conduct by the NACA and the Air Force of a Joint Project for a Recoverable Manned Satellite Vehicle," 29 April 1958.

Source: Folder 18674, NASA Historical Reference Collection, NASA History Division, NASA Headquarters, Washington DC.

Document I-8

Document Title: Hugh L. Dryden, Director, NACA, Memorandum for James R. Killian, Jr., Special Assistant to the President for Science and Technology, "Manned Satellite Program," 18 July 1958.

Source: Folder 18674, NASA Historical Reference Collection, NASA History Division, NASA Headquarters, Washington DC.

Perhaps the most difficult policy question to be resolved in the first half of 1958 revolved around the roles and missions of individual governmental entities in the new space initiative. Virtually every service within the Department of Defense (DOD) sought to control at least the lion's share of the human spaceflight mission. The National Advisory Committee *for Aeronautics (NACA), then in the process of being transformed into NASA, thought it should have control of the mission as well. These rivalries led to debate and disagreement, negotiation, and compromise among these various entities. At first, NACA believed it would have to play a supporting role in the spaceflight initiative, yielding human activities to the military, but it became clear as 1958 progressed that the White House wanted NASA to take the lead, with the military supporting its efforts. This set of documents provided a detailed perspective on these deliberations and their results.*

Document I-5

EXECUTIVE OFFICE OF THE PRESIDENT
BUREAU OF THE BUDGET
WASHINGTON 25, DC

May 10, 1958

MEMORANDUM FOR THE PRESIDENT

Subject: Responsibility for "space" programs

In your letters of April 2, 1958, you directed the Secretary of Defense and the Chairman of the National Advisory Committee for Aeronautics to review and report to you which of the "space" programs currently underway or planned by Defense should be placed under the direction of the new civilian space agency proposed in your message to Congress. These instructions specifically stated that "the new Agency will be given responsibility for all programs except those peculiar to or primarily associated with military weapons systems or military operations."

It now appears that the two agencies have reached an agreement contemplating that certain space programs having no clear or immediate military applications would remain the responsibility of the Department of Defense. This agreement would be directly contrary to your instructions and to the concept underlying the legislation the administration has submitted to Congress.

The agreement is primarily the result of the determination of the Defense representatives not to relinquish control of programs in areas which they feel might some day have military significance. The NACA representatives apparently have felt obliged to accept an agreement on the best terms acceptable to Defense.

Specifically, Defense does not wish to turn over to the new agency all projects related to placing "man in space" and certain major component projects such as the proposed million pound thrust engine development. The review by your Scientific Advisory Committee did not see any immediate military applications of these projects.

The effect of the proposed agreement would be to divide responsibility for programs primarily of scientific interest between the two agencies. This would be an undesirable and unnecessary division of responsibility and would be highly impractical. There would no be any clear dividing line, and unnecessary overlap and duplication would be likely. The Bureau of the Budget would have an almost hopeless task in trying to keep the two parts of the program in balance, and problems on specific projects would constantly have to come to you for resolution. The net result of the proposed arrangement would be a less effective program at higher total cost.

On the other hand, it will be relatively simple to work out practical working arrangements under which responsibility and control of the programs in question would clearly be assigned to the new agency as contemplated in your instructions, and the military interest would be recognized by the participation of the Department of Defense in the planning and, where appropriate, the conduct of the programs.

In the circumstances, it is recommended that you direct that the two agencies consult with the Bureau of the Budget and Dr. Killian's office to be sure that any agreement reached is in accordance with the intent of your previous instructions. It is especially important that the announcement of the agreement now being proposed be avoided at this stage of the consideration by the Congress of legislation to establish the new space agency.

If you approve this recommendation, there are attached memoranda to the Secretary of Defense and the Chairman of the National Advisory Committee for Aeronautics for your signature.

(Handled orally per President's instructions. (AJG, 5/13/58) [AJG is General Andrew Goodpaster, the President's military assistant.]

[Signed Maurice H. Stans]
Director
5/13/58

5/14/58
I notified the Secretary of Defense (General Randall) and Dr. Dryden.
AJG

Document I-6

[SECRET] [DECLASSIFIED}

Washington DC
June 5, 1958

MEMORANDUM for Dr. Dryden

This memorandum is submitted to review my dealings with ARPA during the past several weeks.

A. Background

1. I made my first contact with ARPA personnel on May 14, 1958. At that time the NACA was under the impression that it was to work with Dr. Batdorf to prepare a man-in-space program that would be acceptable to both the NACA and ARPA from a technical standpoint. My first visit to the Pentagon revealed that ARPA had a somewhat different impression of what was to take place. I was told that at the request of Mr. Johnson a panel had been formed in ARPA to create a man-in-space program and to advise him how this program could best be managed. ARPA had formed this panel approximately a week earlier from members of the ARPA technical staff under the Chairmanship of Dr. Batdorf. I was told that this was only one of many such working groups that was concurrently attacking various jobs in ARPA and that the membership on these various panels greatly overlapped. Accordingly, my position on the man-in-space panel was a special one resulting from an invitation by Dr. York.

2. Inasmuch as this situation was not exactly in keeping with my impression of what it should be, I told the panel that while I would sit as a member of their panel I would also consider myself as a liaison representative of the NACA. In this respect, I reminded them that the direct responsibility for the man-in-space program may quite likely be given to the soon to be created civilian space agency. Thus, I would be concerned that the man-in-space program to be formulated would be one that is acceptable to the NASA and that the management responsibility would be one which could be transferred with the least difficulty. I stated further that if there are any final agreements to be reached between ARPA and NACA they would have to be approved by higher authority, presumably Dr. Dryden and Dr. York and quite possibly by knowledgeable people from the White House. Dr. Batdorf concurred with this and stated that the ARPA staff, most of whom work for IDA, serve only in an advisory capacity.

3. My dealings with the ARPA panel have been quite pleasant and I think fruitful. On the majority of the issues the panel has reached essentially unanimous agreement. On controversial subjects my viewpoints are apparently being given fair consideration. In addition, the panel is quite aware that the NACA has a firm position in the man-in-space business. From this standpoint, I have additional influence when the question of acceptability to NACA arises in certain instances.

4. While a good number of the ARPA staff have attended the panel discussions and the presentations made to the panels by the services, those who actually serve on the panel are:

1. Dr. Sam Batdorf, recently from Lockheed
2. Dr. Arthur Stosick, recently from JPL
3. Mr. Bob Youngquist, recently from RMI
4. Mr. Jack Irvine, recently from Convair

5. Captain Robert Truax, recently from BMD (117L Project)
6. Mr. Dick Cesaro, recently from ARDC and NACA

5. The panel has conducted its business by questioning representatives of the Air Force, Navy, Army, and Industry who are familiar with proposed man-in-space programs and by conducting discussions within the panel alone. The Air Force has sent a large number of representatives to two panel meetings to answer questions. These have included people from HQ, ARDC, BMD, and WADC.

B. Present Situation

1. The work of the panel is apparently drawing to a close. We have put together a proposed man-in-space program that is not far different from the Air Force proposal. The essential elements of this program are:

a. The system will be based on the use of the Convair Atlas propulsion system. If the expected performance of the Atlas rocket alone is not obtained, then the Atlas 117L system will be used.
b. The man-in-space flights will be launched from "Pad-20" at AFMTC.
c. Retro-rockets will be used to initiate return from orbit.
d. The non-lifting ballistic type of capsule will be used.
e. The aerodynamic heating during atmospheric entry will be handled by a heat sink or ablation material.
f. Tracking will be carried out primarily with existing or already planned systems. The most important of which will be the G.E. Radio-inertial Guidance System which is highly accurate. [*sic*] The G.E. system will be in existence at AFMTC, San Salvadore, Australia, and Camp Cook.
g. The crew for the orbital flights will be selected from volunteers in the Army, Navy, and Air Force. The crew will be selected in sufficient time to undergo aero-medical training functions.

2. The panel is in unanimous agreement that the man-in-space program should begin immediately. The panel feels that in spite of the unsettled status of both ARPA and NACA that this can be accomplished if a national man-in-space program is adopted. ARPA apparently has $10,000,000 to initiate the program. Future funding and management will of course depend on the outcome of present legislation.

3. The panel is recommending that the Air Force be given the management of the program with executive control to remain in the hands of NACA and ARPA. This could presumably be accomplished by the creation of an executive committee composed of NACA and ARPA people, plus representatives from the contractors, the Air Force, and perhaps Army and Navy.

4. In addition to meeting with the panel I had a short chat with Dr. York on June 4. His views differed from the panel on primarily two issues. He thinks the Atlas alone and the Atlas-117L combination should be considered equally competitive at this time as a propulsion system. The panel considers the 117L

approach as a back up to be dropped as soon as sufficient confidence in the Atlas alone is achieved. Dr. York thinks that contract for the construction of the capsule should be awarded after proposals are received from industry. The panel, although they do not recommend this procedure, believe that it would be much quicker and just as satisfactory to choose a suitable contactor to build a capsule which has been tightly specified.

[Signed]
Maxime A. Faget

Document I-7

Washington, D.C.
May 20, 1958

MEMORANDUM For Files

Subject: Tableing [*sic*] of Proposed Memorandum of Understanding Between Air Force and NACA For a Joint Project For a Recoverable Manned Satellite Test Vehicle

Reference: NACA ltr to DCS/D dtd April 11, 1958

1. On April 11, 1958, Dr. Dryden signed a proposed Memorandum of Understanding for a Joint NACA-Air Force Project for a recoverable manned satellite test vehicle. Minor revisions to the Agreement were discussed and, with Dr. Dryden's approval, agreed on between Colonel Heaton and myself on April 29, 1958.

2. Subsequent to April 29, 1958, it was agreed with Colonel Heaton that the prospective Agreement should be put aside for the time being. The matter may be taken up again when the responsibilities of ARPA and NASA have been clarified.

C. Wood

CloW:dlf

[2]

[April 29, 1958]

MEMORANDUM OF UNDERSTANDING

Subject: Principles for the Conduct by the NACA and the Air Force of a Joint Project for a Recoverable Manned Satellite Vehicle.

A. A project for a recoverable manned satellite test vehicle shall be conducted jointly by the NACA and the Air Force, implementing an ARPA instruction to the Air Force of February 23, 1958. Accomplishment of this project is a matter of national urgency.

B. The objectives of the project shall be:

   a. To achieve manned orbital flight at the earliest practicable date consistent with reasonable safety for the man,

   b. To evaluate factors affecting functions and capabilities of man in an orbiting vehicle,

   c. To determine functions best performed by man in an orbiting weapon system.

C. To insure that these objectives are achieved as early and as economically as possible the NACA and the Air Force will each contribute their specialized scientific, technical, and administrative skills, organization and facilities.

D. Overall technical direction of the project shall be the responsibility of the Director, NACA, acting with the advice and assistance of the Deputy Chief of Staff, Development, USAF.

E. Financing of the design, construction, and operational phases of the project [the following words were in the April 11 version of the memorandum but were deleted on April 29. A handwritten note on the April 29 version of the document says *"this deletion suggested by Silverstein & Gilruth, agreed on by JWC & HCD."* The text continues: as well as of any studies which may be determined necessary to supplement Air Force or NACA studies to permit the accomplishment of the objectives,] shall be the function of the Air Force.

F. Management of the design, construction, and operational phases of the project shall be performed by the Air Force in accordance with the technical direction prescribed in paragraph C. Full use shall be made of the extensive background and capabilities of the Air Force in the Human Factors area.

[Handwritten note at bottom of page – "Col. Heaton advised 2:15 p.m. 4-29-58 that this version agreeable to Director NACA provided that deletion is made as marked in paragraph E, Clo Wood."]

G. Design and construction of the project shall be accomplished through a negotiated contract (with supplemental prime or sub-contracts) obtained after evaluating competitive proposals invited from competent industry sources. The basis for soliciting proposals will be characteristics jointly evolved by the Air Force and NACA based on studies already well under way in the Air Force and the NACA.

H. Flights with the system shall be conducted jointly by the NACA, the Air Force, and the prime contractor, with the program being directed by the NACA and the Air Force. The NACA shall have final responsibility for instrumentation and the planning of the flights.

I. The Director, NACA, acting with the advice and assistance of the Deputy Chief of Staff, Development, USAF, shall be responsible for making periodic progress reports, calling conferences, and disseminating technical information and results of the project by other appropriate means subject to the applicable laws and executive orders for the safeguarding of classified information.

General Thomas D. White
Chief of Staff, USAF
Hugh L. Dryden
Director, NACA

Document I-8

July 18, 1958

MEMORANDUM for Dr. James R. Killian, Jr.
Special Assistant to the President for Science and Technology

SUBJECT: Manned Satellite Program.

1. The current objective for a manned satellite program is the determination of man's basic capability in a space environment as a prelude to the human exploration of space and to possible military applications of manned satellites. Although it is clear that both the National Aeronautics and Space Administration and the Department of Defense should cooperate in the conduct of the program, I feel that the responsibility for and the direction of the program should rest with NASA. Such an assignment would emphasize before the world the policy statement in Sec. 102(a) of the National Aeronautics and Space Act of 1958 that "it is the policy of the United States that activities in space should be devoted to peaceful purposes for the benefit of all mankind."

2. The NASA through the older NACA has the technical background, competence, and continuing within-government technical back-up to assume this responsibility with the cooperation and participation of the Department of Defense. For a number of years, the NACA has had groups doing research on such items as stabilization of ultra-high-speed vehicles, provision of suitable controls, high-temperature structural design, and all the problems of reentry. More recently, the NACA research groups have been working on these problems with direct application to manned satellites. The human-factors problems of this program are not far different from those for the X-15 which the NACA has been studying in cooperation with the Navy and Air Force. Thus, the NACA has enlisted the cooperation of the military services and marshaled the required technical competence. Included in this competence are large, actively-working, staffs in NACA laboratories providing additional technical back-up for the manned-satellite program.

3.The assignment of the direction of the manned satellite program to NASA would be consistent with the President's message to Congress and with the pertinent extracts from the National Aeronautics and Space Act of 1958 given in the appendix to this memorandum.

Hugh L. Dryden
Director
National Advisory Committee for Aeronautics

Attachment [not included]

Document I-9

Document Title: Maxime A. Faget, Benjamine J. Garland, and James J. Buglia, Langley Aeronautical Laboratory, NACA, "Preliminary Studies of Manned Satellites," 11 August 1958.

Source: Folder 18674, NASA Historical Reference Collection, NASA History Division, NASA Headquarters, Washington DC.

Prior to the Mercury, Gemini, and Apollo programs of the 1960s, virtually everyone involved in space advocacy envisioned a future in which humans would venture into space aboard winged, reusable vehicles. That was the vision from Hermann Oberth in the 1920s through Wernher von Braun in the 1950s to the U.S. Air Force's X-20 Dyna-Soar program in the early 1960s. Because of the pressure of the Cold War, NASA chose to abandon that approach to space access in favor of ballistic capsules that could be placed atop launchers developed originally to deliver nuclear warheads to the Soviet Union. This memorandum states the position, one NASA eventually adopted, that advocated using ballistic capsules for human spaceflight. Led by Maxime A. Faget, one of the most innovative thinkers in NACA/NASA, the authors contend that because of the desire to launch humans as soon as possible, moving to a capsule concept represented the only genuine option available for the U.S. A capsule could make use of research on reentry undertaken for ballistic missiles, as well as make possible the ready adoption of ballistic missiles as launchers for spaceflight.

[CONFIDENTIAL] {DECLASSIFIED}

NACA

RESEARCH MEMORANDUM

PRELIMINARY STUDIES OF MANNED SATELLITES

WINGLESS CONFIGURATION: NONLIFTING

By Maxime A. Faget, Benjamine J. Garland, and James J. Buglia

Langley Aeronautical Laboratory
Langley Field, VA.

August 11, 1958

[Note: Only Summary and Introduction are included]

SUMMARY

This paper is concerned with the simple non-lifting satellite vehicle which follows a ballistic path in reentering the atmosphere. An attractive feature of such a vehicle is that the research and production experiences of the ballistic–missile programs are applicable to its design and construction, and since it follows a ballistic path, there is a minimum requirement for autopilot, guidance, or control equipment. After comparing the loads that would be attained with man's allowable loads, and after examining the heating and dynamic problems of several specific shapes, it appears that, insofar as reentry and recovery is concerned, the state of the art is sufficiently advanced so that it is possible to proceed confidently with a manned-satellite project based upon the ballistic reentry type of the vehicle.

INTRODUCTION

This paper is concerned with the simple non-lifting satellite vehicle which follows a ballistic path in reentering the atmosphere. An attractive feature of such a vehicle is that the research and production experiences of the ballistic–missile programs are applicable to its design and construction.

The ballistic reentry vehicle also has certain attractive operational aspects which should be mentioned. Since it follows a ballistic path there is a minimum requirement for autopilot, guidance, or control equipment. This condition not only results in a weight saving but also eliminates the hazard of malfunction. In order to return to the earth from orbit, the ballistic reentry vehicle must properly perform only one maneuver. This maneuver is the initiation of reentry by firing the retrograde rocket. Once this maneuver is completed (and from a safety standpoint alone it need not be done with a great deal of precision), the vehicle will enter the earth's atmosphere. The success of the reentry is then dependant only upon the inherent stability and structural integrity of the vehicle. These are things of a passive nature and should be thoroughly checked out prior to the first man-carrying flight. Against these advantages the disadvantage of large area landing by parachute with no corrective control during the reentry must be considered.

In reference 1, Dean R. Chapman has shown that the minimum severity of the deceleration encountered during a ballistic reentry is related to the fundamental nature of the planet. Thus it can be considered a fortunate circumstance that man can tolerate this deceleration with sufficient engineering margin.

Document I-10

Document Title: Roy W. Johnson, Director, ARPA, DoD, Memorandum for the Administrator, NASA, "Man-in-Space Program," 3 September 1958.

Source: Folder 18674, NASA Historical Reference Collection, NASA History Division, NASA Headquarters, Washington DC.

Document I-11

Document Title: Roy W. Johnson, Director, ARPA, DOD, Memorandum for the Administrator, NASA, "Man-in-Space Program," 19 September 1958, with attached Memorandum of Understanding, "Principles for the Conduct by NASA and ARPA of a Joint Program for a Manned Orbital Vehicle," 19 September 1958.

Source: Folder 18674, NASA Historical Reference Collection, NASA History Division, NASA Headquarters, Washington DC.

One of the issues that NASA, officially established on 1 October 1958, had to work in its first weeks of existence was an agreement on how to manage the human spaceflight program. Laboriously its leadership negotiated with interested organizations in the Department of Defense for transfer of some resources, as well as for support for the conduct of the mission. A constant consideration at the time was the next act of the Soviet Union, which had already several times bested the U.S. in "space firsts." Should more money be allocated to human spaceflight to ensure U.S. primacy in this arena? Should other actions be taken to ensure that the U.S. launched the first human into space? Should the U.S. pursue a capsule approach because of this rivalry with the USSR? The answer to all of those questions was yes, as shown in these documents, but in the end the Soviets still launched Yuri Gagarin first on 12 April 1961.

Document I-10

[SECRET] [DECLASSIFIED]

ADVANCED RESEARCH PROJECTS AGENCY
WASHINGTON 25, D.C.

Sep 3 1958

MEMORANDUM FOR THE ADMINISTRATOR, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

SUBJECT: Man-in-Space Program

In accordance with agreements reached at the meeting with the Deputy Secretary of Defense on August 20, 1958 we have taken the following actions:

(1) Designated an ARPA officer to work with NASA to arrange for the transfer, not later than January 1, 1959, of all IGY tracking stations from the DoD to the NASA.

(2) Advised the Assistant Secretary of the Navy for Air of your intent to request the transfer to NASA of those persons at NRL engaged on the VANGUARD program.

(3) Arranged for visits by NASA teams to AOMC and to West Coast installations of the DoD for the purpose of evaluating capabilities to pursue future NASA projects.

(4) Arranged for the stationing of resident representatives of NASA at AOMC, BMD and NOTS to become familiar with the details of those scientific programs (covered by ARPA Orders 1, 2, 3 and 9) being conducted by ARPA, in anticipation of their transfer to NASA on or about October 1, 1958.

(5) Prepared a comprehensive management recommendation to the Secretary of Defense for coordination of all DOD satellite tracking and data reduction facilities designed to complement those facilities; to be operated by NASA.

Preparations have thus been made for an orderly transfer of appropriate programs without interruption.

I am troubled, however, with respect to one of the projects in which there is general agreement that it should be a joint undertaking. [2]

This is the so-called “Man-in-Space” project for which $10 million has been allocated to ARPA and $30 million to NASA. My concern over this project is due (1) to a firm conviction, backed by intelligence briefings, that the Soviets next spectacular effort in space will be to orbit a human, and (2) that the amount of $40 million for FY 1959 is woefully inadequate to compete with the Russian program. As you know our best estimates (based on some 12 - 15 plans) were $100 to $150 million for an optimum FY 1959 program.

I am convinced that the military and psychological impact on the United States and its Allies of a successful Soviet man-in-space “first” program would be far reaching and of great consequence.

Because of this deep conviction, I feel that no time should be lost in launching an aggressive Man-in-Space program and that we should be prepared if the situation warrants, to request supplemental appropriations of the Congress in January to pursue the program with the utmost urgency.

Certain projects planned and financed by ARPA and now underway will contribute to this undertaking. I list them here for ready reference.

(1) The bio-medical project of WS-117 L will attempt the recovery of three primates, thus affording valuable information on space environmental data.

(2) Approximately fourteen ATLAS/117L flights are scheduled during the next eighteen months in connection with the WS-117L program. This would give a capability during this period of achieving 4, 000 pounds in a low orbit and offers the most promising early capability of placing a man in orbit with sufficient safety considerations.

(3) A project to design a high energy upper stage (liquid hydrogen liquid oxygen) rocket for ATLAS/TITAN with an engine thrust of approximately 30,000 pounds has been authorized. This has promise of placing 8,000 to 10,000 pounds in orbit during 1960.

(4) A project to construct a 1 - 1.5 million pound thrust booster utilizing existing hardware in a "cluster" arrangement has been authorized. This should permit placing 25,000 pounds in orbit by 1961. It is our intention that this project be carefully coordinated with the single-chamber super thrust engine being developed by NASA so that much of the booster equipment later could be used on the large engine when it becomes available in 1964-1965. The early capability afforded by the cluster project would make possible a space platform for manned reconnaissance and for a related military space operating base. [3]

With these projects forming a basis for the propulsion requirements, parallel efforts should go forward as a matter of urgency on the recoverable vehicle itself. It is my understanding from talks with members of our staff that the NASA will concentrate on the "capsule" technique. I agree that this offers the earliest promise and urge that the program be pursued vigorously. As an alternate approach it is the intention of the DoD to proceed with a winged vehicle based on the general concept of the DYNA SOAR Weapon System 464L. The winged vehicle approach is believed to most nearly satisfy the military objectives in regard to flexibility of mission and independence from ground guidance and recovery operations during hostilities. Many of the design requirements, especially those relating to human factors, will be similar for the two approaches. Thus we would expect to make maximum use of the NASA capsule data in our alternate approach.

I therefore urge that you join with me at the earliest practicable date to consider every possible step that we might take to achieve a U.S. lead in this important program.

[signed]
Roy W. Johnson
Director

Document I-11

September 1958

[Handwritten: ARPA]

MEMORANDUM FOR THE ADMINISTRATOR, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

SUBJECT: Man-in-Space Program

This is to confirm that the agreement reached in our discussions of yesterday that ARPA will join with NASA in a joint Man-in-Space program based on the “capsule” technique.

I consider this program to be of the highest urgency and have directed appropriate members of my organization to work with your staff to outline a detailed program for early implementation. I believe it very desirable that at least an outline of an agreed program be available for presentation to the Space Council on October 20.

As indicated yesterday, ARPA is of the opinion that a follow-on winged maneuverable space vehicle is essential to meet military requirements and it is our intention to initiate a modest program in this direction during FY 1959.

[Signed]
Roy Johnson
Director
[Attachment included]

9/19/58

MEMORANDUM OF UNDERSTANDING

Subject: Principles for the Conduct by NASA and ARPA of a Joint Program for a Manned Orbital Vehicle

1. It is agreed that a program for a manned orbital vehicle will be conducted jointly by NASA and ARPA. It is agreed that accomplishment of this program is a matter of national urgency.
2. The objective of this program is to demonstrate the capability of manned orbital flight at the earliest practicable date consistent with reasonable safety for the man. The program will include constructing and testing in flight a manned-orbital vehicle.
3. It is agreed that this program will be supported by NASA and ARPA until it is terminated by the achievement of manned orbital-flights.
4. Technical direction and management of the program will be the responsibility of the Administrator of the NASA, acting with the advice and assistance of the Director of ARPA.
5. It is agreed that the concurrence of the Administrator of NASA will be required for any parts of this program which are carried out by contract.
6. It is the intent in this program to make full use of the background and capabilities existing in NASA and in the military services. [2]
7. It is agreed that a working committee consisting of members of the staff of NASA and ARPA will be established to advise the Administrator of the NASA and the Director of ARPA on technical and management aspects of this program, and that the chairman of this committee will be a member of the NASA staff.

Document I-12

Document Title: Minutes of Meetings, Panel for Manned Space Flight, 24 and 30 September, 1 October 1958.

Source: Folder 18674, NASA Historical Reference Collection, NASA History Division, NASA Headquarters, Washington, DC.

In August 1958, before NASA was officially established, NACA Director Hugh L. Dryden and Robert R. Gilruth, Assistant Director of Langley Aeronautical Research Laboratory, had both informed Congress of their intent to seek $30 million for the development of a piloted satellite vehicle. One month later NASA Administrator T. Keith Glennan and Roy Johnson, Director of the Advanced Research Projects Agency (ARPA), managed to come to a general agreement concerning a joint NASA-ARPA program for developing a vehicle based upon a ballistic capsule concept that had been proposed by engineers at Langley. (See Documents I-10 and I-11.) The panel for Manned Spaceflight, also referred to as the Joint Manned Satellite Panel, was established by executive agreement between NASA and ARPA on 18 September. It held its first meeting on 24 September. In that and subsequent meetings in the following days, the panel established the basic goals and strategies for the initial U.S. piloted spaceflight program.

National Aeronautics and Space Administration
1520 H Street Northwest
Washington 25, D.C.

MINUTES OF MEETINGS

PANEL FOR MANNED SPACE FLIGHT
September 24, 30, October 1, 1958

A meeting of the Panel for Manned Space Flight was held on September 24 and 30 and October 1, 1958, at NASA Headquarters, Washington, D.C.

The following panel members were present:

Robert Gilruth (Chairman), NASA
Dr. S. B. Batdorf, ARPA
D. A.J. Eggers, NASA (Sept. 24)
Max Faget, NASA
George Low, NASA
Warren North, NASA
Walter Williams, NASA (Sept. 24-30)
Roberson Youngquist, ARPA (Sept. 24)

The objectives of this series of meetings were to set up a basic plan for the manned satellite project, determine a preliminary flight test schedule, and establish a funding program. Attached as Appendix A is the draft of "Objectives and Basic Plan." Appendices B and C include the tentative flight test program and flight test schedule. A cost breakdown of the project is attached as Appendix D. [Appendices B, C, and D not included]

It was decided that no aero-medical experiments will be supported by the Manned Satellite Project except those required for the successful completion of the mission. Dr. Lovelace will aid in establishing the aero-medical and pilot training requirements. Mr. Williams mentioned that aero-medical information obtained from the X-15 project should be applicable to the Manned Satellite Project.

Approval was obtained from General Boushey for use of a C-130 airplane in order to expedite some of the capsule and parachute drop tests. [2]

Mr. Williams will determine the feasibility of using a F-104 launch airplane for a portion of the drogue parachute tests.

Dr. Eggers stressed the fact that the panel should consider a lifting vehicle in planning for future manned space flight projects.

[Signed]
Warren J. North
Secretary

Appendix A

OBJECTIVES AND BASIC PLAN FOR THE MANNED SATELLITE PROJECT

I. Objective

The objectives of the project are to achieve at the earliest practicable date orbital flight and successful recovery of a manned satellite, and to investigate the capabilities of man in this environment.

II. Mission

To accomplish these objectives, the most reliable available boost system will be used. A nearly circular orbit will be established at an altitude sufficiently high to permit a 24-hour satellite lifetime; however, the number of orbital cycles is arbitrary. Descent from orbit will be initiated by the application of retro-thrust. Parachutes will be deployed after the vehicle has been slowed down by aerodynamic drag, and recovery on land or water will be possible.

III. Configuration

A. Vehicle

The vehicle will be a ballistic capsule with high aerodynamic drag. It should be statically stable over the Mach number range corresponding to flight within the atmosphere. Structurally, the capsule will be designed to withstand any combination of acceleration, heat loads, and aerodynamic forces that might occur during boost and reentry of successful or aborted missions.

B. Life Support System

The capsule will be fitted with a seat or couch which will safely support the pilot during acceleration. Provision will be made for maintaining the pressure, temperature, and composition of the atmosphere in the capsule within allowable limits for human environment. Food and water will be provided.

C. Attitude Control System

The vehicle will incorporate a closed loop control system which consists of an attitude sensor with reaction controls. The reaction controls will maintain the vehicle in a specified orbital attitude, will [2] establish the proper angle for retro-firing, reentry, or an abort maneuver. The pilot will have the option of manual or automatic control during orbital flight. The manual control will permit the pilot to visually observe various portions of the earth and sky.

D. Retrograde System

The retro-rocket system will supply sufficient impulse to permit atmospheric entry in less than ½ revolution after application of retro-thrust. The magnitude and direction of the retro-thrust will be predetermined on the basis of allowable declarations and heating within the atmosphere, and miss distance.

E. Recovery Systems

A parachute will be deployed at an altitude sufficiently high to permit a safe landing on land or water; the capsule will be buoyant and stable in water. Communication and visual aids will be provided to facilitate rescue.

F. Emergency Systems

An escape system will be provided to insure a safe recovery of the occupant after a malfunction at any time during the mission. Parallel or redundant systems will be considered for the performance of critical functions.

IV. Guidance and Tracking

Ground-based and vehicle equipment will be employed to allow the establishment of the desired orbit within satisfactory tolerance, to determine the satellite orbit with the greatest possible accuracy, to initiate the descent maneuver at the proper time, and to predict the impact area.

V. Instrumentation

Medical instrumentation required to evaluate the pilot's reaction to space flight will be incorporated in the capsule. In addition, instrumentation will be provided to measure and monitor the internal and external cabin environment and to make scientific observations. These data will be recorded in flight and/or telemetered to ground recorders.

VI. Communication

Provisions will be made for adequate two-way communications between the pilot and ground stations. [3]

VII. Ground Support

The successful completion of the manned satellite program will require considerable ground support, such as pre-launch support and an elaborate recovery network.

VIII. Test Program

An extensive test program will be required to implement this project. The test program will include ground testing, development and qualification flight testing, and pilot training.

Document I-13

Document Title: NASA, "Preliminary Specifications for Manned Satellite Capsule," October 1958.

Source: Folder 18674, NASA Historical Reference Collection, NASA History Division, NASA Headquarters, Washington DC.

Most of the design work for what became the Mercury spacecraft took place under the auspices of, and in many cases directly by, Max Faget. This document, written by Faget and his research team, established very detailed specifications for the Mercury spacecraft for the use of industry, necessary for their proposals to build the hardware. These specifications outlined the program and suggested methods of analysis and construction. Faget specifically asked for the construction of a simple, nonlifting vehicle that could follow a ballistic path in reentering the atmosphere without experiencing heating rates or accelerations that would be dangerous to an astronaut. He also called for modest pitch, yaw, and attitude control, as well as a retrorocket pack to bring the capsule down from orbital velocity. Finally, this document established the limits of size, shape, weight, and tolerances of the Mercury spacecraft. This set of specifications became the basis for the capsule's construction by the McDonnell Aircraft Company based in St. Louis, Missouri.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
PRELIMINARY SPECIFICATIONS
FOR
MANNED SATELLITE CAPSULE

OCTOBER 1958

TABLE OF CONTENTS

[1]

1. INTRODUCTION

1.1 This preliminary specification outlines the technical design requirements for a manned satellite capsule. This capsule will be used in the initial research on manned space flight. The research will be concerned primarily with man's ability to adapt to and perform in a space environment as well as in those environments associated with projection into space and with return to the surface of the earth.

1.2 The scope of this specification encompasses the capsule configuration, stability and control characteristics, heating and loads environments, structural design, onboard equipment and instrumentation. In certain areas, specific design approaches are outlined herein. The contractor shall follow the outlined approaches except in cases where mutual agreement is reached between the NASA and the contractor that an alternate approach is to be taken. Suggestions by the contractor of improved alternate approaches are invited.

1.3 The contractor shall undertake and be responsible for the design, fabrication or procurement, integration, and installation of all components of the capsule system as described herein. Details of the responsibilities for the matching of the capsule and the booster vehicle will be clarified at a later date.

1.4 The design approach shall emphasize the safety of the mission. Although not specified herein in every instance, due consideration shall be given to simplicity, redundancy, and the use of backup systems in order to improve mission reliability.

[2]

2. MISSIONS

2.1 General - All missions to be described shall be capable of accomplishment with and without a human occupant and with appropriate animals if desired.

2.2 Primary Mission – The primary mission shall be the launching of a manned capsule into a semi permanent orbit and subsequent safe recovery to the surface of the earth at a designated time and/or position through use of retro thrust and aerodynamic drag. The design mission profile is as indicated in figure 1 [not included] and from histories of pertinent trajectory variables are shown in figure 3 [not included].

2.2.1 The design of the capsule shall be based on the use of a single Atlas D missile as the launching booster. The capsule shall replace the missile nose cone in a manner which requires a minimum of modifications to the booster system.

2.2.2 The launching site shall be Cape Cannaveral, Florida. Launching shall be possible at any azimuth within thirty (30) degrees of due east.

2.2.3 A target value of effective launch weight shall be twenty-four hundred (2,400) pounds. Effective launch weight is defined by the following equation:

$$W_e = W_O + 0.2W_j$$

Where

W_O is the weight of capsule when projected into orbit

W_j is the weight of capsule components jettisoned at Atlas staging

2.2.4 The launch booster system shall be capable of projecting the capsule into orbit with the following tolerances:

2.2.4.1 The projection altitude shall be not greater than one hundred and twenty (120) nautical miles.

2.2.4.2 The perigee altitude shall not be less than one hundred and ten (110) nautical miles.

2.2.4.3 The eccentricity shall not be greater than five thousandths (0.005)

[3]

2.2.5 For the initial orbital missions, the number of orbital cycles per mission shall be two (2); however, an arbitrary number of orbital cycles per mission up to eighteen (18) shall be possible.

2.2.6 The following specifications pertain to the recovery of the capsule from orbit:

2.2.6.1 The nominal position of the point at which entry is initiated shall be such that impact occurs in a prescribed area in proximity to the launching station; however, in the event an emergency, it shall be possible to initiate the entry at any point in the orbit.

2.2.6.2 The entry shall be accomplished by application of retro thrust to produce a perigee altitude within the atmosphere. The magnitude and direction of the retro thrust shall be regulated so that angles of entry into the atmosphere at an altitude of sixty (60) miles shall be between one half (1/2) and three (3) degrees.

2.2.6.3 Consideration shall be given to high altitude deployment of a drogue parachute. This drogue parachute would be deployed near a Mach number of one (1) and is intended to provide improved dynamic stability to the capsule.

2.2.6.4 A landing parachute shall be deployed at an altitude sufficiently great to allow time to deploy a second parachute in event of failure of the first and to reduce sinking speed at impact to less than thirty (30) feet per second. Impact shall be considered to take place at an altitude of five thousand (5,000) feet. Commensurate with the above requirements, deployment altitudes shall be low enough to keep drift from winds aloft from seriously affecting the area of impact.

2.2.6.5 The capsule shall be designed for water landing, and shall be buoyant and stable in the water; however, consideration shall be given in the design to emergency landing on land surfaces. Protection from serious injury to the human occupant shall be afforded under conditions of land impact.

2.2.6.6 The capsule and the systems within the capsule necessary for location, recovery, and survival shall be capable of sustained operation for a period of twelve (12) hours after impact with the surface of the earth. This requirement is in addition to the twenty-eight (28) hours requirement associated with the space flight phase of the operation

[4]

2.3 <u>Checkout missions</u>- In order to expeditiously lead up to successful achievement of the primary mission, the requirements of the following checkout missions shall be considered in the capsule design.

2.3.1 <u>Ballistic trajectories of limited velocity and range for entry and recovery simulation</u>- A typical mission profile of this type is illustrated in figure 3 [not included]. The entry and recovery phases of this mission shall be accomplished in the same manner as specified for the primary mission. The peak decelerations achieved during entry shall equal those applicable to the primary mission. As this type of checkout mission may represent the first flight tests of a manned space capsule, a buildup in velocity and range may be required. Rocket motors which are immediately available shall be used for this checkout mission.

2.4 <u>Aborted missions-</u> During various periods of the launch operation, it may become necessary to abort the mission and escape from the vicinity of the rocket booster system. An active escape system shall be an [illegible] of the capsule until five (5) seconds after booster staging. At times greater than booster staging plus five (5) seconds, escape shall be accomplished by shutting down the Atlas sustainer engine and operating the nose cone separations motors which are part of the Atlas system. If desirable, the capsule retro rockets can be used to produce a more rapid separation after staging.

2.4.1 The following requirements apply to the escape system.

2.4.1.1 The occupant shall remain within the capsule, and escape shall be accomplished by the firing of an escape rocket using solid propellants. In event of an abort, provisions shall be made for a thrust cut-off on the booster rocket.

2.4.1.2 The minimum separation distance after one (1) second from escape rocket firing shall be two hundred fifty (250) feet at ground launch.

2.4.1.3 In an escape from the ground launching pad, the maximum altitude achieved shall be greater than twenty five hundred (2,500) feet.

2.4.1.4 Up to booster rocket staging, the capsule shall accelerate to a minimum velocity lateral to the plane of the trajectory of thirty (30) feet per second in one (1) second during an escape maneuver.

[5]

2.4.1.5 During the firing of the escape rocket and until the capsule decelerates to low dynamic pressure, the capsule shall be aerodynamically stable and shall trim in the same attitude as normally exists in flight when mounted on the booster rocket. During the escape when the dynamic pressure approaches zero, the capsule configuration shall be altered (if necessary) in a manner to provide an aerodynamically stable trim condition in the normal reentry attitude.

2.4.1.6 When the escape maneuver takes place outside the atmosphere, the capsule shall be aligned in the reentry attitude by means of the attitude control system to be specified in section 4.2.

2.4.1.7 Special consideration shall be given to selecting a launch trajectory that will minimize deceleration and heating during entry from an aborted mission.

2.4.1.8 Consideration shall be given to providing a system which will detect [illegible] during launch and which will initiate the abort in [illegible] of this system, the independence of the booster guidance system shall be preserved.

[6]

3. CONFIGURATION

3.1 Configuration requirements. – The configuration selected for the capsule shall fulfill the following requirements:

3.1.1 The external configuration shall have an extremely blunt forebody in the entry attitude.

3.1.2 The countours of the forebody shall be such as to provide the maximum practical wave drag and uniform surface heating consistent with other requirements.

3.1.3 The afterbody shape shall be dictated by requirement for subsonic stability, adequate volume, and low heating as well as requirements for parachute storage and attachment of the escape rocket system.

3.1.4 The overall capsule configuration at the time of entry shall be aerodynamically stable in one direction only (blunt face leading) and shall exhibit no tendency to tumble during entry even in recovery from extreme initial angles of attack.

3.1.5 Oscillatory motions of the capsule during any phase of the mission shall not be of a character to incapacitate or injure a human occupant. If this requirement cannot be met by control of the configuration shape automatic damping means may be employed.

3.1.6 The shape and internal volume of the capsule shall be amenable to certain experiments on manned space flight such as:

3.1.6.1 Limited mobility tests (calisthenics, programmed movements, etc.).

3.1.6.2 Observation tests (external and internal).

3.1.6.3 Manual control tests (open loop and closed loop).

3.1.7 The effect of entry forebody shape on water and land impact loads shall be considered in the design.

3.1.8 The configuration shall be stable in the water with blunt face down and shall be capable of righting itself from any position.

[7]

3.2 Configuration details – A configuration meeting the requirements of these specifications is illustrated in figures 4, 5, and 6. An inboard profile of the configuration as it would appear when ready for the launch operation is shown in figure 4. Configurations for the different phases of flight are shown in figures 5 and 6. [No figures included]

3.2.1 The blunt forebody of the capsule shall incorporate a beryllium heat sink. A heat shield of the ablation type may be considered as an alternate form of heat protection providing experimental data directly applicable to the capsule reentry is obtained which establishes to the satisfaction of the NASA that this form of heat shield is applicable. The capsule forebody shall be attached to the launch rocket system by a suitable adapter.

3.2.2 The pylon-like framework on the launch configuration (figures 5(a) and 5(b)) [not included] shall support solid-fuel rocket motors that shall be used to accomplish an escape maneuver in the event of a malfunction of the launch rocket system. The escape motors shall be mounted on the pylon-like structure with enough ballast to give the launch configuration static stability in its mounted orientation under all flight conditions to the time of staging. On a normal launch, the escape motors and pylon shall be jettisoned by small auxiliary motors at five (5) seconds after staging of the launch rocket system.

3.2.3 In orbit, the capsule will have the configuration shown in figure 5(e) [not included]. The retrograde maneuver shall be accomplished by firing the spherical rocket motors mounted outside of the heat shield. These motors shall then be jettisoned and the entry phase will be made by the configuration illustrated in figure 5(f) [not included].

3.2.4 The capsule is to enter the atmosphere with the blunt face leading. The aerodynamic heating at this face would be absorbed by the heat shield. The area between this heat shield and the pressure vessel (in addition to containing carry-through structure) would contain equipment which is expendable at the time of deployment of the landing parachute, and the heat shield along with this equipment shall be jettisoned at this time. This operation will produce sizable reductions in the parachute loading and will prevent conduction of heat from the hot shield into the pressure vessel during the descent. The bottom contour of the pressure vessel shall be designed from consideration of water and land impact loads. In addition, an inflatable impact bag shall be used to absorb the shock of landing (figure 5(h)) [not included].

[8]

3.2.5 In the event of a malfunction in the launch rocket system, on the ground or in flight, the escape motors shall propel the capsule out of the danger area in the configuration shown in figure 6(b) [not included]. This configuration shall then coast in the pylon-first attitude until the dynamic pressure approaches zero. At this point, the escape rocket system shall be jettisoned and the capsule, with its new center of gravity, will be rotated by aerodynamic moments (figs. 6(c) and 6(d)) [not included] until the heat shield moves to the windward side. If the escape maneuver takes place outside the atmosphere, the rotation of the capsule to the reentry attitude shall be accomplished by means of an attitude control system of a type to be specified in 4.2. At this point, the capsule configuration is [illegible] illustrated in figure 5(f) [not included] for a normal flight. Parachute deployment and heat shield separation shall then be as programmed for a normal flight (fig. 5(g)) [not included].

[9]

4. STABILIZATION AND CONTROL

4.1 General - Stabilization and the control of the capsule shall be provided in accordance with the following outline of the various phases of the primary mission.

4.1.1 Launch- The launch trajectory control and guidance shall be considered an integral part of the launching rocket system. This system (or systems) shall make possible the missions described in Section 2 of this specification.

4.1.2 Orbit – After booster burn out and separation, the capsule shall be automatically stabilized in attitude as specified in Section 4.2. An independent manual control system shall be provided as specified in Section 4.3. A passive optical instrument from which attitude information can be obtained shall also be provided as specified in Section 4.3.3.2.

4.1.3 Entry- During the period from retro firing to build up of atmospheric drag, the automatic control system shall provide attitude stabilization according to Section 4.1.2. After drag build up to 0.05 g units, all [illegible] of the automatic control system shall convert to a damper mode. The manual control system shall function throughout the entire phase.

4.2 Automatic Control System

4.2.1 Requirements

4.2.1.1 The stabilized orientation of the vehicle during orbiting and reentry prior to build up of atmospheric drag shall be such that the longitudinal axis (axis of symmetry) is in the orbital plane and normal to the local earth vertical. The blunt face of the capsule shall be leading. The capsule shall be roll stabilized so that the occupants head is up with respect to the local earth vertical.

4.2.1.2 After drag buildup to 0.05 g all channels of the stabilization system shall convert to a damper mode. The contractor shall study the desirability of imposing a low steady roll rate to reduce the impact error resulting from lift components of aerodynamic force.

4.2.1.3 The alignment described in Section 4.2.1.1 shall be attained within three (3) minutes after booster separation is achieved and maintained continuously throughout the orbiting phase and reentry prior to drag buildup except under the conditions described in Sections 4.2.1.5 and 4.3.

4.2.1.4 The accuracy of the stabilization system shall be within plus or minus five (5) degrees about each of the three (3) axis except under the conditions described in Section 4.2.1.5.

[10]

4.2.1.5 Immediately before and during firing of the retrograde rocket the capsule alignment shall be maintained to within plus or minus one (1) degree of the orientation specified in 4.2.1.1. The contractor shall study the desirability of controlling the pitch attitude of the capsule during firing of the retrograde rocket to the value which has minimum [illegible] to attitude error.

4.2.1.6 The specifications given in Sections 4.2.1.3, 1.4, 1.5, and 1.6 may be relaxed if properly justified by the contractor. Consideration shall be given to the limits [illegible] for emergency firing of the retrograde rocket.

4.2.1.7 A study shall be made to determine the propellant utilization during the mission both for automatic and manual control. The expenditure of propellant in limit cycle oscillations shall be minimized by the design of the control system. The use of the deadband and an impulse chain closely matching the velocity perturbation are examples of such design techniques.

4.2.2 Reaction Controls

4.2.2.1 For attitude control of the capsule, consideration shall be given to a dual-mode system consisting of a high-torque mode and a low torque mode of operation.

4.2.2.2 The high torque mode shall employ reaction jets for free-axis control and shall operate during the following periods of high torque demand: (a) Damping of residual motion of the capsule after booster burnout and separation, (b) Stabilization during the firings of the retrograde rockets, (c) Damping during entry, (d) Periods of high torque requirement in the event that the low torque system becomes saturated.

4.2.2.3 The low torque mode shall employ reaction jets or reaction wheels for three-axis control during the orbiting phase and entry phase prior to drag buildup to stabilize the capsule against both external and internal disturbances.

4.2.2.4 The reaction jets shall be so situated that no net velocity change will be given to the capsule as a result of applying control torque.

4.2.2.5 The maximum disturbance torque for the high torque mode of operation may be assumed to be that resulting from firing of the retro rocket specified in Section 4.4. It may be assumed that the pilot will be in the fully restrained condition during the retrograde firing.

[11]

4.2.2.6 High reliability shall be provided in the reaction control designs. Consideration shall be given to the use of redundancy in the automatic system and in addition, the advantage the manual control system on a safeguard against failures shall be determined.

4.2.3 Attitude Sensing

4.2.3.1 Consideration shall be given to roll and pitch attitude sensing accomplished with a horizon scan system, and yaw sensing obtained using rate gyros to determine the direction of orbital precessional rate of the attitude stabilized capsule.

4.2.3.2 As an alternate to the horizon scan system, the contractor shall study the feasibility of utilizing a stable platform with appropriate programming for this purpose. If such a system is proposed, it may be assumed that the pilot, using an optical device described in Section 4.3, can erect the platform to the alignment specified in Section 4.2.1.1, but it shall be a requirement that the safety of the mission shall not be jeopardized in the event the pilot is unable to perform this function.

4.3 Manual Control System

4.3.1 General- The manual control system shall afford the pilot means of controlling the attitude of the capsule and enable him to achieve a safe reentry in the event of an emergency. The manual control system shall meet the following requirements.

4.3.2 Reaction Controls

4.3.2.1 Three-axis control of the capsule shall be achieved from a small controller(s) located so it is readily accessible from the pilot's normal restrained position.

4.3.2.2 A mechanical linkage shall connect the controller(s) to mechanical valves which control the flow of reaction jets. The reaction jets and all components of the manual control shall be independent of the automatic control system.

4.3.2.3 The manual control jets shall be capable of overcoming the disturbance torque resulting from firing the retrograde rockets as specified in Section 4.4.

4.3.2.4 Adequate safeguard shall be provided to prevent inadvertent operation of the manual controls. Positive action shall be required of the pilot to activate the manual control and de-activate the automatic control when he wishes to change the attitude of the capsule.

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4.3.3 Attitude presentation

4.3.3.1 A display of capsule attitude shall be presented to the pilot to provide a reference from which he will initiate manual control action.

4.3.3.2 An optical system which gives an unobstructed view of the earth when the capsule is stabilized in orbit (as described in section 4.2.1.1) shall be conveniently located in the pilot's field of vision when in his normal restrained position.

4.3.3.3 The optical system specified in 4.3.1 shall have features which will allow the pilot to derive capsule attitude information within sufficient accuracy to enable him to level the capsule within 2 degrees of the orbit attitude specified in 4.2.1.1.

4.4 Retrograde rocket system

4.4.1 Description – The entry shall be initiated by the firing of a retrorocket system incorporating a cluster of (3) three solid-propellant rockets all of which shall be fired simultaneously.

4.4.1.2 The retrorockets shall be mounted external to the heat shield and shall be jettisoned after firing.

4.4.2 Requirements

4.4.2.1 The magnitude of the retro-impulse shall produce a velocity decrement of five hundred (500) feet per second.

4.4.2.2 A study shall be made to determine environmental protection for the retrorockets and adequate protection shall be incorporated in the design.

4.4.3 Method of firing

4.4.3.1 The retrograde rockets shall be fired upon signal from a timer device carried on board. The timer shall be set at launch and reset periodically by command link from ground control.

4.4.3.2 Under emergency conditions, the pilot shall be able to fire the retrograde rockets. Safeguards shall be provided to prevent inadvertent firing. The pilot shall be able to fire the individual rockets simultaneously or individually through use of redundant circuits.

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5. STRUCTURAL DESIGN

5.1 <u>Design loading and heating requirements</u>

5.1.1 <u>General scope</u>- the requirements of this specification apply to the following:

5.1.1.1 The strength and rigidity of the structure of the capsule and related components which include surfaces and supports provided for reacting aerodynamic, hydrodynamic, and inertial forces.

5.1.1.2 The strength of any control systems and their supporting structure that are provided for use during the launch, orbit, entry, or aborted mission phase including such items as retrorockets, escape rockets, attitude control rockets, and parachutes.

5.1.1.3 The strength of fittings attached to the capsule for the purpose of transmitting forces to the structure.

5.1.2 <u>General Loads requirements</u>

5.1.2.1 <u>Ultimate factor of safety</u> – In lieu of an ultimate factor of safety, design may be based on a specified probability of destructive failure based on the design mission and specified deviations from the design mission.

5.1.2.2 Ultimate strength – Failure shall not occur under design ultimate loads. Excessive leakage of the pressure capsule under ultimate load is considered as a failure.

5.1.2.3 Temperature – The effects of the temperature on loading conditions and allowable stresses shall be considered where thermal effects are significant.

5.1.3 Loading types - The following types of loads are to be considered for all loading conditions:

5.1.3.1 Aerodynamic Loads

5.1.3.1.1 Maneuver (static – dynamic)

5.1.3.1.2 Gust

5.1.3.1.3 Wind shear

5.1.3.1.4 Buffeting

5.1.3.1.5 Flutter

5.1.3.2 Inertial loads

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5.1.3.3 Impact loads (water and land)

5.1.3.4 Loads or stresses induced by vibration including noise effects

5.1.3.5 Loads or stresses induced by heating

5.1.4 Loading conditions - The following trajectory phases must be examined for loading conditions.

5.1.4.1 Ground handling – The effect of all ground handling conditions must be considered such as the strength of fittings attached to the capsule for purpose of transmitting handling loads to the capsule.

5.1.4.2 In-flight conditions

5.1.3.2.1 General – Air loads and inertial loads for all phases of the mission shall be associated with the design trajectories with deviations from the design trajectories to be specified by the proved statistical reliability of the propulsion and control systems.

In addition, certain specified conditions of malfunction of the propulsion and control systems shall be considered specified. The structural weight penalties associated with these malfunctions shall be assessed.

Consideration should also be given to the penalties in mission profile caused by structural weight increases due to malfunction of the propulsion or control system. The mission profile parameters for which a mission will be aborted rather than considered for design shall be designated by the limitations given in 2.2 of this specification for the primary mission.

5.1.4.2.2 Launch phase - Loading conditions shall be considered as indicated in 5.1 of this specification for all phases of launch trajectories including capsule separation.

5.1.4.2.3 Aborted mission - The possibility of an aborted mission during all phases of the launching operation and trajectory shall be considered; however, aborted trajectories which would result in axial accelerations greater than twenty-five (25) g need not be considered. (Safety features will, if necessary, include means for anticipating unsafe launch trajectories so that an abort maneuver can be accomplished to keep the g level below twenty-five (25).)

5.1.4.2.4 Orbital phase – The following effect should be considered: Possibility of meteorite damage – The probability of penetration of the pressure capsule by meteorites such that the pressure loss would prove fatal shall be less than 0.001 for a twenty-eight (28) period.

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5.1.4.2.5 Entry – The loading conditions for entry are specified by the design trajectory with deviations as indicated in 5.1 of this specification. Consideration should also be given to the reactions of the retrorocket.

5.1.4.2.6 Parachute deployment – The loads on the capsule, parachute, and related equipment shall be considered for entry and aborted mission conditions as given in 2.2, 2.4, and [illegible] of this specification.

5.1.4.2 Landing – Consideration shall be given to impact loads for water and land impact conditions.

(a) Water - Consideration shall be given to water impact loads in rough water as well as calm water. The capsule design must be such that the buoyancy and water stability is not affected by impact.

(b) Land - Consideration shall be given to emergency impact on land surfaces. The capsule design must be such that the human occupant will survive without injuries severe enough to prevent his own escape from the capsule.

5.1.5 Loads calculations - The loads on the structure and distribution of air and water loads used in design shall be those determined by the use of acceptable analytical methods and with the use of experimental data which are demonstrated to be applicable. The applicable temperature, Mach number, and Reynolds number effects must be included for the existing flow regime.

5.2 Assumed methods of construction for preliminary design – For the purpose of a feasibility study, a type of construction has been assumed which is compatible with the environment of anticipated vehicle trajectories. The principle components are a pressure capsule, external heat and micrometeorite shielding, and [illegible] layers of heat and noise insulation. With this arrangement, integrity of the pressure capsule structure and control of the internal environment can be maintained during widely varying external environmental conditions. A summary of major design requirements for each of these components and brief descriptions of possible structural solutions are given in the following sub-sections.

5.2.1 Pressure capsule –A construction is required capable of sustaining internal pressures up to fifteen (15) psi with negligible air leakage after being subjected to the vibratory and sound pressure loadings associated with launch. It must also withstand collapsing pressures up to two (2) psi to withstand a blast wave from booster failure, and be vented to preclude the possibility [16] of greater collapsing pressures during a normal mission. The capsule must be designed to withstand rigid body accelerations of twenty-five (25) g axially and four (4) g laterally corresponding to maximum which might be encountered during launch and entry. The trapped atmospheric pressure may be utilized to enhance structural stability and strength during the launch phase, but structural integrity during all entry phases shall not depend upon internal pressure for stabilization. The resulting design shall not be vulnerable to explosive decompression if punctured. The capsule must be leak resistant after a water impact loading of approximately fifteen (15) g's.

The capsule may be divided into three main sections for descriptive purposes; a bottom which supports the internal equipment and which will be subject to a water or earth impact, a mid-section designed to accommodate an entrance hatch, viewing ports, and a top dome designed to accommodate parachute attachments, and mounts for the escape rocket system. Each of these sections may experience somewhat different temperature time histories, with a possible temperature difference between sections of three hundred (300) degrees Fahrenheit. The maximum temperature of each part shall be held to six hundred (600) degrees Fahrenheit through use of heat shielding. Stresses in the capsule induced by differences in thermal expansion between the capsule and its external heat shielding shall be reduced to tolerable values through suitable flexibility in shield mounting.

These design requirements may be met by a shell of titanium honeycomb sandwich. A vessel of this material provides maximum strength, stiffness, and heat resistance with the least weight. A more conventional construction capable of meeting the requirements is a welded semi-monicoque shell of either titanium or stainless steel. The material shall be chosen for maximum ductility and weldability.

5.2.2 Heat and micro-meteorite shielding – An analysis of the convective heating during atmospheric entry revealed the need for heat protection for both the blunt face and afterbody of the vehicle. In addition, the expected frequency of strikes by micro-meteorites of various sizes indicated that a shield thickness equivalent to 0.010 inch of steel is desirable for protection of the underlying pressure capsule against impacts.

Stagnation heating associated with the probable range of entry angles ½ to 3 degrees, indicates duration of heating as long as 500 seconds and maximum heating rates in the range of 50 to 100 Btu/ft^2. A total heat input of about 8000 Btu/ft^2 is associated with the entry angle of ½ degrees with lesser inputs for greater angles. A beryllium heat sink appears feasible for front face heat protection. Recent tests have indicated that this type of heating input may be compatible with the behavior of some of the available ablation materials. Hence, a back up approach for protection is an ablating shield.

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The front shield must be supported on the capsule bottom and/or sidewalls in a manner which permits ready disengagement at parachute deployment to expose the landing bag system. The method of support must not cause excessive stresses in the shield during capsule pressurization. For the heat sink type of shield, thermal expansion capability relative to the capsule must be provided.

Estimates of afterbody heating have led to predictions of radiation equilibrium temperatures on the side shields of one thousand and four hundred (1,400) to one thousand six hundred (1,600) degrees Fahrenheit. The total heat input is in the order of one thousand (1,000) Btu/ft^2. The simplest and lightest weight form of heat protection for these areas appears to be obtained with radiation shields. These shields must be flutter free and yet be free to expand thermally with respect to the capsule structure. Although they are vented, a conservative design criterion is that they be able to carry the local pressure loading. This criterion insures adequate local stiffness and increased resistance to noise fatigue. They must withstand sound pressure fluctuations caused by boundary-layer noise and booster engine noise.

[Illegible] have been made on various shield configurations and it appears that a shield constructed on a 0.010-inch thick longitudinally corrugated nickel base alloy may be satisfactory. Such a shield provides a low probability of being punctured by micrometeorites in a twenty-eight (28) hour orbital period, and with a proper corrugation depth and support spacing can meet the other design requirements.

5.2.3 Heat and Acoustical Insulation – The shielding arrangement previously described implies the use of insulation between the shields and the capsule structure. This insulation must be able to withstand a transient temperature pulse of fifteen hundred (1,500) degrees Fahrenheit, and not deteriorate due to vibration. Transient heating calculations show that 3/8 lb/ft^2 of commercially available insulations should provide the required heat protection to the capsule structure during the entry maneuver.

Heat soaked up by the structure must also be prevented form heating the capsule contents. The insulation required on the inner wall must also be effective in damping sound pressure waves. It is estimated that 1/8 lb/ft^2 of dual-purpose insulation should reduce the total heat transmitted to the capsule contents to twenty-five (25) Btu/ft^2 of wall area during entry. The combination of two metal walls and two insulation layers should be capable of providing a 30 db reduction in noise at frequencies above six hundred (600) cps.

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6. ONBOARD EQUIPMENT

6.1 Capsule environment controls

6.1.1 General

6.1.1.1 Equipment shall be provided for control of the pressure, temperature, and humidity within the capsule and within a suitable pressure suit to be worn by the occupant.

6.1.1.2 Equipment shall be provided for the supply of breathing gas for the control of the oxygen partial pressure and carbon dioxide concentration in the breathing gas.

6.1.1.3 Equipment shall be provided for the control of the oxygen partial pressure and the carbon dioxide concentration of the capsule atmosphere.

6.1.1.4 The foregoing equipment shall be as simple and passive in operation as practical.

6.1.1.5 The absorptivity and emissivity of the capsule to radiation in the infrared shall be such that the shell is basically cold and that only small heat addition is required to maintain the internal temperature limits of the capsule; however, a study of the effects of the entry temperature pulse shall be made to establish if any cooling requirements exist.

6.1.1.6 The possibility of buildup of toxic contaminations and objectionable odors in the capsule shall be evaluated and if required, provisions shall be incorporated for their removal.

6.1.1.7 Adequate drinking water and food should be provided for twenty-four (24) hour orbital period and a forty-eight (48) hour post-orbital period. The food should be of the low residue type.

6.1.1.8 Provision shall be made for the disposal and/or storage of human excretions.

6.1.1.9 Protection against failure of the capsule environmental control systems shall be achieved by incorporation of appropriate redundancies.

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6.1.2 Quantitative requirements

6.1.2.1 The capsule temperature shall be maintained between fifty (50) and eighty (80) degrees Fahrenheit.

6.1.2.2 The relative humidity in the capsule shall be maintained between the limits of twenty (20) and fifty (50) percent.

6.1.2.3 The capsule pressure shall never be less than local atmospheric pressure.

6.1.2.4 The partial pressure of the oxygen supplied to the occupant of the capsule shall be maintained between one hundred and fifty (150) and three hundred (300) mm Hg in either the normal or in any emergency condition.

6.1.2.5 The carbon dioxide content of the breathing gas shall be limited to less than one (1) percent.

6.1.2.6 The environmental control systems shall be capable of maintaining the foregoing conditions for: (a) the part of the prelaunch period when the environment cannot be maintained by external supply, (b) for a space flight period of twenty-eight (28) hours, (c) for the landing and recovery period of twelve (12) hours. The last condition can be waived if it can be demonstrated that satisfactory ventilation to the external atmosphere can be achieved in rough seas (through use of a snorkel-type apparatus, for example).

6.1.2.7 The character of the vibrations and the acoustic noise within the capsule shall be considered in the design and alleviation of undesirable conditions shall be provided.

6.1.2.8 Where it can be shown that any quantitative requirement herein severely restricts the design, consideration shall be given to a limited adjustment of the requirements.

6.2 Pilot support and restraint

6.2.1 A couch shall be provided which will safely and comfortably support the human occupant.

6.2.2 As a basis for the design, acceleration environments associated with the launch, the aborted launch, the entry parachute deployment, and the landing impact (land and water) shall be considered. In particular, aborted launch conditions in which peak accelerations of the order of twenty (20) g units shall be withstood by the occupant without incurring serious or permanent injury.

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6.2.3 The support system shall be oriented within the capsule so that the peak accelerations can be withstood without repositioning during flight.

6.2.4 The support system shall distribute the loads over as large an area on the subject as practical and as uniformly as practical (eliminate pressure points).

6.2.5 Shock absorption shall be provided in the support system for the reduction of high but short term accelerations existing under such conditions as parachute deployment and landing impact.

6.2.6 Particular attention shall be paid to the elimination of the possibility of large negative accelerations on the occupant. Such conditions are most likely to occur during asymmetric impacts with water and land surfaces.

6.2.7 The occupant shall be firmly restrained in the support system by a suitable harness that shall provide satisfactory support for the conditions of maximum accelerations in a direction to lift the occupant off the couch. Such a condition will occur after burnout of the escape rocket when the escape takes place at the maximum dynamic pressures.

6.3 Landing system

6.3.1 General

6.3.1.1 A landing system shall be employed which shall utilize two (2) independent parachute systems mounted side by side and a system of air bags for landing impact protection.

6.3.1.2 The two independent parachute systems shall be deployed sequentially, but the reserve system shall be deployed only if the primary system fails to deploy satisfactorily.

6.3.1.3 In addition to the main landing parachute, a drogue parachute for the purpose of capsule stabilization shall be deployed at an altitude of approximately seventy thousand (70,000) feet and a Mach number of one (1).

6.3.1.4 The primary landing-parachute shall be deployed at an altitude of approximately ten thousand (10,000) feet. The primary landing parachute shall be deployed by releasing the drogue parachute from the capsule in such a manner as to serve as a pilot chute. The reserve landing parachute shall be deployed by a normal pilot chute.

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6.3.1.5 At deployment of the primary landing parachute, the heat shield and expendable equipment shall be jettisoned and the landing impact bag shall be inflated.

6.3.2 <u>Drogue and pilot parachutes</u>

6.3.2.1 The drogue parachute canopy shall be a FIST ribbon type and shall be capable of opening at Mach numbers up to one and one-half (1.5). This canopy shall have a diameter large enough to provide adequate dynamic stability to the capsule.

6.3.2.2 This canopy shall be built to conform to applicable military specifications.

6.3.2.3 The parachute shall incorporate a metallic coating in a manner to provide a suitable radar reflector.

6.3.2.4 The drogue parachute shall be forcibly deployed by means a of a mortar tube. The deployment bag and packed drogue chute shall be housed in this mortar tube and shall be capable of withstanding the burning powder charge resulting from firing of the mortar. The bridle between the deployment bag of the main chute and the drogue chute shall be forty-five (45) feet in length. The mortar shall have sufficient force to propel the drogue chute and bag a distance equivalent to the bridle length.

6.3.2.5 The pilot chute for the reserve landing parachute shall be of standard pilot chute construction. This parachute shall be deployed in the same manner as specified in 6.3.2.4. To aid deployment, lead shot may be sewn in at the apex. There shall be a forty-five (45) foot bridle between the deployment bag and the pilot chute.

6.3.3 <u>Main landing parachutes</u> – The two main parachutes shall be of equal size and shall be an extended skirt design (similar to Pioneer Parachute Co. design drawing 1.425). Each of these parachutes shall be a proven type having previously been flight tested under conditions representative of the present application. The parachute shall be constructed to withstand the shock loads of opening at twenty-thousand (20,000) feet.

6.3.3.1 The gore colors shall be natural and international orange alternately arranged.

6.3.3.2 The main canopy and risers shall be packaged in a deployment bag. The main parachute deployment bag shall conform to the interior of the parachute canister.

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6.3.3.3 Actuation of deployment of the drogue chute shall be by reliable and proven barometric switches. Each switch on each chute shall be independent of the other although the secondary chute firing sequence should be arranged such that the primary chute is jettisoned prior to actuating the secondary chute. However, if the primary chute fails to jettison, this should not prevent the secondary chute actuation.

6.3.3.4 Provision should be made for manual override of the automatic system should it fail.

6.3.3.5 Provision shall be made for satisfactory operation of the chutes in case of abort.

6.3.3.6 Provision shall be made for release of the parachutes after impact.

6.3.4 <u>Landing impact bag</u>

6.3.4.1 The landing impact bags shall be constructed of an inflatable material and shall be located behind the heat shield in the deflated condition. On separation of the heat shield, these bags shall be inflated.

6.3.4.2 The bags shall be designed so they will deflate on impact under a constant predetermined load.

6.3.4.3 The bags shall be constructed and located in such a manner that they shall be effective under conditions of drift, parachute oscillation, and uneven landing terrain.

6.3.5 <u>Helicopter pickup provisions</u> – Provision shall be made for a helicopter pickup of the capsule after landing. An attachment point shall be located at approximately the parachute attachment point. Auxiliary attachment points shall also be provided just above the capsule water line.

6.4 <u>Cockpit layout</u>

6.4.1 The contractor shall submit proposed layouts of the capsule interior to the contracting agency for approval. In addition to the environment equipment specified in section 6.1, these layouts shall show the location and approximate appearance of all pilot-actuated controls, instruments, and warning devices.

6.4.2 Consideration shall be given to the restrictions imposed on the pilot by the restraining harness specified in Section 6.2.7 and by acceleration forces in the selection of location and method of actuating all pilot-operated controls and in the grouping and placement of instruments and warning devices so as to provide an optimum display of information.

6.4.3 The contractor shall submit a list of all instruments, pilot actuating devices and warning devices to be displayed to the pilot to the contracting agency for approval. This list shall include those instruments specified or described in Section 7.

6.4.4 Consideration shall be given to the location and operation of the optical instrument for display of capsule attitude and navigational information specified in Section 4.3.3. Consideration shall also be given to a means of displaying capsule attitude information to the pilot during the launch and entry period where the optical presentation may be inadequate.

6.5 <u>Communications. –</u>

6.5.1 This specification is intended to include only the vehicle systems. However, these systems must be completely compatible with the ground station complex. It is intended that wherever practicable the systems of telemetry, tracking, and voice communications now existing will be used.

6.5.2 <u>List of communications systems</u> – The following systems of communications will be required aboard the vehicle:

Two-way voice communication

Command receiver from ground to vehicle

Telemetry from vehicle to ground
Radio tracking beacon (108 megacycles)

Rescue beacons (HF and UHF) and other recovery aids.

S- and X- band beacons for GE Guidance System, with retro-rocket firing command system

C-band radar tracking beacon

Flashing lights, for tracking

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6.5.2.1 The two-way voice communications system will utilize frequencies in both the HF and UHF bands. In the event of failure, a HF-UHF transceiver normally intended for use during the recovery phase may be employed at any time.

6.5.2.2 Two command receivers will be operated continuously on VHF to accept coded commands from ground stations. Verification of the reception of the commands will be transmitted via telemetry. The command receivers will be capable of accepting and decoding retrograde rocket firing commands. Also, it will be used to turn on the telemetry system.

6.5.2.3 Initial guidance and orbit insertion will be accomplished through utilization of the GE Guidance system. Additional tracking data will be obtained from FPS-16 radars, from the 108 Megacycle Minitrack complex and other radio tracking devices, and from visual observations.

6.5.2.4 The 108 megacycle-tracking beacon will have an output of not less than 0.10 watts, and will have frequency stability commensurate with Doppler measuring techniques.

6.5.2.5 The C-band radar tracking beacon is to be compatible with the FPS-16 radar equipment, and will have an output peak power of at least 100 watts. The beacon receiver shall have the capability of triggering the beacon at line-of-sight ranges up to 1000 statute miles.

6.5.2.6 Consideration should be given to the installation of high-intensity flashing lights to aid ground observers in sighting the vehicle during dark phases of the orbit.

6.5.3 Antennas – Antennas will be provided for all systems – voice communications, telemetry, tracking, guidance, command, and rescue. Antennas for each system will provide maximum coverage for each phase of the mission. Design will be simplified somewhat by the vehicle stabilization, in that coverage is required only for one hemisphere, during the orbiting phase. Recovery system antenna will protrude from the upper part of the capsule in such a manner to prevent loss of signal from water or salt spray. Multiplexers will be utilized where necessary to limit the number of antennas. Early developmental flights will determine vehicle skin temperatures, enabling more precise antenna design. This will aid in decisions as to types of antennas.

6.5.4 Recovery – The tracking of the vehicle shall be facilitated, during the landing phase, by the ejection of radar chaff at the opening of the drogue chute.

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The vehicle shall contain a suitable small rescue beacon to facilitate air search. It shall transmit suitable signals on 8.364 and 243.0 megacycles and have a range of at least two hundred (200). In the case of the low frequency signal, a thousand (1000) mile range would be desirable. It shall have self-contained batteries suitable for at least twenty-four (24) hours operation.

A high-intensity flashing light system operating from self-contained batteries and automatically starting upon landing shall be provided with provision for twenty-four (24) hours operation. The lights shall be suitably mounted for maximum sighting distance.

A light weight transceiver shall be used for voice communication backup during the recovery phase. It shall have self-contained batteries, have a range of approximately 200 miles, be suitable for twenty-four (24) hours operation and have a suitable antenna on the vehicle.

So-Far bombs which will automatically fire at reasonable time interval after landing shall be used so that signals received at suitable stations will aid in locating the vehicle.

Dye marker shall be deployed upon landing to aid in the visual location of the vehicle during the search phase.

6.6 Navigational Aids

6.6.1 The pilot shall be provided with a means of navigation. To provide a back up to the ground range tracking facilities, in the event of failure of the capsule tracking beacons or other contingency that would exceed the capability of the ground range system. This operation would entail the determination of altitude, velocity position and local earth vertical, and ground track over the earth.

6.6.2 The optical periscope, or equivalent specified in Section 4.3.3 and a chronometer, shall be provided to fulfill the above requirements. Also manual aids in the form of simplified tables or displays shall be provided to facilitate navigational problems based on observations of earth, sun, moon, or stars. The periscope will be used to indicate the misalignment of the longitudinal axis of the capsule with respect to the flight path over the earth. In the case of failure of the stabilization system, it will allow the pilot to manually align the capsule with the flight path prior to firing the retro rockets.

6.7 Power Supply

6.7.1 The main supply shall be of the silver-zinc type. It shall be suitable for providing the capsules various power-requirements for the twenty-eight (28) hour orbital flights plus the twelve (12) hour recovery phase.

6.7.2 Consideration should be given to the use of an emergency silver-zinc battery to operate vital equipment during the reentry phase in case of failure of the main power supply.

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7. INSTRUMENTATION

7.1 General - In the design of the various instrumentation components, reliability, weight, and power requirements are to be considered of greatest importance.

7.1.1 The data to be measured are separated into the following categories:

a) Aero-Medical Measurements
b) Internal Environment
c) Vehicle Measurements
d) Operational Measurements
e) Scientific

7.2 List of Instrumentation.- The following detailed list of required measurements includes the data required on the first orbital manned flight and does not reflect the requirements for the unmanned flight tests. This list is to be considered only tentative and will be altered in accordance with the current needs of the project.

7.2.1

Aero Medical	Pilots Ind.	T.M.	On-Board Recording
Electro Cardiogram	x	x	
Respiratory rate and depth	x	x	
Suit, Pressure	x	x	x
Body Temperature	x	x	
Motion Picture of Pilot	x		
Voice Recording	x	x	
Alarm (May Day)	x	x	x
Mental Activity and Phys. Coordination		x	x

7.2.2

Capsule Environment	Pilots Ind.	T.M.	On-Board Recording
O_2 Partial Pressure (omit if single gas system)	x	x	x
CO_2 Partial Pressure x	x	x	
O_2 Flow Rate	x		x
CO_2 Filter Status	x		x

O2 Reserve	x	x	x
Cabin Pressure	x	x	x
Air Temperature	x		x
Humidity			x
Motion Pictures Inst. Panel			x
Noise Level			x
Vibration			x

7.2.3 Vehicle Measurements	Pilots Ind.	T.M.	On-Board Recording
Acc. -3 lin	(1 long.) x	x	x
Time	x	x	x
Q	x	x	x
Static Pressure	x		x
Attitude –3 from Stab Sensors	x	x	x
Structural Temperatures	x	x	x
Pilot Control/ Motions 3			CPT/x
Stabilizer Control /Motions 3			CPT/x

7.2.4 Operational Measurements

Power Supply Voltage	x	x	x
Sequence of Events (Chute, Retro-Sep., etc.)			x

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Failure Signals for System	x	x	x
Reaction Gas Supply Pressure	x	x	x

7.2.5 Scientific Observations and Photographic Measurements

Cosmic Radiation			x
Meteorite Impacts			x
Earth and Sky Cameras			x

7.3 Recording – Four methods of data recording shall be employed as follows:

On-board data recording,

Telemetering to ground recorders,

On-board tape recording of voice,

Photographic recording of pilot and instrument panel.

7.3.1 General – It is evident, in the detailed instrument listing, that as many as three different systems are frequently used to record the output of a single data sensor or pickup. As it is not desirable from the standpoint of weight and power to use separate pickups for each system, a satisfactory isolation technique must be employed to avoid cross talk and interference between the several systems being fed from a common pickup. Where this is not feasible, duplicate pickups may be employed.

Provision shall be made for pre-launch check-out of all the instrument and communication systems. The pilot shall be provided with a suitable interphone connection with ground personnel to assist in this check-out procedure.

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7.3.2 On-Board Data Recording – The on-board recorder shall handle the measurements as indicated in the detailed data list. This recorder shall operate on a continuous basis during launch, reentry and abort or emergency maneuvers. During orbit flight and after landing, the data recorded may be programmed to operate periodically to conserve the use of recording medium.

With the exception of EKG and respiratory rate and depth, which have fairly high frequency content, the data may be sampled at rates as low as once per second.

7.3.3 Telemetering to Ground Recorders – Data will be telemetered to ground stations to provide necessary real time information concerning pilot, capsule, and life support system. In addition, telemetry will afford back-up in the event the on-board recorded data are lost for any reason.

These data will be transmitted via radio lines operated in the 225-260 megacycle telemetry band. Reliability will be improved through the use of two independent telemetry systems.

In addition to the two UHF links, the 108 megacycle beacon will be modulated with several channels of physiological and capsule environment data, for continuous transmission to ground stations.

One UHF system will operate continuously, with output power of at least 0.25 watts. A second UHF system with 4 watts output power will operate only on a coded command signal from the ground. Upon interrogation, the system will operate for a period of 6 minutes, at which time it will turn itself off and be in ready status for the next interrogation.

[30]

All telemetered data will be tape recorded at the ground stations. In addition, certain physiological and other data will be displayed in real time for quick observation by engineering and medical personnel.

7.3.4 On-Board Tape Recording of Voice- The on-board recording of voice will be required continuously during launch, reentry, and abort maneuvers. During orbit and after landing, the voice recorder shall be turned on by the pilot to record comments and observations. In addition, all voice messages sent to ground stations by the pilot shall be recorded by this equipment.

7.3.5 Photographic Recording

7.3.5.1 Pilot and Instrument Panel - Two cameras are to be provided for use within the capsule. One for recording the pilot's appearance and motions and the other for recording the indication of the pilot's instruments. The frame rates may be as low as 3 fr/sec during the launch and reentry and 1 frame every 10 seconds during orbit. The lighting for cameras and general illumination shall be a duplicate system.

7.3.5.2 Photographic Recording of Earth and Sky – Cameras shall be used to record pictures of the earth with a 360 degree horizon coverage. As the line of sight at 120 mile altitude in about 2000 miles, the frame rate may be as low as 1 frame every 3 minutes to provide a 50% overlap of picture coverage.

[31]

8. TESTING

8.1 The capsule, all subsystems, and components shall be designed to withstand the environmental stresses encountered in the missions previously outlined. Suitable simulated environmental ground tests shall be performed by the contractor to establish proof of operational reliability and performance.

8.2 A program of research and development testing of the capsule will be undertaken by the NASA. This program will include full-scale flight tests of simplified capsules. The simplified capsules are not a part of the present specifications.

8.3 The capsules supplied by the contractor will be used in a qualification test program to be conducted by the NASA. This qualification program will have as its final objective the accomplishment of the mission described in 2.1.

Document I-14

Document Title: Paul E. Purser, Aeronautical Research Engineer, NASA, to Mr. R. R. Gilruth, NASA, "Procurement of Ballistic Missiles for Use as Boosters in NASA Research Leading to Manned Space Flight," 8 October 1958, with attached, "Letter of Intent to AOMC (ABMA), Draft of Technical Content," 8 October 1958.

Source: Folder 18674, NASA Historical Reference Collection, NASA History Division, NASA Headquarters, Washington DC.

When NASA was established it had virtually no in-house capability to build its own launch vehicles, and so its leaders quickly moved to procure that capability from other organizations in the federal government. This effort took two forms. First, it met with organizations that were developing ballistic missiles with the intention of acquiring some of them for its use. Second, it sought to acquire and enhance capability to develop its own launchers in the future. One was a short-term fix and the other a more long-term solution. This memorandum documents the short-term fix, reporting on a key meeting at the Army's Redstone Arsenal in Huntsville, Alabama, in which NASA and the Army agreed to acquire eight Redstone ballistic missiles for test and operations during Project Mercury for recompense of approximately $7.5 million.

NASA – Langley
October 8, 1958

MEMORANDUM For Mr. R. R. Gilruth

Subject: Procurement of ballistic missiles for use as boosters in NASA research leading to manned space flight

1. A meeting of NASA, ARPA, and Army personnel was held on October 5, 1958 at the Army Ballistic Missile Agency, Huntsville, Alabama. Personnel involved were: Mr. P. D. Purser, NASA; Mr. M. A. Faget, NASA; Mr. W. J. North, NASA; Dr. S. B. Batdorf, ARPA; Major Dunham (?), Army; Brigadier General Barclay, ABMA; Dr. W. von Braun, ABMA; Mr. Mrazek, ABMA; Mr. Carter, ABMA; Colonel Drewry, AOMC; Lieutenant Colonel James, AOMC; and other ABMA personnel. As a result of this meeting, it appears that the services and facilities of the Army Ballistic Missile Agency should be utilized in the NASA research program leading to manned space flight and that the Army is interested in participating in this program.

2. It appears that ABMA has available, in various stages of completion, some 4 to 6 REDSTONE missile boosters which probably can be used as boosters for sub-orbital reentry tests of manned capsules. Other REDSTONEs can be made available on 12 to 14 month lead time basis.

3. It is anticipated that ABMA would furnish the design, construction, and launching of the boosters and the mating of the boosters and capsules.

Certain wind-tunnel tests and some research and engineering studies on the part of ABMA will also be required.

4. It is recommended, in view of the urgency of the subject program, that a letter-of-intent based on the attached draft be issued to the Army Ordinance Missile Command as soon as feasible. The proposed letter carries a financial obligation of $2,400,000 to ABMA in order to allow their studies to begin immediately. It is anticipated that the total obligation to ABMA under this part of the program will be approximately $7,500,000.

Paul E. Purser
Aeronautical Research Engineer

Enc: Draft of letter-of-intent to AOMC
PEP. Jbs

Letter-of-Intent to AOMC (ABMA)

Draft of Technical Content

October 8, 1958

Commanding General
Army Ordinance Missile Command
Huntsville, Alabama

1. The National Aeronautics and Space Administration intends to request that the Army Ordinance Missile Command participate in a program of research leading to manned space flight. As a part of this program, it is intended that the Army Ordinance Missile Command design, construct, and launch approximately eight (8) research and development launching vehicles utilizing the REDSTONE ballistic missile booster and its associated guidance and control equipment. It is anticipated that these vehicles will be required for launching on or about the following dates:

October 1, 1959	April 1, 1960
December 1, 1959	May 1, 1960
February 1, 1960	June 1, 1960
March 1, 1960	July 1, 1960

Or at such earlier times as may appear feasible following further study and discussion between the National Aeronautics and Space Administration and the Army Ordinance Missile Command. The payloads for these vehicles will be developmental and prototype versions of habitable capsules and will be supplied by the National Aeronautics and Space Administration. Details of the payloads and missions will be determined at a later date.

2. You are requested to submit as soon as possible, for review and approval by the National Aeronautics and Space Administration, detailed develop-

ment and funding plans for the design, construction, and launching of these vehicles. These plans shall include time schedule for the work and estimates of the work to be performed at:

   a. AOMC
   b. By contract
   c. By other Government agencies [2]

3. There is hereby made available a total of $2,400,000 ($300,000 per vehicle) under appropriation symbol for obligation by the Army Ordinance Missile Command only for purposes necessary to accomplish the work specified herein. These funds are immediately available for direct obligation and for use in reimbursing the Army Ordinance Missile Command for costs incurred under this project. These funds are not available for construction of facilities. Upon approval of detailed development and financial plans, as required herein or in accordance with amendments to this request, these funds will be increased as appropriate.

4. The Administrator of the National Aeronautics and Space Administration or his designated representatives will provide policy and technical guidance for this project. The Army Ordinance Missile Command will exercise the necessary detailed technical direction. This general relationship may be specified in greater detail at a later time if such action is necessary.

5. The Administrator of the National Aeronautics and Space Administration will be kept informed of progress on the project by proper management, technical, and accounting reports.

6. The disposition of equipment and materials procured in connection with this project is subject to direction of the National Aeronautics and Space Administration. All reports, manuals, charts, data, and information as may be collected or prepared in connection with the project shall be made available to the National Aeronautics and Space Administration prior to release to other agencies or individuals under procedures to be approved. Such procedures may include, in the future, simultaneous release to the NASA and to other specified agencies.

7. AOMC shall be responsible for preserving the security of these projects in accordance with the security classification assigned and with the security regulations and procedures of the Department of the Army.

8. Notwithstanding any other provisions of this request, AOMC shall not be bound to take any action in connection with the performance of this work that would cause the amount for which the Government will be obligated hereunder to exceed the funds made available, and the authorization of the Army Ordinance Missile Command to proceed with the performance of this work shall be limited accordingly. AOMC shall be responsible for assuring that all commitments, obligations, and [3] expenditures of the funds made available are made in accordance with the statutes and regulations governing such matters provided that whenever such regula-

tions require approval of higher authority such approvals will be obtained from or through the Administrator, National Aeronautics and Space Administration, or his designed representative.

Document I-15

Document Title: S. B. Batdorf, ARPA, Memorandum for File, "Presentation of MIS Program to Dr. Glennan," 14 October 1958.

Source: Folder 18674, NASA Historical Reference Collection, NASA History Division, NASA Headquarters, Washington DC.

One of the first decisions T. Keith Glennan had to make after taking office as NASA's first Administrator was to approve Project Mercury. This decision came on 5 October 1958. Glennan wrote in his memoirs that, "I am certain that the allocation of such a program to NASA had been agreed between Dryden, Killian, and DOD before NASA was born," suggesting that the briefing to the new Administrator and his decision to support it was more of a fait accompli than anything else. But Glennan's reflection on the decision is telling. "As one looks back, it is clear that we did not know much about what we were doing," he wrote. "Yet the Mercury program was one of the best organized and managed of any I have been associated with." The decision to invest management of Project Mercury to a Space Task Group based at Langley Research Center, taken at the same time, proved equally auspicious. The hard-driving leader, Robert R. Gilruth, provided critical oversight, loyalty to NASA Headquarters, and technical competence that helped ensure success.

This document describes an early briefing to Keith Glennan about planning for a Man in Space (MIS) mission. It was written by one of the individuals who had led early planning for the mission with the Department of Defense's Advanced Research Planning Agency.

INSTITUTE FOR DEFENSE ANALYSES
ADVANCED RESEARCH PROJECTS DIVISION
Washington 25, D.C

October 14, 1958

MEMORANDUM FOR FILE

SUBJECT: Presentation of MIS [Man in Space] Program to Dr. Glennan

At the rather urgent invitation of Mr. Gilruth, I attended the presentation to Dr. Glennan of the MIS Program at NASA Headquarters, 9:00 p.m., October 7. Those present were Dr. Glennan, Dr. Dryden, Dr. Silverstein, and Messrs. Gilruth, Faget, Low, North, Crowley, and Wood.

At the beginning of the discussion, Dr. Silverstein outlined the history of the MIS Program and showed Dr. Glennan a copy of the proposed memorandum of understanding. Dr. Glennan appeared to accept all of it except the section requiring joint approval on all contracts. He felt that it would not only be clearer from a management point of view, but in addition he would vastly prefer to have ARPA contribute its money to NASA to dispose of as it sees fit. I believe he might accept the section as written as a second best solution to the problem but intends to discuss his preferred solution with Mr. Johnson.

It was brought out that the public relations problem is a particularly difficult one in this project. The possibility of firing from some place other than Canaveral was discussed but does not seem to be feasible. It was decided that the public relations aspect needs to be carefully planned right from the start, and they will probably put a man on this fulltime as soon as possible. Dr. Glennan proposes to present the MIS Program at an early meeting of the space council and possible to solicit OCB advice on the matter of handling public relations.

Dr. Glennan attaches a very great time urgency to this project and agrees with the desirability of seeking application of emergency funds of the Secretary of Defense as proposed by Mr. Johnson last week. Dr. Dryden indicated that the MIS Committee should go ahead and plan on the assumption that the money will be available regardless of the source from which it comes. [2]

The last item of business was a rather lengthy dispute as to how the program should be managed within the NASA. It was decided that Dr. Dryden's recommendation would be followed, namely that the work would be done by a task force under Gilruth, reporting to Silverstein. This task force might have most of its members at the Langley Laboratory, but the Langley management would have no hand or voice in the management of the project. Dr. Glennan appeared very pleased with the project plan and admonished the committee to put it into operation as rapidly as possible.

[Signed]
S.B. Batdorf

Copies to:
MIS Panel
Mr. Johnson
Adm. Clark
Dr. York
Mr. Gise
Mr. Godel
Mr. Smith

Document I-16

Document Title: Robert R. Gilruth, Project Manager, NASA, Memorandum for Associate Director, NASA, "Space Task Group," 3 November 1958.

Source: Folder 18674, NASA Historical Reference Collection, NASA History Division, NASA Headquarters, Washington DC.

The creation of the Space Task Group based at Langley Research Center proved a critical decision for the management of Project Mercury. NASA handpicked the members of this group from among the best in the agency and placed Robert Gilruth in charge. Gilruth, perhaps more than any other NASA official, served as the godfather of human spaceflight in the U.S. Under his direction NASA successfully completed Projects Mercury, Gemini, and Apollo. His organization recruited, trained, and oversaw the astronauts and the human spaceflight program throughout the heroic age of spaceflight. Yet, his name is lesser known than many others associated with these projects. He was a contemporary on par with Wernher von Braun, and he certainly contributed as much to human spaceflight as any of his colleagues, yet his name is rarely mentioned as a key person. He is a representative of the engineering entrepreneur, a developer and manager of complex technological and organizational systems, accomplishing remarkably difficult tasks through excellent oversight of the technical, fiscal, cultural, and social reins of the effort.

This memorandum identifies the individuals selected by Gilruth as the original members of the Space Task Group. Many of the Group's original members went on to be central to the development of the U.S. human spaceflight program.

NASA - Langley
November 3, 1958

MEMORANDUM For Associate Director

Subject: Space Task Group

1. The Administrator of NASA has directed me to organize a space task group to implement a manned satellite project. This task group will be located at the Langley Research Center but, in accordance with the instructions of the Administrator, will report directly to NASA Headquarters. In order that this project proceed with the utmost speed, it is proposed to form this space task group around a nucleus of key Langley personnel, many of whom have already worked on this project.

2. It is request, therefore, that initially the following 36 Langley personnel be transferred to the Space Task Group:

Anderson, Melvin S. (Structures)
Bland, William M., Jr. (PARD)
Bond, Aleck C. (PARD)
Boyer, William J. (IRD)
Chilton, Robert G (FRD)
Donlan, Charles J. (OAD)
Faget, Maxime A. (PARD)
Field, Edison M. (PARD)
Gilruth, Robert R. (OAD)
Hammack, Jerome B. (FRD)

Hatley, Shirley (Steno.)
Heberlig, Jack C. (PARD)
Hicks, Claiborne R., Jr. (PARD)
Kehlet, Alan B. (PARD)
Kolenkiewicz, Ronald (PARD)
Kraft, Christopher C., Jr. (FRD)
Lauten, William T., Jr. (DLD)
Lee, John B. (PARD)
Livesay, Norma L. (Files)
Lowe, Nancy (Steno.)
MacDougall, George F., Jr. (Stability)
Magin, Betsy F. (PARD)
Mathews, Charles F. (PARD)
Mayer, John P. (FRD)
Muhly, William C. (Planning)
Purser, Paul E. (PARD)
Patterson, Herbert G. (PARD)
Ricker, Harry H., Jr. (IRD)
[2]
Robert, Frank C. (PARD)
Rollins, Joseph (Files)
Sartor, Ronelda F. (Fiscal)
Stearn, Jacquelyn B. (Steno.)
Taylor, Paul D. (FSRD)
Watkins, Julia R. (PARD)
Watkins, Shirley (Files)
Zimmerman, Charles H. (Stability)

[Signed]
Robert R. Gilruth
Project Manager

PEP.jbs

[Handwritten at bottom of document] To Personnel Officer for admin. This request is OK with the exception of Boyer. On Buckley's recommendation substitute Kyle for Boyer.
FL Thompson
Acting Director 11-4-58]

Document I-17

Document Title: Abe Silverstein, Director of Space Flight Development, NASA, Memorandum for Administrator, NASA, "Code Name 'Project Mercury' for Manned Satellite Project," 26 November 1958.

Source: NASA Collection, University of Clear Lake Library, Clear Lake, Texas.

Document I-18

Document Title: George M. Low, NASA, Memorandum for Dr. Silverstein, NASA, "Change of Manned Satellite Project name from "Project Mercury" to "Project Astronaut," 12 December 1958.

Source: National Archives and Record Administration, Forth Worth, Texas.

In the fall of 1958, NASA was preparing to implement its initial human spaceflight effort. The space agency decided to name the effort "Project Mercury," after the messenger of the gods in ancient Roman mythology. The symbolic associations of this name appealed to Abe Silverstein, NASA's Director of Space Flight Development. On December 1958, the 55th anniversary of the first flight of the Wright brothers at Kitty Hawk, T. Keith Glennan announced the name for the first time. A last-minute attempt by the head of the Space Task Group, Robert Gilruth, to change the name to "Project Astronaut" was not successful.

Document I-17

Washington, D.C.
November 26, 1958

MEMORANDUM For Administrator, NASA

Subject: Code name "Project Mercury" for Manned Satellite Project.

1. Considerable confusion exists in the press and in public discussions regarding the Manned Satellite Project because of the similarity of this program with other Man-in-Space proposals.

2. At the last meeting of the Manned Satellite Panel it was suggested that the Manned Satellite Project be referred to as Project Mercury.

3. It is recommended that the code name Project Mercury be adopted.

[Signed]
Abe Silverstein
Director of Space Flight Development

Cc: Robert Gilruth, Langley Task Group
Dr. S.B. Batdorf, ARPA

Document I-18

Washington, D.C.
December 12, 1958

MEMORANDUM For Dr. Silverstein

Subject: Change of Manned Satellite Project name from "Project Mercury" to "Project Astronaut"

1. Bob Gilruth feels that "Project Astronaut" is a far more suitable name for the Manned Satellite Project than "Project Mercury."
2. If you agree, this should be brought to Dr. Glennan's attention immediately. Present plans call for Dr. Glennan to refer to "Project Mercury" in his policy speech on December 17.

George M. Low

Low:lgs

Document I-19

Document Title: George M. Low, Program Chief, Manned Space Flight, NASA, Memorandum for Administrator, NASA, "Status Report No. 1, Manned Satellite Project," 9 December 1958.

Source: National Archives and Record Administration, Fort Worth, Texas.

If there was any one person at NASA who obsessed over the details of each of the human spaceflight projects of the agency's heroic years it was George M. Low, in 1958 NASA's Manned Spaceflight Program Chief. Low had been born in Vienna, Austria, and came to the U.S. in 1940. After completing his B.S. in aeronautical engineering he joined NACA in 1949 at Lewis Flight Propulsion Laboratory. He also held important positions in Gemini and Apollo before serving as Deputy Administrator of NASA in 1969 to 1976 and then as acting administrator from 1970 to 1971. Low prepared notes at least weekly on all of the initiatives for which he was responsible. They were always both comprehensive and candid. He heavily focused on the technical issues and, until he came to NASA Headquarters in late 1969, rarely commented on policy, but his regular memoranda on these various programs represent an historical treasure trove. This status report is an example of Low's approach to documentation. He ensured that his superiors understood the key issues at play, but he also had a concern for history by leaving these detailed commentaries, to which he often appended key documents.

Washington, D.C.
December 9, 1958

MEMORANDUM For Administrator

Subject: Status Report No. 1,
Manned Satellite Project

1. This is the first of a series of weekly or biweekly status reports on the Manned Satellite Project. In general, these reports will consist of short statements concerning only the progress made during the reporting period. For completeness, however, this first report will contain a summary of the progress made since the formal inception of the project.

2. Capsule and Subsystems

a. Preliminary specifications mailed to prospective bidders on October 23, 1958.

b. Bidders conference held at Langley Field on November 7, 1958. About 38 firms represented.

c. Nineteen firms indicated by November 14 that they plan to prepare proposals. Final specifications sent to these firms on November 17.

d. Proposals must be received by December 11.

e. Technical assessment will be started by members of the Space Task Group on December 12. Mr. Charles Zimmerman heads the technical assessment team. Concurrently, cost and management assessment will be carried out by Mr. A. E. Siepert's office.

f. Source Selection Board will meet on December 29. Membership: Messrs. Gilruth, Wyatt and Low, and representatives from the Offices of the General Counsel and of the Director of Business Administration; ARPA has been invited to participate in a non-voting capacity.

3. Booster Procurement

a. Little Joe. This booster consists of a cluster of four Sergeant rockets; it is capable of imparting a [2] velocity of 6000 ft/sec to a full-scale capsule, and will be launched from Wallops. A contractor is now being selected.

b. Redstone. The Redstone vehicle is also capable of achieving a velocity of 6000 ft/sec with a full-scale capsule; it will be used for manned short-range ballistic flights. ABMA has submitted a tentative proposal for 8 boosters at a total cost of $13.179 million. The Redstones will be ordered as soon as a firm proposal is received.

c. Thor or Jupiter. Either vehicle has a capability of boosting a full-scale capsule to about 16000 ft/sec. A tentative decision to purchase Jupiter was made on December 8; this decision will be firm if proposed flight test schedules can be met. Probable cost for 3 vehicles: $5.634 million.

d. Atlas. This booster will be used both for sub-orbital and orbital flights. Funds have been transferred to AFBMD for one Atlas C and nine Atlas D boosters.

4. Flight Test Operations

a. Several full-scale dummy capsules have been dropped from a C-130 airplane. Purpose: to check subsonic stability and parachute deployment. Initial results: parachute deployment is satisfactory.
b. The first Atlas Flight (Atlas C) is scheduled for June or July 1959. Primary purpose: to check ablation heat shield.

5. Pilot Selection: The aero medical group at Langley (Maj. White, USAF, Lt. Voas, Navy, and Capt. Augerson, Army), have set up a tentative procedure for pilot selection and training. Briefly, the plan calls for a preliminary meeting on [3] December 22 with representatives from the services and industry. These representatives will "nominate" a pool of 150 men by January 21. From this pool, 36 candidates will be selected by February 15. A series of physical and other tests will eliminate all but 12 by the middle of March; these 12 men will then go through a nine months training and qualification program. Six men are finally expected to qualify.

George M. Low
Program Chief
Manned Space Flight

Cc: Dr. Dryden
Dr. Silverstein
Mr. Sanders

Low:lgs

Document I-20

Document Title: Invitation to Apply for Position of Research Astronaut-Candidate, NASA Project A, Announcement No. 1, 22 December 1958.

Source: Folder 18674, NASA Historical Reference Collection, History Division, NASA Headquarters, Washington, DC.

In November 1958 aeromedical consultants working for the Space Task Group at Langley worked out preliminary procedures for the selection of astronauts to pilot the Mercury spacecraft. Their proposal involved meetings with industry and the military services which would result in the nomination of 150 men. This would be narrowed down to 36 to undergo extensive physical and psychological testing. Ultimately, 12 would be selected to undergo training and qualification, of which only 6 were expected to fly.

This plan led Charles Donlan, Technical Assistant to the Director of Langley; Warren J. North, a former NACA test pilot and head of the office of Manned Satellite; and Allen O. Gamble, a psychologist detailed from the National Science Foundation, to draft job specifications for applicants for the astronaut program. Although carefully drawn up, this plan was abandoned when President Eisenhower (during the Christmas holiday) decided that only military test pilots should be allowed to apply. This eliminated the option of including civilians in the civilian manned space program, but greatly simplified the selection process.

Even though NASA Administrator T. Keith Glennan had announced on 17 December that the program would be called "Project Mercury," this document still uses the name preferred by the Space Task Group, "Project Astronaut."

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
Washington 25, D.C.

NASA Project A
Announcement No. 1
December 22, 1958

Invitation to apply for Position of
RESEARCH ASTRONAUT-CANDIDATE
with minimum starting salary range of $8, 330
to $12, 770 (GS-12 to GS-15) depending
upon qualifications
at the NASA Langley Research Center
Langley Field, Virginia

I. DESCRIPTION OF PROJECT ASTRONAUT

The Manned Satellite Project is being managed and directed by NASA. The objectives of the project are to achieve, at the earliest practicable date, orbital flight and successful recovery of a manned satellite; and to investigate the capabilities of man in a space environment. To accomplish these objectives, a re-entry vehicle of the ballistic type has been selected. This vehicle not only represents the simplest and most reliable configuration, but has the additional advantage of being sufficiently light, so that it can be fitted on an essentially unmodified ICBM booster. The satellite will have the capability of remaining in orbit for 24 hours, although early flights are planned for only one or two orbits around the earth.

Although the entire satellite operation will be possible, in the early phases, without the presence of man, the astronaut will play an important role during the flight. He will contribute to the reliability of the system by monitoring the cabin environment, and by making necessary adjustments. He will have continuous displays of his position and attitude and other instrument readings, and will have the capability of operating the reaction controls, and of initiating the descent from orbit. He will contribute to the operation of the communications system. In addition, the astronaut will make research observations that cannot be made by instruments; these include physiological, astronomical, and meteorological observations.

Orbital flight will be accomplished after a logical buildup of capabilities. For example, full-scale capsules will be flown on short and medium range ballistic flights, before orbital flights will be attempted. Maximum effort will be placed on the design and development of a reliable safety system. The manned phases of the flight will also undergo a gradual increase in scope, just as is common practice in the development of a new research aircraft. [2]

II. DUTIES OF RESEARCH ASTRONAUT-CANDIDATES

Research Astronaut-Candidates will follow a carefully planned program of pre-flight training and physical conditioning. They will also participate directly in the research and development phase of Project Astronaut, to help insure scientifically successful flights and the safe return of space vehicles and their occupants. The duties of Research Astronaut-Candidates fall into three major categories:

a. Through training sessions and prescribed reading of technical reports, they will acquire specialized knowledge of the equipment, operations, and scientific tests involved in manned space flight. They will gain knowledge of the concepts and equipment developed by others and, as their knowledge and experience develops, they will contribute their thinking toward insuring maximum success of the planned flights.

b. They will make tests and act as observers-under-test in experimental investigations designed (1) to develop proficiency and confidence under peculiar conditions such as weightlessness and high accelerations; (2) to enable more accurate evaluation of their physical, mental, and emotional fitness to continue the program; and (3) to help elicit the knowledge necessary to evaluate and enable the final development of communication, display, vehicle-control, environmental-control, and other systems involved in space flight.

c. They perform special assignments in one or more of their areas of scientific or technical competence, as an adjunct to the regular programs of the research team, the research center, or NASA. These assignments may include doing research, directing or evaluating test or other programs, or doing other work which makes use of their special competencies.

Appointees who enter this research and training program will be expected to agree to remain with NASA for 3 years, including up to one year as Research Astronaut-Candidates. During the initial months final selection will be made of about half of the group to become Research Astronauts. Candidates who are not at that point designated Research Astronauts will have the option of continuing with NASA in other important capacities which require their special competence and training, without loss of salary and with other opportunities for advancement, and may remain eligible for future flights. [3]

III. QUALIFICATION REQUIREMENTS

A. Citizenship, Sex, Age

Applicants must be citizens of the United States. They must be males who have reached their 25th birthday but not their 40th birthday on the date of filing application.

Applicants must be in excellent condition and must be less than 5 feet 11 inches in height.

B. Basic Education

Applicants must have successfully completed a standard 4-year or longer professional curriculum in an accredited college or university leading to a bachelor's degree, with major study in one of the physical, mathematical, biological, medical, or psychological sciences or in an appropriate branch of engineering or hold a higher degree in one of these fields. Proof of education will be required (see paragraph IV-4, below).

C. Professional Experience or Graduate Study

In addition to a degree in science or engineering or medicine, applicants must have had one of the following patterns of professional work or graduate study or any equivalent combination:

1. Three years of work in any of the physical, mathematical, biological, or psychological sciences.

2. Three years of technical or engineering work in a research and development program or organization.

3. Three years of operation of aircraft or balloons or submarines, as commander, pilot, navigator, communications officer, engineer, or comparable technical position.

4. Completion of all requirements for the Ph.D. degree in any appropriate field of science or engineering, plus 6 months of professional work.

5. In the case of medical doctors, 6 months of clinical or research work beyond the license and internship or residency.

Preference will be given to applicants in proportion to the relatedness of their experience or graduate study to the various research and operational problems of astronautics. [4]

NASA desires to select and train a team of Astronaut-Candidates representing a variety of fields including physical and life sciences and technology.

D. Hazardous, Rigorous, and Stressful Experience

Applicants must have had a substantial and significant amount of experience which has clearly demonstrated three required characteristics: (a) willingness to accept hazards comparable to those encountered in modern research airplane flights; (b) capacity to tolerate rigorous and severe environmental conditions; and (c) ability to react adequately under conditions of stress or emergency.

These three characteristics may have been demonstrated in connection with certain professional occupations such as test pilot, crew member of experimental submarine, or arctic or antarctic explorer. Or they may have been demonstrated during wartime combat or military training. Parachute jumping or mountain climbing or deep sea diving (including with SCUBA), whether as occupation or sport, may have provided opportunities for demonstrating these characteristics, depending upon heights or depths attained, frequency and duration, temperature and other environmental conditions, and emergency episodes encountered. Or they may have been demonstrated by experience as an observer-under-test for extremes of environmental conditions such as acceleration, high or low atmospheric pressure, variations in carbon dioxide and oxygen concentration, high or low ambient temperatures, etc. Many other examples could be given. It is possible that the different characteristics may have been demonstrated by separate types of experience.

Pertinent experience which occurred prior to 1950 will not be considered. At least some of the pertinent experience must have occurred within one year preceding date of application.

Applicants must submit factual information describing the work, sport, or episodes which demonstrate possession of these three required characteristics. See paragraph 5 in next section.

IV. MATERIAL TO BE SUBMITTED

These positions are to be filled through a procedure which requires sponsorship of each candidate by a responsible organization. An indication of this sponsorship and a rating of the candidate will be made on a Nomination Form by a member of the sponsoring organization, preferably a superior well acquainted with the candidate. The Nomination Form is attached to this announcement for distribution to solicited organizations, and will be filled out by them and returned by January 12, 1959, if at all possible, to Personnel Office (Project A), NASA, Langley Field, Virginia. [5]

The following materials must be submitted by the applicant himself no later than January 26, 1959 to:

Personnel Office (Project A)
NASA
Langley Field, Virginia

1. Standard Form 57 (Application for Federal Employment). These forms will be furnished to applicants, but copies can be obtained from any U.S. Post Office or Federal agency.

2. Standard Form 86 (Security Investigation Data for Sensitive Position). This form will be furnished to applicants. Those applicants who are invited to report in person for further testing will be asked to bring with them one copy of this form completed in rough draft.

3. Standard Forms 88 (Report of Medical Examination) and 89 (Report of Medical History). These forms will be distributed to applicants. They should be completed by the applicant (paragraph 1 through 14 on S.F. 88 and all appropriate paragraphs of S.F. 89) and taken to the nearest military hospital, base, or procurement office authorized to administer flight physicals. A special letter addressed to such military installations is attached to this announcement, to be detached for use. Applicants should report for these physicals no later than January 21 in order to allow time for receipt of the forms at Langley by January 26. The examining military agencies will forward the S.F.'s 88 and 89 direct to NASA, Langley.

4. College transcript(s). Each applicant must submit a transcript (not necessarily an official copy) of his college or university record including descriptive course titles, grades and credits. These should accompany the application if possible.

5. A description of hazardous, rigorous, and stressful experiences pertinent to section D, above. This description should not exceed 2 or 3 typed pages. It must be factual (dates, events, etc.) and should be corroborated where practicable.

6. A statement concerning the pertinence of the applicant's professional or technical background to the problems of astronautical research and operations. This should not exceed one typed page.

7. A statement as to why the applicant is applying for this position. This statement should not exceed one typed page. [6]

V. SELECTION PROGRAM

On the basis of evaluations of the above-described applications and supporting material, a group of men will be invited to report to the NASA Space Task Force at Langley Field, Virginia, on February 15, 1959. For about three weeks these men will be given a variety of physical and mental tests on a competitive basis to evaluate their fitness for training for the planned space flights. This will involve trips to Washington, D.C., and other locations and will include tests with such equipment as decompression chambers and centrifuges and also aircraft flights. At the end of this competitive testing program all the candidates will return to their homes and jobs.

During the ensuing period of 2 to 3 weeks, laboratory and other test results will be evaluated and a small group of men will be finally selected to become Research Astronaut-Candidates. These men will be notified to report for duty at NASA, Langley Field, on or about April 1, 1959. Travel and moving expenses for them (and their families, if married) will be provided.

VI. APPOINTMENTS AND PAY

These appointments are to civilian positions in the National Aeronautics and Space Administration. They are excepted appointments due to the unusual nature of the duties and the selection process, but carry the benefits and protections of the U.S. Civil Service System including a high level of insurance and retirement.

Original appointments of Research Astronaut-Candidates will be to pay levels commensurate with their backgrounds of education and experience, within the pay range of $8,330 to $12,770 per year (GS-12 to GS-15).

As these men become proficient in the field, they will become eligible for Research Astronaut positions with salaries commensurate with those of the most highly skilled NASA Research Pilots and Aeronautical and Space Scientists.

Document I-21

Document Title: Dr. William S. Augerson, Human Factors Branch, NASA, Memorandum for Chief, Operations Division, NASA, "Scientific Training for Pilots of Project Mercury," 27 March 1959.

Source: Folder 18674, NASA Historical Reference Collection, NASA History Division, NASA Headquarters, Washington, DC.

As the first astronauts were selected for Project Mercury from among the test pilot cadre in existence in the various military services, questions arose about the other types of skills NASA desired of those that would fly in space. Since one of the key components of Mercury was the expansion of scientific knowledge, the scientific community wanted the most qualified people possible to engage in this endeavor. In addition to the pilot training all astronauts received before coming to NASA, consensus quickly mounted to further train the Mercury astronauts to undertake scientific research. The additional scientific training required for Project Mercury was not rigorous, as demonstrated by this memorandum, but enhanced the capability of crewmembers to perform experiments on-orbit.

NASA - Space Task Group, Langley
March 27, 1959

MEMORANDUM For Chief, Operations Division

Subject: Scientific training for pilots of Project Mercury

1. It is recommended that pilots of Project Mercury be given graduate level training in areas relating to astronautics and geophysics. It is further recommended that they receive this training early in the course of the project.

2. Justification

a. Background information in the area of astronautics is an important requisite to understanding of the environment into which these men will be traveling. It will aid them in understanding the vehicle design and the operational procedures. While some of this information can be provided by Space Task Group engineers, they will not have time to provide more than a minimum of information in this area.

b. It has been stated officially that Project Mercury will investigate human performance in space environment. Since one of the important scientific and peaceful activities of man in space is scientific observation, simple scientific observations should be made by the astronaut. To make these observations, training will be required. The following areas are possible activities:

   i. Simple astronomical observations; that is, coronal studies.

   ii. Simple meteorological observations; that is, synoptic weather reports from visual observations and photographs.

   iii. Simple biophysical studies.

   iv. Radiation physics studies

c. These pilots will become important "scientific ambassadors" after completing this mission, and should have a general knowledge in areas related to astronautics. This may be of additional importance in a period when other nations may ridicule our space effort as an unscientific stunt. Even in this country, there are persons who believe this project should be more than an aerodynamic flight study. [2]

d. By giving training early, there will be less interference with the project and will provide time for individual growth along lines of personal interest.

e. By equipping pilots with training in these areas, we may provide an extra benefit from this project in terms of useful information obtained. It is believed that their grasp of the whole project may be improved.

3. Procedure

   a. To condense the maximum information in the minimum time, it is recommended that a university, such as Harvard, MIT, or Penn., be asked to construct a special (if no appropriate course exists) two-three-week course in July or August in a survey of astronautics and geophysics.

   b. It is recommended that this be further supplemented by an occasional seminar with local or visiting experts in these areas to help keep the astronauts up-to-date on current research; for example reports on data from cloud-cover satellites.

   c. Some of the pilots may wish to work with some of the groups doing supporting research; for example, radiation studies administered by the Washington office.

   d. It is recommended that attempts be made, while performing simulated missions, to find out what observations the men can make. It is believed that by using the synthesizing ability of the individual, good meteorological studies can be made using apparatus already in the vehicle.

4. It is understood that there is reason for contrary opinions to the above. However, it is believed that the efficiency of the vehicle system will be such that time for scientific observations will be available (especially on 28-hour missions) and that the expense of this operation makes it desirable to obtain all the data we can from it. The training necessary to perform these tasks can be given fairly easily considering the experience and intelligence of these pilots. Even if no observations are permitted, it is believed that training in the area of astronautics and geophysics will aid in the operational accomplishment of Project Mercury.

Dr. William S. Augerson
Human Factors Branch

Document I-22

Document Title: George M. Low, Program Chief, Manned Space Flight, NASA, Memorandum for Administrator, NASA, "Pilot Selection for Project Mercury," 23 April 1959.

Source: Folder 18674, NASA Historical Reference Collection, NASA History Division, NASA Headquarters, Washington, DC.

Astronaut selection became a topic of interest to many in the general public early on. Who was chosen and why? What criteria were used? Who might have been excluded from consideration, either intentionally or not? This memorandum documents an issue that arose almost simultaneously with the unveiling of the Mercury Seven astronauts in mid-April

1959. Why were there no Army or civilian pilots selected? NASA was exceptionally conscious of the interservice rivalries extant in the DOD and sought to ensure that Army personnel received consideration, even going so far as to undertake a special screening of some candidates, but in the end found none that met NASA's selection criteria. In accordance with President Eisenhower's December 1958 decision to limit the pool of candidates to military test pilots, civilians were not systematically considered in this first round of astronaut selection, although a few applications were screened.

Washington, D.C.
April 23, 1959

MEMORANDUM for Administrator

Subject: Pilot Selection for Project Mercury

1. The criteria used for the pilot selection were established at a meeting held at NASA Headquarters on January 5, 1959. This meeting was attended by Dr. Lovelace, General Flickinger, Mr. Gilruth, and others. Capt. Augerson was present and represented the Army. At the time, Capt. Augerson appeared to be in full agreement with the selection criteria, although it was even then apparent that these criteria might exclude Army participation.

2. At the time of our first briefing of the astronauts on February 9, 1959, Gen. Flickinger informed Dr. Silverstein that no Army men had met all of our selection criteria. He suggested that we should approach the Army for names of men who came close to qualifying. Dr. Silverstein agreed and asked Gen. Flickinger to contact the Army. Gen. Flickinger, in turn, asked Capt. Augerson to supply NASA with names of candidates that he thought would qualify.

3. Several days later, Capt. Augerson appeared with the files of six Army men. He turned these over to Mr. Donlan and the group participating in the selection proceedings. After it was ascertained that none of these men met our selection criteria, and after another discussion with Dr. Silverstein, it was decided not to consider these Army men as candidates for Project Mercury. Capt. Augerson was informed of this decision.

4. On the subject of possible civilian participation, approximately ten letters were received by me. Several letters were obviously from cranks, while others were sincere. None of the civilians met our selection criteria. All letters received were answered. Other letters may have been received in other parts of the organization.

5. The heads of the flight activities at all. NASA Centers and Stations were contacted by either Mr. Gilruth or by myself. They, in turn, sought volunteers for Project Mercury among their pilots. None of the NASA pilots volunteered although several expressed interest in joining the Project at a later date.

[Signed]
George M. Low
Program Chief
Manned Space Flight

cc: Dr. Dryden
Dr. Silverstein
Mr. North

GML:lgs

Document I-23

Document Title: George M. Low, NASA, Memorandum for House Committee on Science and Astronautics, "Urgency of Project Mercury," 27 April 1959.

Source: Folder 18674, NASA Historical Reference Collection, NASA History Division, NASA Headquarters, Washington, DC.

From virtually the beginning of the Mercury program, its leaders at the Space Task Group believed that it should receive the nation's highest priority. This status ensured ready cooperation from other federal entities and streamlined procurement and other regulations. Only programs and projects deemed critical to national defense received this designation. In 1958 numerous spaceflight efforts such as the Minuteman and Polaris ICBM development efforts, the Vanguard program, and satellite reconnaissance were already on what was officially named the DOD Master Urgency List. Admittance to the DX, the part of the DOD Master Urgency List associated with the highest industrial procurement priority, required the approval of the National Security Council, but it had already delegated authority to the Secretary of Defense to approve DX status on space projects. Space Task Group leaders, therefore, had to convince Secretary Neil H. McElroy of the significance of Project Mercury. This did not prove an easy task. While senior officials agreed that Mercury was important, key officials at the White House, Congress, and NASA Headquarters regarded both the development of a one-million-pound-thrust rocket, which eventually became the Saturn I, and space science efforts as equally important. However, a priority list is only useful if some items have less priority than others. Why should Project Mercury receive this special designation?

When NASA Deputy Administrator Hugh L. Dryden initiated the request for DX status to the DOD on 14 November 1958, he specifically requested that both the "manned satellite and the one-million-pound-thrust engine" be added, but because of disagreements, especially within the National Aeronautics and Space Council (NASC) created by the same act that has chartered NASA, consideration of this proposal was deferred until a united position could be crafted. It took several months of discussion during the winter of 1958 to 1959 before consensus could be achieved, and only on 27 April 1959, did Eisenhower approve DX status for Mercury. This memorandum prepared by George Low explains to the Congressional committee overseeing NASA the agency's policy with respect to balancing urgency and astronaut safety.

April 27, 1959
In reply refer
To: DAL

MEMORANDUM: For House Committee on Science and Astronautics

Subject: Urgency of Project Mercury

The primary goal of Project Mercury is to achieve orbital flight, and successful recovery, of a manned satellite at the earliest practicable date, and to study man's capabilities in a space environment. This project is NASA's most urgent program, and is being pursued at a rate that will give this nation a highly reliable space vehicle and completely prepared astronaut at the earliest moment.

We have also a desire to be first, because we realize that much in the way of national prestige comes from space flight achievements. But, we cannot place the prestige of the nation above the safety of the astronaut. With this overriding consideration for the safe return of the pilot, we must recognize that another country may accomplish a manned space mission before we do.

But neither the value nor the success of Project Mercury can be gauged by whether it is the first, second or third manned space flight. Mercury is a stepping-stone in the manned exploration of space. From the Mercury program will develop this nation's plans for more advanced manned satellites, space laboratories and stations, missions to the moon, and interplanetary explorations. The most vigorous pursuit of Project Mercury is required to insure that this nation will enjoy a role of leadership in future manned explorations of space.

Document I-24

Document Title: George M. Low, Program Chief, Manned Space Flight, NASA Memorandum for Mr. R. R. Gilruth, Director, Project Mercury, NASA, "Animal Payloads for Little Joe," 19 June 1959, with attached Memorandum from T. K. G (T. Keith Glennan) to George M. Low, 15 June 1959.

Source: National Archives and Record Administration, Fort Worth, Texas.

In preparation for the human flights of Project Mercury, NASA decided to undertake several tests of the spacecraft using the Little Joe booster to launch the capsule on a sub-orbital trajectory. The Little Joe booster was produced specifically for Mercury test usage, and consisted of four Pollux or Castor motors grouped with four smaller Recruit motors. Out of a total of eight Little Joe flights, two carried American-born rhesus monkeys (Macaca mulatta). This memorandum discusses the use of these monkeys, obtained from the School of Aviation Medicine at Brooks Air Force Base, San Antonio, Texas. The Little Joe 2 (LJ-2) mission carried an American-born rhesus monkey (Macaca mulatta) named "Sam," an acronym for School of Aviation Medicine, to the edge of space. The mission launched on 4 December 1959, from Wallops Island, Virginia, and flew 51 miles toward space. Sam was housed in a cylindrical capsule within the Mercury spacecraft. Approximately one minute into the flight, traveling at a speed of 3,685 mph, the Mercury capsule aborted from the Little Joe launch vehicle. It was safely recovered in the Atlantic Ocean after a flight of only 11 minutes, 6 seconds.

A second rhesus flight took place on 21 January 1960, flying only 8 minutes, 35 seconds to an altitude of 9 miles. Its passenger, "Miss Sam," also returned safely after taking part in a Max Q abort and escape test.

NASA Headquarters

June 19, 1959

MEMORANDUM: For Mr. R. R. Gilruth, Director
Project Mercury

Subject: Animal Payloads for Little Joe

1. I am enclosing a copy of a memorandum from the Administrator requesting that only American-born rhesus monkeys will be used in Mercury flights.

2. I understand that we have been assured by the School of Aviation Medicine that all rhesus monkeys supplied by them for the Little Joe flights meet the above requirements. However, I suggest that SAM be informed that "birth certificates" of these monkeys will be required at the time of each flight.

George M. Low
Program Chief
Manned Space flight

[handwritten at bottom: "Hindoos might object"]

Attachment:
Memo to George Low
Dtd 15 June 1959
GM: mdp
Cc: Dr. Smith
Dr. Worf
Dr. Henry – Langley STG
Mr. Sanders
Mr. C. Wood without attachment
Mr. W. Hjornevik without attachment

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
1520 H STREET NORTHWEST
WASHINGTON 25, DC

15 June 1959

MEMORANDUM TO:

George Low
Office of Space Flight Development

Following the public announcements of the use of the American-born rhesus monkey in the recent Jupiter test, the Secretary of HEW raised questions with the Defense Department and with NASA as to the intention of these agencies with respect to the use of Indian-born rhesus monkeys in the future. A copy of the response of the Department of Defense prepared by Admiral John Clark is attached for your information [not included]. For NASA, I informed [Health, Education, and Welfare] Secretary Flemming that we proposed to use relatively few biological specimens and where we felt a rhesus monkey was indicated as the proper animal, we would use American-bred animals. Please take this as your instruction to abide by this statement on my part.

[Signed]
T.K.G

Cc: Dr. Silverstein
Dr. Randt

Attachment:
Thermofax copy of Memo dtd 6/11/59
From Adm. Clark, ARPA, to Secy.,
HEW [not included]

Document I-25

Document Title: NASA, "Information Guide for Animal Launches in Project Mercury," 23 July 1959.

Source: Folder 18674, NASA Historical Reference Collection, NASA History Division, NASA Headquarters, Washington, DC.

In all, there were four launches of Mercury spacecraft with primates aboard to test the life support systems of the vehicle. The first of these was the Little Joe 2 flight of 4 December 1959 with Sam, an American-born rhesus monkey, aboard. Sam was recovered, several hours later, with no ill effects from his journey. He was later returned to his home at the School of Aviation Medicine at Brooks Air Force Base, San Antonio, Texas, where he died in November 1982. Miss Sam, another rhesus monkey and Sam's mate, was launched on 21 January 1960, on the Little Joe 1B mission. She was also recovered and returned to the School of Aviation Medicine. On 31 January 1961, Ham, whose name was an acronym for Holloman AeroMed, became the first chimpanzee in space, aboard the Mercury Redstone 2 (MR-2) mission on a sub-orbital flight. Ham was brought from the French Camaroons, West Africa, where he was born in July 1957, to Holloman Air Force Base in New Mexico in 1959. Upon the completion the successful flight and a thorough medical examination, Ham was placed on display at the Washington Zoo in 1963 where he lived until 25 September 1980, when he moved to the North Carolina Zoological Park in Asheboro until his death on 17 January 1983. Enos became the first chimp to orbit the Earth on 29 November 1961, aboard Mercury Atlas 5 (MA-5) launched on 29 November 1961, from Cape Canaveral, Florida. This two-orbit, 88 minute, 26 second flight, proved the capability of the Mercury spacecraft. Enos died at Holloman Air Force Base of a non-space related case of dysentery

11 months after his flight. Because of the interest in and the sensitivity about these primate flights, NASA took considerable pains to explain how the animals were treated and what role they played in the program, as shown in this information guide. These guidelines were approved by Deputy Administrator Hugh Dryden, Associate Administrator Richard Horner, and Director of Space Flight Development Abe Silverstein on 23 July 1959.

[7-23-59]

NASA INTERNAL USE

INFORMATION GUIDE FOR ANIMAL LAUNCHINGS IN PROJECT MERCURY

1. Background

Animals will be used in the Project Mercury developmental program to gain information on the biological response to space flight. Problems facing manned orbital flight essentially are engineering in nature, and the animal program will be relatively simple in scope. Knowledge from animal flights will contribute information to the program in the areas of life support systems; instruments to measure physiological reactions in the space environment; prove out design concepts when they are near known limits in such areas as high-g loads; test equipment and instrumentation under dynamic load conditions, and to develop countdown procedures and train personnel in these procedures prior to manned flight.

NASA has selected three animals for developmental work in the Mercury program: rhesus monkey (Macaca Mulatta), chimpanzee and mouse. Primates were chosen because they have the same organ placement and suspension as man. Both rhesus and chimp have relatively long medical research backgrounds, and the type of rhesus born and bred in American vivarium has a 20-year research background as a breed. The chimp is larger and more similar to man in body systems, and will be used for advanced developmental flights with the McDonnell Aircraft Corporation capsule. A "mouse drum" will be used to study the effects of weightless flight and may be the first biological package to be sent into orbit in the Mercury program.
(Page 2 contains a summary of flights and test objectives.)

Management of the animal program is the responsibility of the NASA Space Task Group. Responsibility for supply, training, installation and post-flight evaluation has been assigned to:

USAF Aeromedical Field Laboratory, Hol[l]oman AFB – Chimps
USAF School of Aviation Medicine, Randolph AFB – Rhesus
USAF Aeromedical Laboratory, WADC, Wright-Patterson AFB- Mice

The U.S. Army and U.S. Navy will provide advice and assistance through out the program.

[2]

STUDY OF LITTLE JOE FLIGHTS AND TEST OBJECTIVES

(All at Wallops Station)

Flight #	Animal	Capsule	Mission*
1.	None	NASA	Escape system-booster quals.
2.	Rhesus	NASA	High-angle re-entry
3.	Rhesus	NASA	High-angle re-entry
4.	Rhesus	NASA	Low-angle re-entry
5.	Chimp	MAC	Maximum load escape

6. Backup booster

OTHER ANIMAL FLIGHTS IN PROJECT MERCURY

(All at Atlantic Missile Range)

Redstone	Chimp	MAC	Ballistic flight quals.
Atlas	Chimp	MAC	High-g escape
Atlas	Mouse drum	MAC	Weightless flight
Atlas	Chimp	MAC	Orbital flight

Notes:

* Mission- physiological measurements and environmental readings will be taken during all animal flights.

There will be two animals available for each flight, one of which will be used as a backup.

The above is not necessarily the order in which flights will take place.

[3]

2. Information Procedures

The press will be permitted to witness two Little Joe launches – one of the early flights to be determined by the Deputy Administrator and the Director of Space Flight Development, and Flight No. 5 identified on Page 2.

Procedures at both Wallops Station and the Atlantic Missile Range will be in accordance with the joint NASA-DOD East Coast Launching Plan. For each launching open to the press, a press kit will be prepared containing handout materials on: 1-Program objectives; 2-Launching vehicle, and 3-Project Mercury background.

Only qualified NASA personnel will be permitted to make public statements on the program. The Defense Department, through the Assistant Secretary of Defense for Public Affairs, will be asked to cooperate in this desire so that objective information goals will be attained.

A. Pre-Launch Activities (At Wallops Island) – The afternoon before the first open launch at Wallops, the press will be permitted to view the Little Joe booster. This activity will take place before the animal subject (in the case of an animal flight) is inserted in the capsule. Photography will be permitted. The press kit will be handed out simultaneously at Wallops and in Washington on a "Hold for Release Until Launched" embargo.

Meanwhile, the Navy will be asked to provide photographic coverage on the recovery ships, and a billet for one NASA OPI representative.

The logistics briefing at Wallops will cover press release details, safety requirements and general test objectives. The Wallops Station will provide bus transportation on Wallops Island. No members of the launching team will be required until phase (c) below.

B. Launch Activities - The press will meet at the Mainland Dock two hours before launch for transportation to arrive at the viewing site one hour before scheduled launch.

C. Post-Launch Activities (Wallops Island) – A brief post-launch briefing will be held either at the viewing site or at the cafeteria building on Wallops. This briefing will discuss the launching phase, mission profile, and any recovery data available at that time. Representatives of the launching team and Space Task Group will participate.

[4]

(Washington) - NASA Washington will be the source of all post-launch scientific information. A Technical press briefing will be conducted about 24 hours after the launch to summarize all information known at that time. Representatives on the panel will be from NASA Headquarters; Space Task Group; STG Biomedical Group; Launching Team, and Recovery Team.

Pre-launch information activities require training and housing still and motion pictures of the animal subjects. The responsible agency (i.e., USAF) will be asked to provide footage and a selection of photographs in these areas.

NASA will take and provide photographs (still and motion picture) of the animals in biopacks and the biopack insertion into the capsule.

At no time will the animal subjects be available to the press either for photography or viewing. NASA will follow this policy for these reasons:

1- Test results are influenced by excitement, particularly since the animal subjects have led sheltered lives. A minimum of crowd activity is justified from both scientific and clinical standpoints.

2- Elimination of all but necessary scientific persons curtails added chances of the primates contacting diseases.

3- Complex handling procedures for the animals will not be required.

4- The undesirable effects of the "Roman Holiday" atmosphere are eliminated.

While the above procedures indicate fairly full-dress coverage, the press will be permitted on the spot viewing at only two of the five Wallops Station launchings. NASA OPI will assure that there will be no interruption of scientific activities and personnel until after the launch.

For the launches not open to the press, a NASA OPI representative will witness the firings and prepare releases on them.

Press activities at AMR are governed by the joint NASA-DOD agreement, but will be supplemented with the requirement that the animal subjects will at not time be available to the press, for the above reasons.

3. Summary

NASA OPI will conduct information activities associated with animal launches in a factual manner which will satisfy requirements [5] for accurate reporting and non-interference with scientific personnel conducting the program.

Two launches at Wallops Island will be open to news media.

NASA and DOD personnel will be requested not to comment on aspects of the technical program outside their cognizance. Lines of responsibility are clear:

Management and overall responsibility – Space Task Group
Boosters- Langley Research Center (Little Joe)
- Army Ballistic Missile Agency (Redstone, Jupiter)
- Air Force Ballistic Missile Division – (Atlas)
Medical data correlation – NASA biomedical group
Capsule recovery - U.S. Navy under DOD assignment (Note: the Assistant Secretary of Defense for Public Affairs has been designated sole liaison to NASA for the Mercury project. He is expected to detail cognizant military agencies to act in his name.)
Information - NASA OPI (Headquarters and field)

Before there is any critical deviation from this plan, the NASA Director of Public Information will discuss details with the Director, Space Flight Development and Director, Space Task Group.

-END-

Document I-26

Document Title: A. J. Goodpaster, Brigadier General, USA, Memorandum of Conference with the President, 29 September 1959.

Source: Dwight D. Eisenhower Presidential Library, Abilene, Kansas.

From the beginning of his first term in January 1953 President Dwight D. Eisenhower had a strategy for defeating the Soviet Union. It revolved around long-term economic, military, international, and social and moral perquisites that would enhance the U.S. as the world leader. It represented a commitment to constant pressure on the Soviet Union on a broad front, but refrained from a confrontation that would require nuclear war to resolve. A key ingredient of this strategy involved not responding to every situation vis à vis the Soviet Union as a crisis. Accordingly, he resisted the crisis sentiment that Sputnik and the early space race fostered among many policy-makers in Washington. This memorandum captures the spirit of that resistance by reporting on the President's questioning of NASA's proposed budget. Eisenhower's approach to space activities stressed the development of launch vehicles for use in the ICBM program, satellite technology for reconnaissance and communications, infrastructure required to support these activities such as tracking and launch facilities, and utilitarian science that either directly supported those missions or was a natural byproduct of them. Eisenhower's space program, however, did not include any real commitment to, or belief in, the goal of human spaceflight. In Eisenhower's view, human spaceflight did not have a serious national security component, and therefore was probably not worthy of significant federal expenditures. NASA Administrator T. Keith Glennan was largely in sympathy with the President's objectives, but faced pressures from elsewhere to surpass the Soviet efforts, hence the large increase in NASA's budget for fiscal year 1961. Senator Lyndon B. Johnson (Dem-Texas), for one, vowed to put additional funding into any NASA budget submission so that it could do so. Glennan wrote in his diary that "Congress always wanted to give us more money . . . Only a blundering fool could go up to the Hill and come back with a result detrimental to the agency." This memorandum reflects these realities as NASA began undertaking Project Mercury.

[SECRET] [DECLASSIFIED]

September 30, 1959

MEMORANDUM OF CONFERENCE WITH THE PRESIDENT
September 29, 1959

Others present: Dr. Kistiakowsky
General Goodpaster

The President began by saying had heard that Dr. Glennan is putting in for some $800 million in the FY-61 budget for space activities. He though this was much too great an increase over the current year and in fact said that he thought a program at a rather steady rate of about a half-billion dollars a year is as much as would make sense. Dr. Kistiakowsky said that he has had about the same figure in his mind, but pointed out that this amount would not allow enough funds for space "spectaculars" to compete psychologically with the Russians, while being a great deal more than could be justified on the basis of scientific activity in relation to other scientific activities.

The President recalled that he has been stressing that we should compete in one or two carefully selected fields in our space activity, and not scatter our efforts across the board. He observed that other countries did not react to the Russian Sputnik the way the U.S. did (in fact, it was the U.S. hysteria that had most affect on other countries), even the United States did not react very greatly to the Soviet "Lunik" – the shot that hit the moon.

The President said he had understood that, through the NASA taking over ABMA, there was supposed to be a saving of money, but that it appeared this would in fact increase the NASA budget. He thought that Dr. Glennan should be talked to about this, away from his staff, who are pushing a wide range of projects, and advised not to overstress the psychological factor. The President thought we should take the "man in space project" and concentrate on it. He added he did not see much sense to the U.S. having more than one "super-booster" project. There should be only one.

[2]

Dr. Kistiakowsky said he strongly agreed on this. He pointed out that, by putting ABMA into NASA, there would be an over-all saving of money. The President reiterated that there is need for a serious talk with Dr. Glennan. He thought ABMA should be transferred to NASA and that we should pursue one big-booster project. Our concentration should be on real scientific endeavor. In the psychological field, we should concentrate on one project, plus the natural "tangents" thereto. He thought perhaps Dr. Glennan is overrating the need for psychological impact projects. Dr. Kistiakowsky said that the Defense Department states that if Dr. Glennan does not push fast enough in space activities, Defense will do so. The President said we must also talk to Dr. York, and call on him to exercise judgment. He asked that a meeting be set up, to be attended by Dr. Glennan, Dr. Dryden, Dr. Kistiakowsky, Dr. York, and Secretary Gates in about ten days. The President stressed that we must think of the maintenance of a sound economy as well as the desirability of all these projects. He thought perhaps NASA sights are being set too high, including too many speculative projects.

Dr. Kistiakowsky said that if Dr. Glennan goes in with a lower budget, there will be need for the President to support him publicly, because there will be a great deal of criticism about this. Dr. Kistiakowsky himself thinks that such a limitation may be wise, however, particularly when one contrasts the $60 million being given to the Science Foundation for research purposes with the $3/4 billion proposed to go into space activity, but a much lower NASA budget may not allow us to "compete" with the USSR. The President commented that the space activity is in the development and production state, which is more expensive, and Dr. Kistiakowsky recognized that, of course, this is true.

[Paragraphs 6-12 not included]

A.J. Goodpaster
Brigadier General, USA

Document I-27

Document Title: Wernher von Braun, Director, Development Operations Division, Army Ballistic Missile Agency, to Robert R. Gilruth, Space Task Group, NASA, 9 October 1959.

Source: National Archives and Record Administration, Forth Worth, Texas.

Wernher von Braun (who was working for the U.S. Army at the time but transferred to NASA in1960), together with his German-led rocket team, wrote this memorandum to Robert Gilruth of the Space Task Group, which points out two critical aspects of early relations in NASA. First, it demonstrates the friendly rivalry that existed between competing entities in the Agency. Wernher von Braun, certainly pleased to be of assistance to a colleague and exceptionally mindful of the high quality of work required in building space technology, also enjoyed pointing out the flaws that he saw in the construction of the Mercury spacecraft by McDonnell Aircraft Corporation that Gilruth's group was managing. Gilruth and von Braun demonstrated this type of relationship throughout the era. Second, the memorandum demonstrates the intense level of "contractor penetration" that von Braun's team was famous for in the management of its spaceflight projects. Industry officials sometimes complained that working for von Braun's engineers required acquiescing in a technical take-over in which government inspectors, many of whom were more qualified to do the work than the industry technicians, constantly peered over the shoulders of the company workers and got involved in every aspect of the project. The comment in this memo on "soldering rods" would certainly be considered today to be a governmental intrusion into something that was the proper province of the company. The longstanding debate over "contractor penetration" lasted throughout Project Mercury, and indeed to the present, as NASA sought to strike a balance between necessary oversight and contractor autonomy. The letter was apparently drafted by Joachim Kuettner, von Braun's associate who was the project engineer for the Mercury-Redstone portion of Project Mercury.

Kuettner/vonBraun/bh/4814

ORDAB-D 252

9 October 1959

Mr. Robert R. Gilruth
NASA- Space Task Group
Langley Field, Virginia

Dear Bob:

I am writing this letter in full knowledge that I am poking my nose into something that's none of my business. But I am convinced that projecting a man two hundred miles down-range simply requires the ultimate in teamwork. This team composed of NASA, McDonnell, and ABMA must operate flawlessly to drive on to a touchdown; for this time, there is human life at stake.

It has come to my attention that one of our ball carriers has his shoelaces untied and doesn't know it. If he trips and falls we may all lose the game and our astronaut his life. So I feel that I must pass along to you what has been brought to my attention, at the risk of making a few people sore.

On a recent trip to McDonnell Aircraft Corporation, ABMA personnel were permitted to tour the facilities used to fabricate electrical cable harnesses. They discovered to their great consternation that in MAC's electrical shops procedures long since discarded by ABMA as being inadequate and dangerous are still in practice.

Samples:

-Soldering irons of excessive wattage are being used to make joints in pygmy connectors. (Reason: The shop is not air-conditioned; large cooling fans prohibit the use of correct, smaller soldering irons.)

-Poor connections are being hidden by potting compound (making inspection impossible).

It has been our experience that conventional methods of soldering for aircraft are simply not acceptable in the missile [2] field where any and all component [failures] usually result in an aborted mission. In MERCURY the life of an astronaut and the success of the entire project could be jeopardized by one bad solder connection.

I don't want to blame anyone in particular at MAC. I don't even know who is responsible for this electrical shop. But I should like to suggest that you have someone from Langley look into this. While we would prefer to leave it up to you to take any further actions that you may deem advisable we are at your disposal if we can be of any further help.

Sincerely yours,

[Signed]

WERNHER VON BRAUN
Director
Development Operations Division

Copies furnished:
AB-DSRM (Record)
AB-D (Info)

Document I-28

Document Title: Mercury Astronauts, Memorandum For [Mercury] Project Director, NASA, "Exchange of Visits with Russian Astronauts," 21 October 1959.

Source: National Archives and Record Administration, Fort Worth, Texas.

From the start of their careers at NASA, the seven Mercury astronauts were eager to make contact with their Soviet counterparts. These efforts were discouraged by NASA and White House leadership.

It was not until the 1960s that NASA astronauts and Soviet cosmonauts met each other in various places around the world. These visits were arranged for mostly propaganda purposes on both sides. American intelligence officials also foresaw the opportunity to pierce some of the secrecy surrounding the Soviet program if the two sets of pilots could talk with each other. The first such interchange took place following the flight of Gherman Titov, when he visited with John Glenn at a May 1962 technical meeting in Washington, DC. The two men and their wives toured the Capitol and visited President John F. Kennedy in the White House. The next exchange between astronauts and cosmonauts did not take place until June 1965 when astronauts James A. McDivitt and Edward H. White, along with Vice President Hubert H. Humphrey, met Yuri Gagarin at the Paris Air Show. As years passed cosmonauts and astronauts began to meet more frequently and freely.

NASA – Space Task Group
Langley Field, Virginia
October 21, 1959

MEMORANDUM: For Project Director

Subject: Exchange of visits with Russian Astronauts

1. The Russians have recently announced their man-in-space program and have given some publicity to the pilots selected. In the eyes of the rest of the world, it appears that Project Mercury is placed in a competitive position, whether we like it or not. This, of course, sets up for another barrage of unfavorable propaganda when, and if, the Russians achieve space flight before we do.

2. Certain action at this time might place us in a better position to gain information about their program and also take the propaganda initiative away from the Russians with regard to manned space flight. Suggested action is to propose mutual visits between the Astronauts of the two countries with the purpose of sharing information on training and mutual problem areas.

3. Propaganda-wise, we apparently stand to gain a great deal and could lose little or nothing.

    a. The U.S. would have taken the initiative in sponsoring international cooperation in the manned space field.

  b. Such a proposal would support, to the world, our statements of the peaceful intent of Project Mercury as a scientific exploration with no ulterior motives.
  c. It is in keeping with the current political atmosphere engendered by the Khrushchev visit and the proposed presidential visit to Russia.

4. There appears to be little we could lose, in that practically all of the details of Project Mercury are already public domain and have been covered repeatedly in the press. The Russian program, on the other hand, has been secret, so anything we could learn would be new information.

5. Refusal of the Russians to cooperate in such a proposal would certainly reflect unfavorably in the eyes of other countries. These are countries already concerned about where the American-Russian space race is leading.

[2]

6. Timing of such a proposal is very important. If such a proposal is made, it should be done very soon, before either Russia or the U.S. has accomplished a man-in-space mission.

7. If we wait until we make the first orbital flight, and then propose an exchange, it would appear that we are “rubbing it in” a little and are willing to throw a little information to our poor cousins who could not do it themselves. This would probably do us more harm than good in the attitude with the rest of the world.

8. If, on the other hand, we wait until the Russians have made the first orbital flight before we propose such an exchange, it would appear that we are trying to get information on how they did it because we have not been able tot do the same thing. This would also do us harm in the eyes of other countries.

9. To summarize, we stand to gain information in an exchange of visits, while giving little information that is not already known. Propaganda value of such a proposal and visit should be very favorable for us, if the proposal is made from the U.S. and before either country has made an orbital flight.

10. One way to assess the value of such a proposal is to think of our reaction and the reaction of other countries if the Russians make such a proposal first. It appears that we stand to gain by making the proposal first.

11. It is realized that there are many considerations involved in such a proposal. NASA, State Department, Intelligence, and many other government sources concerned must have vital inputs that will determine whether the proposal is not only feasible, but advisable.

12. The proposal is herewith submitted for consideration.

M. Scott Carpenter
Lieutenant, USN

Leroy G. Cooper
Captain, USAF

John H. Glenn
Lt. Col., USMC

Virgil I. Grissom
Captain, USAF

Walter M. Schirra
Lt. Cmdr., USN

Alan B. Shepard
Lt. Cmdr., USN

Donald K. Slayton
Captain, USAF

Document I-29

Document Title: Charles L. Wilson, Captain, USAF, ed., WADC Technical Report 59-505, "Project Mercury Candidate Evaluation Program," December 1959.

Source: Folder 18674, NASA Historical Reference Collection, NASA History Division, NASA Headquarters, Washington, DC.

The selection of the astronauts for Project Mercury involved numerous organizations and types of activities for the various candidates. One of the key organizations was the Aeromedical Laboratory of the Wright Air Development Center in Dayton, Ohio. This U.S. Air Force facility was one of the most prestigious in the world and had been involved in aerospace medicine for many years. Its scientists had conducted tests on NASA's astronaut candidates in the spring of 1959 to ascertain which of them might be most appropriate for spaceflight. This technical report discusses how and why the center became involved in the initial astronaut selection process and the work undertaken in choosing the Mercury Seven.

WADC TECHNICAL REPORT 59-505

PROJECT MERCURY CANDIDATE EVALUATION PROGRAM
Charles L . Wilson, Captain. USAF, MC
Editor

Aerospace Medical Laboratory

December 1959

Project No. 7164
Task No. 71832

WRIGHT AIR DEVELOPMENT CENTER
AIR RESEARCH AND DEVELOPMENT COMMAND
UNITED STATES AIR FORCE
WRIGHT-PATTERSON AIR FORCE BASE, OHIO

INTRODUCTION

C. L. Wilson, Capt., USAF, MC

The National Aeronautics and Space Administration (NASA), a U.S. Government civilian agency, has been assigned the task of exploring the feasibility of space travel. As a result of thorough and exhaustive study, NASA has concluded that certain aspects of space travel are feasible and, furthermore, that some will be practicable in the very near future. One profile of space travel envisions that a human pilot, transported in a life support system (capsule), could be thrust into orbit by a liquid fuel rocket, maintained there for several revolutions around the earth, and successfully and safely recovered from orbit. Project Mercury intends to realize this vision.

Among the many strategic questions to be answered is: “Who will the pilot be?” This report describes how and why the Aerospace Medical Laboratory participated in the selection of the seven Mercury Astronauts.

HISTORY

The Human Factors Division of the Air Research and Development Command (ARDC) has been keenly aware of the need for clarification of the parameters of human endurance, safety, and comfort during periods of unusual stress. In 1952 Brig.Gen. Don Flickinger, USAF, MC, began directing biomedical research toward the development of tests to assist in selecting pilots for special research projects. Under his guidance Capt. T. F. McGuire, USAF, MC, of the Aerospace Medical Laboratory, employed a series of physiological, psychological, and biochemical tests which were incorporated into a stress-test program. Dr. McGuire’s experience extended over a 4-year period, during which time he tested several special groups. These included USAF pilots and young volunteers from the University of Dayton. In his final months at the Aerospace Medical Laboratory he stress-tested 12 USN underwater demolition men (frogmen) kindly loaned by the Underwater Demolition Unit 11, Little Creels, Virginia. The results of his research are presented in Stress Tolerance Studies, Part I, and Tolerance to Physical Stress, Part II. Part III is being completed and will contain a supportive bibliography. Dr. McGuire rightfully should receive credit for his work in this field and development of early prototype crew selection profiles. Several new tests have been made available since then and are discussed later.

Captain F. J. Leary, USAF, MC, of the Aerospace Medical Laboratory also gained considerable experience in candidate evaluation. His research brought about modification of the cold pressor test to its present form. Previous testing utilized the immersion of one foot, then both feet. He also studied the reproducibility of physiological response on the same subject when tested on different days. He developed early scoring techniques based on physiological response. Modifications of his techniques were employed in the Mercury Candidate Evaluation Program.

Captain W.S. Augerson, USA, MC, was immensely valuable in the development of the final test profile. He assisted in a review of literature, experienced the actual tests, and offered valuable opinions on areas where improvement was indicated.

Two assistant investigators during the period of 1957 to 1958 were Gardner Edwards, M, D. (then a University of Virginia medical student on a USAF-sponsored scholarship), and Robert McAdam, associate professor of physical education, Northern Illinois University.

[2]

APPROACH TO THE PROBLEM OF CANDIDATE EVALUATION

The ultimate purpose of any crew recommendation development program is to devise and validate tests which can be used with reliability in selecting crew members for future projects. The Project Mercury Candidate Evaluation Program was an important stage in this ARDC development program. Since the actual approach to this research problem departs from the ideal approach, it will help to present both the ideal and actual methods of attack.

Ideal Approach to Problem:

1 . The candidates must be medically acceptable and technically capable before they will he considered as potential candidates.

2. Those who are tested must be the actual project candidates. A large candidate population will increase the reliability of the results.

3. The test profile must simulate all aspects of the stresses anticipated during the actual project. The simulated stresses must be combined in the same relationship and intensity as they would occur during the project.

4. A battery of nonsimulating but relevant tests must be included in the testing program. These tests will be used to identify significant correlations between the response to simulating and nonsimulating tests. The ultimate goal is to replace simulating tests with the more easily administered, nonsimulating tests in future programs

5. In the final recommendation of candidates, the investigators must only interpret subject performance on the simulating tests. Nonsimulating test performance will not affect recommendation of this first group of candidates.

6. All candidates, both recommended and not recommended, must enter the project.

7. At the completion of the project all of the participants must be graded on the effectiveness of their performances.

8. The investigators must then seek significant correlations between subject performances on the various simulating and nonsimulating tests and successful mission performances.

9. Those nonsimulating tests bearing significant correlation with successful mission performances may then be used to select future subjects from an identical population for identical projects. These future crew members will be highly reliable risks in successfully completing their missions. This is the goal of all endeavors at crew selection.

Actual Approach to Problem:

Inherent errors are frequently introduced when making a transition from an ideal to an applied test program due, for example, to time limitations, accelerated schedules, or unforeseen changes. The actual approach to the problem is stated below, preceded by an underlined restatement of the ideal approach:

1. The candidates must be medically acceptable and technically capable before they will be considered as potential candidates. The candidates were medically acceptable and technically capable. They met the following requirements: a. were pilots in the Department of Defense, b. had received engineering degrees, c. had successfully graduated from a military test pilot school, d. had achieved at least 1500 hours of total flying time, and e. each man's height was 5'11" or less One hundred and ten men met the above requirements. Sixty-nine of these men were invited to a [3] NASA briefing where the detailed plans of Project Mercury were revealed. The subjects were then asked if they desired to volunteer as competitive candidates. Fifty-five of them volunteered.

2. Those who are tested must be the actual project candidates. A large candidate population will increase the reliability of the results. Those who were tested actually were the Project Mercury candidates. The 55 men who were accepted were given a series of interviews and psychological tests. On the basis of the data thus obtained, 32 were chosen for the final phase of the selection program. The 32 candidates were sent to the Lovelace Foundation, Albuquerque, New Mexico, for extensive medical histories, physical examinations, and biochemical and physiological tests.* A large random candidate population was not used. If the candidate population had been larger it would have been impossible to process them in time to meet the close time schedules of the project.

3. The test profile must simulate all aspects of the stresses anticipated during the actual project. It was impossible to devise a laboratory situation which exactly duplicated the stresses anticipated during Protect Mercury. A rational alternative approach was to list the anticipated stresses and to use what laboratory tools were available.

Anticipated Stresses:

a. The men who were chosen could expect a 2- to 3-year period of intensive training including a study of space-frame structures, propulsion, inertial guidance, systems reliability, aerodynamics, and physiology. They would actively participate in training exercises such as: physical fitness, capsule parachute landings, ballistic trajectory flights, and underwater escape from capsules. These represent a prolonged period of genuine stresses.

The best practical laboratory tools to test these areas were: (1) review their past accomplishments, (2) extract personal histories, and (3) conduct psychiatric interviews and psychological tests. Additional information could be derived from observation of these candidates during moments of calibrated hazing such as: acceleration, pressure suit testing, immersing feet in ice water, and isolating the subject. The accumulated impressions of these trained observers should guarantee highly reliable maturity in those recommended.

b. Psychological and physical stresses will exist before, during, and after each flight. The psychological stresses will include fears and anxiety about possible accidents or death. Although well disguised in the mature test pilot, they will be present. The psychiatric evaluation should reveal those who are stable and reliable.

The physical stresses of blast-off and orbit will include acceleration, noise, vibration, weightlessness, tumbling if stabilization is not achieved, and possible capsule depressurization. Those insults of re-entry will contain deceleration, noise, vibration, and heat if the cooling system fails. Landing will be accompanied by deceleration. Before recovery there is the possibility that the capsule will sink. There is also the possibility of isolation in a remote and uninhabitable climate and topography.

The physical facilities available at the Aerospace Medical Laboratory are able to duplicate the important physical and psychological stresses mentioned above. These facilities include: human centrifuge, extremely low-pressure (high-altitude) chamber, heat-controlled test rooms, equilibrium-vibration chair, intense noise generator, aircraft (C-131B) specially modified to safely fly Keplerian trajectories (weightlessness), tumbling turntable, psychiatric interviewing rooms, and anechoic chamber.

Simulating Tests:

* The tests performed at the Lovelace Foundation are detailed in the Appendix. [not included]

Those tests simulating stresses anticipated during Project Mercury are: transverse g profiles (acceleration tests) and vibration-equilibrium and intense noise profiles (biological acoustical tests). Weightlessness tests were not performed on the candidates for one main reason: it would have been impossible in scheduling always to meet the minimum flying safety requirements for each flight each day for 6 weeks. Tumbling tests are so unpleasant and the nausea so prolonged as to warrant its exclusion for the profile.

4. The simulated tests must be combined in the same relationship and intensity as they would occur during the project. The physical separation of test facilities rendered it highly impractical to improvise superimposed stress. While a multi-stress facility was desirable, it was not mandatory for study of the candidates. In any interpretation, partial data when expertly gathered is much more desirable than no data at all. This reasoning serves to defend the approach that was finally taken.

5. A battery of nonsimulating but relevant tests must be included in the testing program. These tests must be easy to administer and safe. A battery of easily administered and safe nonsimulating tests was incorporated into the program. They were (physical fitness tests): Harvard step, Flack, cold pressor, and tilt table. A battery of more complex nonsimulating tests was also devised. The investigators believed these might correlate significantly with simulating tests. The complex tests cannot be easily and/or safely administered. These tests are: positive g to blackout (acceleration); extensive anthropometric and photogrammetric measurements, somatotyping (anthropological); urinary catacholamines, plasma corticosteroids, urinary 3-methoxy-4-hydroxymandelic acid (biochemical); speech intelligibility (biological acoustical); 2 hours of heat stress (thermal); treadmill, MC-1 partial pressure suit (physical fitness); all tests administered (psychological); and maximum breathing capacity, bicycle ergometer, electrical stimulation of muscles (Lovelace Foundation).

6. In the final recommendation of candidates the investigators must only interpret subject performance on the simulating tests. Nonsimulating test performance will not affect recommendation of this first group of candidates. Some of these nonsimulating tests were interpreted and did affect the recommendation of candidates. This was intentional. The sum total of data gathered from all of the simulating tests, although valuable, was insufficient to render candidate recommendations with confidence. However, the investigators agreed that, if they were also allowed to interpret some of the nonsimulating tests with which they were intimately familiar, they could then attach great confidence to the final recommendations. It was unanimously agreed that each investigator-group would be allowed to interpret the nonsimulating tests which they chose. The main goal of this particular crew selection development program was to recommend outstanding candidates. An important but secondary goal was to discover the existence of significant correlations. It was unsound practice to omit data or impressions which might possibly affect the success of Project Mercury. Those nonsimulating tests which were interpreted and which did affect the final candidate recommendations were: positive g (acceleration); index of strain (thermal); Harvard step, Flack, cold pressor (only if feet were prematurely withdrawn), treadmill, MC-1 partial pressure suit (if subject terminated test for psychological reasons), tilt table (physical fitness tests); and all tests administered (psychological).

Those nonsimulating tests which were not used in the final candidate recommendations were: all measurements (anthropological); all measurements (biochemical); speech intelligibility (biological acoustical); and cold pressor test development of hypertension and/or tachycardia, MC-1 test development of presyncope or tachycardia >160, Valsalva overshoot., and tilt table (physical fitness tests).

7. <u>All candidates both recommended and not recommended must enter the project</u>. All of the candidates did not enter the project. The final selection took into consideration all of the assets of the candidates. These assets included past training, experience, recommendations from the Lovelace Foundation, and recommendations from the Aerospace Medical Laboratory (AML).

8. <u>At the completion of the project all of the participants must be graded on the effectiveness of their performances</u>. The above condition has not been satisfied as this report nears completion. It will require several years to satisfy this condition.

9. <u>The investigators must then seek significant correlations between subject performances on the various simulating and nonsimulating tests and successful mission performances</u>. Since condition [5] <u>8</u>. is not satisfied, this condition also cannot be satisfied. An alternative approach has been used. It has been assumed that the Mercury Astronauts are the best potential group to fulfill the mission of Project Mercury. It has also been assumed that they will carry out the mission successfully. There is confidence that these assumptions will mature into fact. Based upon these assumptions a significant correlation study has been sought. Ideally, it is premature. Practically, it is valuable, since the program has demonstrated tests that should be pursued in future crew recommendation studies.

Each chapter has been written by the appropriate principal investigator. Throughout this report the candidates will be referred to by alphabet letters assigned to their names. There is no relationship between these alphabetical designations and their names or NASA numbers. It is impossible for the reader to identify a particular subject's name or performance. This system was designed to maintain the privileged communication due each candidate.

REFERENCES

0.1. McGuire, T. F. <u>Stress Tolerance Studies</u>, Part I. Unpublished Data. 1958.
0.2. McGuire, T. F. <u>Tolerance to Physical stress</u>, Part II. Unpublished Data. 1958.

[pp. 6-98 not included]

[99]

CHAPTER X

DISCUSSION AND RECOMMENDATIONS

Thirty-one highly selected adult males were the subjects of a crew recommendation study. Data were gathered from the performance of each subject on each test. One hundred and four performance variables were correlated. The following statements represent preliminary impressions from this Project Mercury Candidate Evaluation Program. It is recognized that the investigators were studying a small, highly selected population. Therefore, it is difficult to render conclusions on statistical significance.

1. Psychological stability is the most important consideration in evaluating a candidate. The intelligence, maturity, and motivation of a candidate are vital areas to be assessed before rendering a recommendation.

2. Excellent physiological performance was a secondary consideration in the final Committee recommendations.

3. The main value of a severely stressful physiological test was the interpretation of the psychological response to that stress test. Whenever a subject terminated a severe test for psychological reasons, he was not recommended by the Committee.

4. It is possible to eliminate subjects by use of stressful tests. It is not presently possible to select subjects with confidence, where selection is based entirely upon their excellent physiological performances.

5. No single, nonsimulating test has been identified which will be of great assistance in recommending crew members. A large battery of tests, such as were performed, lends confidence to the final recommendations.

6. Whenever a candidate is being considered for a special mission, it is desirable that a large number of trained observers each have the opportunity to test him and to render an opinion before the final recommendation

7. This study has demonstrated that there is no statistically significant difference in the physiological or biochemical responses of the Mercury Astronauts when compared with the remainder of the NASA candidates.

8. There is no evidence to support a thesis which maintains that visual inspection, biochemical measurements, or physiological responses of a candidate are of principal value in rendering a reliable recommendation of suitable candidates. These are secondary considerations.

9. While the hormones and their metabolites are valuable research tools, this study has demonstrated that they were not significantly different in the Mercury Astronauts when compared with the remaining NASA candidates.

10. There is every reason to suspect that safe, standardized, moderately stressful and severely stressful tests (such as having the subject walk on the treadmill until he voluntarily terminates) would be of great assistance in future crew recommendation programs, since severe stress also tests the candidate's motivation.

11. It is believed that testing of those who did not volunteer as candidates would be valuable, since the nonvolunteer group might lack the same intensity of motivation which was possessed by the volunteers.

Document I-30

Document Title: John Glenn, Mercury Astronaut, NASA, to Lieutenant Commander Jim Stockdale, USN, 17 December 1959.

Source: Folder 18674, NASA Historical Reference Collection, NASA History Division, NASA Headquarters, Washington, DC.

This letter from astronaut John Glenn to then Lieutenant Commander James B. Stockdale, United States Navy, offers a personal perspective on the early Mercury program and the role of the astronaut in it. Stockdale, a classmate of Glenn's at the Navy's Test Pilot School at Patuxent River, Maryland, would later gain fame as one of the earliest heroes of Vietnam when he was shot down in 1965 and was held as a prisoner of war in the Hoa Lo prison for seven years. Debilitated by torture and maltreatment, Stockdale could hardly walk upon his return to the U.S. in 1973. He received the Medal of Honor in 1976. Stockdale eventually retired from the Navy as a Vice Admiral. In 1992, he was a candidate for Vice President on a ticket headed by Ross Perot.

December 17, 1959

Lt. Commander Jim Stockdale, USN
VF-24
C/O FPO
San Francisco, California

Dear Jim:

Quite a bit of water over the dam or under the bridge since I saw you last. Saw Phil Bolger at the TPT Reunion a couple of months ago and, in talking about various and sundry subjects, your name came up <u>naturally</u>. I don't know if you fall in the category of various or sundry, but anyhow, Phil reminded me again of something I had already known before and that was of your interest in the space program. So I thought I would give you a short run down on what we have been doing.

How are things doing on the USS Boat incidentally? I don't have any idea if you are still deployed or not, but I think from what Phil said that this letter will probably find you still at sea.

This past 8 or 9 months has really been a hectic program to say the least and by far the most interesting thing in which I have ever taken part, outside of combat. It is certainly a fascinating field, Jim, and growing so fast that it is hard to keep up with the major developments, much less everything in the field.

Following our selection in April, we were assigned to the Space Task Group, portion of NASA at Langley Field, and that is where we are based when not traveling. The way it has worked out, we have spent so much time on the road that Langley has amounted to a spot to come back to get clean skivvies and shirts and that's about all. We have had additional sessions at Wright Field in which we did heat chamber, pressure chamber, and centrifuge work and spent a couple of weeks this fall doing additional centrifuge work up at NADC, Johnsville, Pennsylvania. This was some program since we were running it in a lay-down position similar to that which we will use in the capsule later on and we got up to as high as 16 g's. That's a batch in any attitude, lay-down or not.

With the angles we were using, we found that even lying down at 16 g's, it took just about every bit of strength and technique you could muster to retain consciousness. We found there was quite a bit more technique involved in taking this kind of g than we had thought. Our tolerances from beginning to end of runs during the period we worked up there went up considerably as we developed our own technique for taking this high g. A few runs a day like that can really get to you. Some other stuff we did up there involved what we call tumble runs or [2] going from a +g in 2 seconds to a –g and the most we did on this was in going from a +9g to a –9g. Obviously, a delta of 18. This was using pretty much a standard old A/N seat belt, shoulder harness type restraint system that we have used in Beechcraft for many years. When we first talked about doing this, I didn't think it would be possible at all, but in doing a careful build-up, we happily discovered that this was not so horrible. At +9g to –9g, we were bouncing around a bit but it was quite tolerable.

I guess one of the most interesting aspects of the program has been in some of the people we have been fortunate enough to meet and be briefed by. One of the best in this series was the time we spent at Huntsville, Alabama, with Dr. Wernher von Braun and crew. We were fortunate enough to spend an evening with him in his home until about 2:30 in the morning going through a scrap book, etc., from Peenemunde days in Germany and, in general, shooting the bull about his thoughts on the past, present, and future of space activities. This was a real experience for a bunch of country boys fresh caught on the program and a very heady experience as you can imagine.

We have had a good run-down at Cape Canaveral and got to see one of their shots. I guess that is one of the most dramatic things I have ever seen. The whole procedure they go through for a night launch at the Cape is just naturally a dramatic picture far better than anything Hollywood could stage. When the Big Bird finally leaves the pad, it doesn't have to be hammed up to be impressive.

Much of our work, of course, has involved engineering work on the capsule and systems. My particular specialty area has been the cockpit layout and instrumentation presentation for the Astronauts. This has been extremely interesting because we are working on an area way out in left field where our ideas are as good as any one else's. So, you try to take the best of your past experiences and launch from there with any new ideas you can contrive. This is the kind of development work, as you well know, that is by far the most enjoyable.

We just finished an interesting activity out at Edwards Air Force Base doing some weightless flying in the F-100. This was in the two-place F-100 so that we could ride in the rear seat and try various things such as eating and drinking and mechanical procedures while going through the approximately 60-second ballistic parabola that you make with the TF-100. That started at about 40,000 feet, 30 degree dive to 25,000, picking up about 1.3 to 1.4 Mach number, pull out and get headed up hill again at 25,000 and about a 50 to 60 degree climb angle, at which point they get a zero-g parabola over the top to about 60 degrees down hill.

[3]

You can imagine quite a bit in a full minute in those conditions and contrary to this being a problem, I think I have finally found the element in which I belong. We had done a little previous work floating around in the cabin of the C-131 they use at Wright Field. That is even more fun yet, because you are not strapped down and can float around in the capsule doing flips, walk on the ceiling, or just come floating full length of the cabin while going through the approximately 15-seconds of weightlessness that they can maintain on their shorter parabola. That was a real ball and we get some more sessions with this machine some time after the first of the year.

Before this next year is out, we should get the manned Redstone ballistic shots started which will put us to orbital altitude of 105 nautical miles, but not up to the orbital speeds so that we arc back down off the Cape about 200 miles from the pad. We figure now that the first actual manned orbital shots should follow in mid to late 1961.

If you get back this way, Jim, be sure and give me a call. There is no information available yet at all on follow-on programs and what or who might get involved in them. I know you are probably still interested in that who part.

I don't know if this letter is too informative, but if it gets any longer we will have to grade it like a TPT flight report - by the pound.

Give my regards to the family and I hope you get off that unprivate yacht before too long

Sincerely,
[Signed John Glenn]

Document I-31

Document Title: Robert B. Voas, NASA Space Task Group, "Project Mercury Astronaut Training Program," 30 May 1960.

Source: NASA Collection, University of Houston, Clear Lake Library, Clear Lake, Texas.

During the build up to the first U.S. spaceflight, NASA's public affairs staff allowed controlled media access to the Mercury astronauts; numerous photographs abound showing the Mercury Seven engaged in weightless simulations during parabolic flight, centrifuge tests, altitude chamber research, physical fitness training, survival school, pilot proficiency preparation, or a host of other activities. But even so, few understood how these various activities fit together and led to the creation of the astronaut team that flew on Project Mercury. This document helps to explain this process, providing a general outline of the nature of the various activities of the astronauts as they prepared for their missions, and the reasons for undertaking such rigorous activities.

PROJECT MERCURY ASTRONAUT TRAINING PROGRAM

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[1]

SUMMARY

This paper gives a general outline of the NASA Project Mercury Astronaut training program. Basic considerations which entered into the development of the program are listed. Six primary training areas are described, together with the training equipment and facilities which have been employed. Problem areas for future training programs are discussed.

INTRODUCTION

Any training program must be based on three factors: the nature of the job for which training is required, the characteristics of the men to be trained, and the facilities and time available in which to do the training. In Project Mercury the Astronaut's job involves both flight and nonflight tasks. He is expected to contribute to systems design and to the development of operational procedures through his daily contact with the project engineers. It was considered that by virtue of the selection process, the Astronaut had the required skills to make these contributions; therefore, no training was attempted for these nonflight tasks. The Astronaut's in-flight activities can be broken down into six areas: (1) "programming" or monitoring the sequence of vehicle operations during launch, orbit, and reentry; (2) systems management - the monitoring and operation of the onboard systems, such as the environmental control, the electrical systems, the communications systems, and so forth (3) the vehicle attitude control; (4) navigation; (5) communications; and (6) research and evaluation. In addition to these in-flight activities, the Astronaut has a number of ground tasks connected with the flight operations. He has a role in the countdown and preparation of the vehicle; in communications from the ground to the vehicle; and in the recovery program following the flight. It is for these activities associated with the flight itself that a training program was undertaken. More detailed descriptions of the Astronaut's tasks are available in papers by Slayton (ref. 1) and Jones (ref. 2). It should be noted that the Astronaut's job is only one of many associated with space flight for which training is required. Brewer (ref. 3) has outlined the overall training requirements for Project Mercury.
[2]

The Astronaut selection program was designed to select individuals who would require a minimum of training in order to fulfill the Mercury job requirements. Particularly desired were individuals who had sufficient experience in aircraft development operations to make immediate contributions to the Project Mercury program. On this basis, the following criteria were adopted as the minimum requirements for qualification as a Project Mercury Astronaut:

(1) Age - less than 40

(2) Height - Less than 5 ft 11 in.

(3) Excellent physical condition

(4) Bachelor's degree (or equivalent)

(5) Graduate of test-pilot school

(6) 1,500 hours flying Time

(7) Qualified jet pilot

Records of 508 Air Force, Navy, Marine, and Army pilots who had graduated from test-pilot school were reviewed and screened on the basis of these requirements. Of these, 110 met the seven basic requirements. Forty-one of these pilots were eliminated through further screening based on recommendations from instructors at the test-pilot schools. The remaining 69 pilots were interviewed and given an opportunity to volunteer for the Project Mercury program. Of these, 37 pilots either declined or were eliminated as a result of the initial job interviews. The remaining 32 who were considered to be qualified in education and experience were given detailed medical examinations and were exposed to the physical stresses expected in the space flight. The nature of these tests has been described in more detail in references 4 and 5. On the basis of the medical examination and the stress tests, the number of candidates was reduced to 18, from which were selected the seven who demonstrated the most outstanding professional background and knowledge in relationship to the job requirements. Through this procedure, a group of experienced test pilots with extensive training in engineering, excellent health, and a high motivation in the Mercury Project were selected for the training program. The availability of such individuals makes it possible to utilize to a great extent self-instruction and to minimize the amount of formal group training required.

At the outset, few, if any, facilities were available to support the training program. Both training devices and training manuals have become available in stages throughout the first 12 to 15 months of the training program. The more elaborate and complete training devices were [3] not placed in operation until over a year after its initiation. As a result, the early part of the training program depended upon review of design drawings in vehicle components and on travel to various Mercury production facilities to attend design briefings. Great dependence was put upon verbal presentations by scientists of the NASA Space Task Group and of the prime contractor. In addition, early in the program, extensive use was made of established Armed Forces aeromedical facilities for familiarizing the Astronauts with the conditions of space flight. Thus, the training methods and the order in which topics were presented were, to a great extent, dictated by the resources available at the time the program was initiated.

Since mature, intelligent trainees were selected and since little if any training equipment was available initially, it might have been argued that the Astronauts should be allowed to work completely on their own without any attempt to a group program. There are, however, a number of desirable factors to be gained by such a program. A planned group program facilitates the scheduling of activities with other organizations. In addition, a structured program permits more efficient use of instructor and student time. It also makes possible progress from one aspect of the operation to the next in an appropriate sequence. Sequence in training activities is important, since learning is simplified if material is presented in a logical order. An organized program also insures completeness in that no major training requirement is overlooked. Finally, since this project represents a first effort of its kind, the use of a group program facilitates the collecting of records and the evaluation both of the Astronaut's progress and of the various training activities.

The program which has resulted from these considerations has allotted about one-half of the time to group activities and the other half to individually planned activities in each Astronaut's area of specialization. A review of the Astronauts' travel records provides an example of the relative division of their time between group training and other duties associated with the development of the Mercury vehicle. During the 6-month period from July 1 to December 31, 1959, the Astronauts were on travel status almost 2 months or 1 out of every 3 days. Half of this travel time (28 days) was spent on four group-training activities: a centrifuge program; a trip to Air Force Flight Test Center, Air Force Ballistic Missile Division, and Convair; a weightless flying program; and trips to fly high-performance aircraft during a period when the local field was closed. The other half of their travel time (27 days) was devoted to individual trips to attend project coordination meetings at McDonnell and the Atlantic Missile Range, or for pressure-suit fittings, couch moldings, and viewing of qualification tests at McDonnell, B. F. Goodrich Co., and their subcontractors' plants. These individual activities, while providing important trailing benefits, are primarily dictated by the Project Mercury development program requirements and are not considered part of the group training program.
[4]

The extent to which the Mercury crew space area is "customized" to the seven Astronauts and the time required to fit the man to the vehicle should be noted. Each man has had to travel to B. F. Goodrich for a pressure-suit fitting and to a subcontractor for helmet fittings; then to the Air Crew Equipment Laboratory for tests to the suit under heat and lowered pressure; then to McDonnell for couch molding. Usually, he has been required to return to the suit manufacturer for a second fitting and to McDonnell for final fittings of the couch and studies of his ability to reach the required instruments and controls in the capsule. While the Mercury vehicle is more limited in size than future spacecraft, the cost of space flight and the limited personnel involved will probably always dictate a certain amount of customizing of the crew space. The time required for this hype of activity should not be underestimated.

TRAINING PROGRAM

The Astronaut training program can be divided into six major topic areas. The primary requirement, of course, is to train the Astronaut to operate the vehicle. In addition, it is desirable that he have a good background knowledge of such scientific areas related to space flight as propulsion, trajectories, astronomy, and astrophysics. He must be exposed to and familiarized with the conditions of space flight such as acceleration, weightlessness, heat, vibration, noise, and disorientation. He must prepare himself physically for those stresses which he will encounter in space flight. Training is also required for his duties at ground stations before and after his own flight and during the flight of other members of the Astronaut team. An aspect of the training which might be overlooked is the maintenance of the flying skill which was an important factor in his original selection for the Mercury program.

Training in vehicle operation. – Seven training procedures or facilitates were used in developing skills in the operation of the Mercury capsule. These included lectures on the Mercury systems and operations; field trips to organizations engaged in the Mercury Projects; training manuals; specialty study programs by the individual Astronaut; mockup inspections; and training devices. To provide the Astronaut with a basic understanding of the Mercury system, its components, and its functions, a lecture program was set. up. A short trip was made to McDonnell at which time a series of lectures on the capsule systems was presented. These systems lectures were then augmented by lectures on operations areas by Space Task Group scientists. This initial series of lectures provided a basis for later self-study, in which use was made of written descriptive material as it became available. Individual lectures have been repeated as the developments within project Mercury have required a series of lectures on capsule systems by both Space Task Group and McDonnell personnel have been scheduled to coincide with the delivery [5] and initial operation of the fixed-base Mercury trainer. In these lectures, the same areas are reviewed in an attempt to bring the Astronauts up-to-date on each of the systems as they begin their primary procedures training program.

In addition to this lecture program, indoctrination trips have been made to the major facilities concerned with the Project Mercury operations. Two days were spent at each of the following facilities: McDonnell, Cape Canaveral, Marshall Space Flight Center, Edwards Flight Test Center, and Space Technology Laboratories and Air Force Ballistic Missile Division. One day was spent at Rocketdyne Division, North American Aviation, and five days were spent at Convair/Astronautics. At each site there was a tour of the general facilities together with a viewing of Mercury capsule or booster hardware and lectures by top-level personnel covering their aspect of the Mercury operation. The Astronauts also had an opportunity to hear of related research vehicles such as the X-15 and Discoverer and received a brief discussion of the technical problems arising in these programs and their significance to Project Mercury.

Obtaining current and comprehensive study materials on a rapidly developing program such as Project Mercury is a major problem. McDonnell has been providing manuals covering Project Mercury systems. The first of these was the Indoctrination Manual and was delivered at the time of an early Astronaut visit in May 1959. No attempt was made to keep this manual current and a first edition of a full systems manual (Familiarization Manual) was issued in September 1959. It quickly became out of date, however, and a new manual, a second edition of the Familiarization Manual was issued in December of the same year. A first copy of the Capsule Operations Manual (Astronauts' Handbook) was delivered in June of 1960. During initial phases of the program, the Astronauts have had to depend primarily on capsule specifications and specification control drawings for written information on capsule systems. Copies of these, however, were not always available and they were too large to compile into a single manual.

Valuable aids to the Astronauts in keeping abreast of the status of the development program are the regularly issued reports of the Capsule Coordination Group Meetings. At these meetings, the status of each of the capsule systems is reported and any changes are discussed. Miscellaneous reports on boosters and on programs conducted by cooperating agencies have also been provided to the Astronauts. Maintaining an up-to-date flow of accurate information on vehicle development status is a critical problem not only for the Mercury training program, but in all probability, for most near-future space flight applications since training must proceed during the vehicle development phase.

Another method employed to aid in the dissemination of information to the Astronauts was to assign each a specialty area. These assignments [6] were as follows: M. Scott Carpenter, navigation and navigational aids; Leroy G. Cooper, Redstone booster; John A. Glenn, crew space layout; Virgil I. Grissom, automatic and manual attitude control system; Walter M. Schirra, life support system; Alan B. Shepard, range, tracking, and recovery operations; and Donald K. Slayton, Atlas booster. In pursuing these specialty areas, each man attends meetings and study groups at which current information on capsule systems is presented. Regular periods are set aside for all the men to meet and report to the group. Another important source of information about the vehicle, particularly in the absence of any elaborate fixed-base trainers, bas been the manufacturer's mockup. Each of the men has had an opportunity to familiarize himself with the mockup during visits to McDonnell.

Following the initial familiarization with the Mercury system, the primary training in vehicle operation is being achieved through special training devices developed for the Mercury program. Early training in attitude control was accomplished on the Langley Electronics Associates Computer (fig. 1) [not included] which was combined with a simulated Mercury attitude display and hand controller. This device was available during the simmer of 1959. Later, another analog computer was cannibalized from an F-100F simulator and combined with actual Mercury hardware to provide more realistic displays and controls. This MB-3 trainer (fig. 2) [not included] also included provision for the Mercury couch and the pressure suit.

In addition to these two fixed-base simulators, three dynamic simulators were used to develop skill in Mercury attitude control. The first, of these, the ALFA (Air Lubricated Free Attitude) Simulator (fig. 3) [not included] permits the practice of orbit and retrofire attitude control problems by using external reference through simulated periscope and window displays. A simulated ground track is projected on a large screen which is viewed through a reducing .lens to provide the periscope display. This simulator also permits training in the use of earth reference for navigation. The Johnsville Centrifuge (fig. 4) [not included] was used as a dynamic trainer for the reentry rate damping task because it adds the acceleration cues to the instruments available in the fixed-base trainers. It also provides some opportunity to practice sequence monitoring and emergency procedures during launch and reentry. Another dynamic simulation device used to provide training in recovery from tumbling was the three-gimbaled MASTIF (Multi-Axis Spin Test Inertia Facility) device at the NASA Lewis Laboratory (fig. 5) [not included]. In this device, tumbling rates up to 30 rpm in all three axes were simulated and the Astronaut was given experience with damping these rates and bringing the vehicle to a stationary position by using the Mercury rate indicators and the Mercury-type hand controller.

Two more elaborate trainers became available in the summer of 1960. These trainers provide practice in sequence monitoring and systems management. The McDonnell Procedures Trainer (fig. 6) [not included] is similar to the fixed-base trainers which have become standard in aviation operations. The [7] computer used on the MB-3 has been integrated with this device to provide simulation of the attitude control problem. External reference through the periscope is simulated by using a cathode ray tube with a circle to represent the earth. Provision has been made for pressurizing the suit and for some simulation of heat and noise effects. The environmental control simulator (fig. 7) [not included] consists of the actual flight environmental control hardware in the capsule mockup. The whole unit can be placed in a decompression chamber in order to simulate the flight pressure levels. This device provides realistic simulation of the environmental-control system functions and failures. Effective use of these two simulators is predicted upon adequate knowledge of the types of vehicle systems malfunctions which can occur. A failure-mode analysis carried out by the manufacturer has provided a basis for determining the types of malfunction which are possible and the requirements for simulating them (ref. 2). A record system on which possible malfunctions are listed on cards, together with methods of their simulation, has been set up. On the back of these cards there is space for noting when and under what conditions this failure has been simulated and what action the Astronaut took to correct it. In this way, it is hoped that the experience in the detection and correction of systems malfunctions can be documented.

Training in space sciences. – In addition to being able to operate the Mercury vehicle, the Astronaut will be required to have a good general knowledge of astronomy, astrophysics, meteorology, geophysics, rocket engines, trajectories, and so forth. This basic scientific knowledge will enable him to act as a more acute observer of the new phenomena with which he will come in contact during the flight. It will also provide a basis for better understanding of the detailed information which he must acquire on the Mercury vehicle itself. In order to provide this broad background in sciences related to astronautics, the Training Section of the Langley Research Center set up a lecture program which included the following topics: Elementary Mechanics and Aerodynamics (10 hours); Principles of Guidance and Control (4 hours); Navigation in Space (6 hours);

Elements of Communication (2 hours); Space Physics (12 hours). In addition, Dr. W. K. Douglas, Flight Surgeon on the Space Task Group staff, gave 8 hours of lectures on physiology.

Following this initial lecture program, training in specific observational techniques is planned. The first activity of this program was training in the recognition of the primary constellations of the zodiac at the Morehead Planetarium in Chapel Hill, North Carolina. A Link trainer body was modified with a window and headrest to simulate the capsule external viewing conditions. Using this device, the Astronauts were able to practice the recognition of constellations which the Planetarium was programmed to simulate orbital flight. Future plans call for further training in star recognition together with methods of observing solar and meteorological events, earth and lunar terrain, and psychological and physiological reactions. These activities will be in support of [8] a primary objective of the Project Mercury program which is to determine man's capability in a space environment. The training program contributes to this objective in three ways:

(1) First, by establishing base lines, both for the Astronaut's performance and his physiological reactions. These base lines can then be compared with psychological and physiological. factors in the space environment.

(2) Second, through the program in basic sciences described above, the Astronaut is given sufficient background with which to appreciate the importance of the observations which he can make in the space environment.

(3) Specific training in observational techniques and the use of scientific equipment arms him with the skills with which to collect data of value to science.

Thus, the training program attempts to lay the ground work for the scientific activities of the Astronauts, as well as to provide the specific skills which are required to fly the Mercury vehicle.

Familiarization with conditions of space flight. – An essential requirement of the training program is to familiarize the Astronaut with the novel conditions which man will encounter in space flight. An important part of the Astronaut training program has been to provide the trainees with an opportunity to experience eight types of conditions associated with Mercury flights: high acceleration, weightlessness, reduced atmospheric pressures, heat, disorientation, tumbling, high concentration of CO_2, and noise and vibration.

The Astronauts experienced acceleration patterns similar to those associated with the launch and reentry of the Mercury first at the Wright Air Development Division (WADD) in Dayton, Ohio, and later at the Aviation Medical Acceleration Laboratory at Johnsville, Pennsylvania. During this training, they were able to develop straining techniques which reduced the problem of blackout and chest pain. It was generally the opinion of the Astronauts that the centrifuge activity was one of the most valuable parts of the training program.

The Astronauts were given an opportunity to experience weightless flying both in a free-floating condition in C-131 and C-135 aircraft and strapped down to the rear cockpit of a F-100 F fighter. While the latter is more similar to the Mercury operation, the Astronauts, being experienced pilots, felt that there was little or no difference between this experience and their normal flying activities. The free-floating state, however, they felt was a novel and enjoyable experience. Since the longer [9] period of weightlessness available in the F-100E aircraft is valuable for collecting medical data, while the C-131 aircraft appears to give the most interesting experiential training, both types of operations appear to be desirable in a training program. The fact that the pilots experienced no unusual sensations during weightlessness when fully restrained was an encouraging finding for the Mercury operation and supports the desirability of selecting flying personnel for this type of operation.

The Astronauts experienced reduced atmospheric pressure while wearing full pressure suits first at WADD and later at Air Crew Equipment Laboratory (ACEL); in addition to reduced pressure, they also experienced thermal conditions similar to those expected during the Mercury reentry while wearing a full pressure suit. At the Naval Medical Research Institute (NMRI), they were given an opportunity to become familiar with the body's thermal response and the effect of moderate heat loads on the body's regulatory mechanisms was demonstrated. At the end of March 1960, the Astronauts experienced disorientation in the U.S. Naval School of Aviation Medicine Slowly Revolving Room. As already mentioned, they have also experienced angular rotation up to 50 rpm in all three axes on a gimbaled device with three degrees of freedom at the NASA Lewis Laboratory.

In order to indicate the effects of the high concentration of CO_2 which might result, from a failure of the environmental. control system, the Astronauts were given a 3 hour indoctrination period in a sealed chamber at NMRI In this chamber, they experienced a slow buildup of CO_2 similar to that which they would encounter in the event of failure of the environmental system. None of the men showed any adverse effects of symptoms from this training; As part of the selection program, the Astronauts experienced high noise and vibration levels at WADD. During the second Johnsville centrifuge program, noise recorded of the Mercury test flight was played back into the gondola. Further opportunities to adapt to the high noise levels associated with the Mercury launch will be provided by a sound system connected to the McDonnell Procedures Trainer at Langley Field.

Physical fitness Program. – To insure that the Astronaut's performance does not deteriorate significantly under the various types of stresses discussed in the previous section, it is important that he be in excellent physical condition. Since most of the trainees entered the Project Mercury program in good physical health, a group physical fitness program, with one exception, has not been instituted. SCUBA training was undertaken because it appeared to have a number of potential benefits for the Project Mercury, in addition to providing physical conditioning. It provides training in breathing control and analysis of breathing habits, and in swimming skill (desirable in view of the water landing planned in the Mercury program). Finally, there is, in the buoyancy of water, a partial simulation of weightlessness, particularly if vision is [10] reduced. Aside from this one organized activity, each individual has been undertaking a voluntary fitness program tailored to his own needs. This program has included, for most of the Astronauts, three basic items. First of all, as of December 1959, they have reduced or completely stopped smoking. This was an individual, voluntary decision and was not a result of pressure by medical personnel, but a result of their own assessment of the effect of smoking on their tolerance to the stresses to be encountered in the flight, particularly acceleration. Some of the members of the team who have a tendency to be overweight have initiated weight-control programs through proper diet. Nearly all members make it a habit to get some form of daily exercise.

Training in ground activities. – Frequently overlooked are the extent. and the importance of the ground activities of the Astronauts. Their knowledge of the vehicle and its operation makes them specially qualified for certain ground operations. The training in ground procedures has fallen into the three main areas; countdown procedures, ground flight monitoring procedures, and recovery and survival. The Astronauts are participating in the development of the countdown procedures and will be training themselves in their own part of the countdown through observation of countdown procedures for the initial unmanned shots, and finally, by participating in the preparation procedures for the actual manned flights.

An important aspect of the Astronaut's activities when not actually flying the vehicle will be to aid in ground communications with the Mercury capsule. Since he is fully familiar with the capsule operation and intimately acquainted with the Astronaut who will be in the capsule, he makes a particularly effective ground communicator. Procedures for ground monitoring and communicating personnel are presently being developed with the aid of the Astronauts. At Langley Field, a ground monitoring station simulator will be tied in with the McDonnell procedures simulator. By using this device, ground station activities can be practiced and coordinated with capsule simulator training. They will also participate in training exercises at the Mercury Control Center at Cape Canaveral. Finally, just prior to manned flights, Astronauts not involved in launch activities will be deployed to remote communications stations, at which time they will have an opportunity for some on-site training.

A final area of ground training is in recovery and survival procedures. Study materials such as maps and terrain descriptions of the areas under the Mercury orbits are being obtained. They will be augmented by survival lectures and by field training in survival at sea and in desert areas. Finally, extensive training on egress from the capsule into the water has been given. This activity was accomplished in two stages, using the Mercury egress trainer (fig. 8) [not included]. Phase I made use of a wave-motion simulation tank at Langley Field for initial training followed by a Phase II program in open water in the Gulf of Mexico.

[11] Maintenance of flight skills. – One of the continuing problems in training for space flight is the limited opportunity for actual flight practice and proficiency training. The total flight time in the Mercury capsule will be no more than 4 to 5 hours over a period of 3 years for each Astronaut. The question arises as to whether a1l the skills required in operating the Mercury vehicle can be maintained purely through ground simulation. One problem with ground simulation relates to its primary benefit. Flying a ground simulator never results in injury to the occupant or damage to the equipment. The penalty for failure is merely the requirement to repeat the exercise. In actual flight operations, failures are penalized far more severely. A major portion of the Astronaut's tasks involves

high-level decision making. It seems questionable whether skill in making such decisions can be maintained under radically altered motivational conditions. Under the assumption that vigilant decision making is best maintained by experience in flight operations, the Mercury Astronauts have been provided with the opportunity to fly high-performance aircraft. The program in this area is a result of their own interest and initiative and is made possible by the loan and maintenance of two F-102 aircraft by the Air Force.

IMPLICATIONS FOR FUTURE PROGRAMS

In conclusion, the problems with implications for future space flight projects which have been encountered in development of the Mercury program can be reviewed. In developing skills in operation of the vehicle, the difficulty of providing up-to-date information on the systems when the training must progress concurrently with the development program has been discussed. Concurrent training and development should tend to be a feature of future space flight programs, since many of these will be experimental in nature, rather than operational.

All spacecraft have in common the problem of systems which must be kept functional for long periods without recourse to ground support. Even in the event of emergency termination of the mission with immediate return to earth, prolonged delay may occur before safe conditions within the atmosphere have been achieved. Thus, emphasis on “systems management” will increase in future space operations. Recognition of malfunctions has always been a part of the pilot’s task; usually, however, little in-flight maintenance is attempted. Since aborts are dangerous and, in any event, involve greater delay before return, the Astronaut must do more detailed diagnoses of malfunctions and more in-flight maintenance. This will require extensive knowledge of the vehicle systems and training in malfunction isolation and correction. In order to provide this training as many as possible of the numerous malfunctions which can occur in even a relatively simple space vehicle must be identified and simulated. Considerable effort has been devoted to this area in the Mercury training and [12] development program and it should become an increasingly important feature of future programs.

The physical conditions (heat, acceleration, and so forth) associated with space flight are simulated to permit the trainees to adapt to these stressors in order that during the actual flight such stimuli may be less disturbing. Present measures of the adaptation process are inadequate to provide criteria for training progress. A second purpose for the familiarization program was to give the trainees an opportunity to learn the specific skills required to minimize the effects of these factors on their performance. However, in many cases, the skills required have not been fully identified or validated. For example, in developing straining techniques for meeting increased acceleration, the efficacy of a straining technique has not been fully demonstrated nor has the technique itself been adequately described. As yet, inadequate data are available on the effects of combining physical stress factors. Therefore, it is difficult to determine the extent to which the increased cost and difficulty of providing multiple stress simulation is warranted. In the present program, it has been possible to simulate both reduced atmospheric pressure and acceleration on the centrifuge. Initial experience seems to indicate that this is desirable but not critical. However, further data on the interacting effects of these stresses are required before any final conclusions can be developed.

A factor in space flight not yet adequately simulated for training purposes is weightlessness. Short periods of weightlessness have been used in the present program, as described previously. True weightlessness can be achieved through too short a period to be fully adequate for training purposes. On the other hand, ground simulation methods using water seem to be too cumbersome and unrealistic to be fully acceptable substitutes. At the present time, this lack of adequate simulation does not seem to be critical since the effects of weightlessness on performance appear to be minor and transitory. Should early space flights uncover more significant problems, greater efforts will be justified in developing weightless simulation methods.

Finally, it seems important to reiterate the requirements for reproducing adequate motivational conditions in the training program. The basic task of the Astronaut is to make critical decisions under adverse conditions. The results of the decisions he makes involve not just minor discomforts or annoyances, but major loss of equipment and even survival. Performance of this task-requires a vigilance and decision-making capability difficult to achieve under the artificial conditions of ground simulation. It appears probable that-training in ground devices should be augmented with flight operations to provide realistic operational conditions.

[13]

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Document I-32

Document Title: Abe Silverstein, Director of Space Flight Programs, NASA, Memorandum for Administrator, NASA, "Astronaut Selection Procedure for Initial Mercury-Redstone Flights," 14 December 1960.

Source: Folder 18674, NASA Historical Reference Collection, NASA History Division, NASA Headquarters, Washington, DC.

For all of NASA's human spaceflight initiatives, the method of crew selection for individual missions has been one of its most contentious and misunderstood. The process outlined in this memorandum for choosing the first astronauts to fly in Project Mercury is instructive of the process. It called for each of the Mercury Seven to identify three top candidates other than themselves, and then for a board to recommend a selection of the top three, with actual selection made by the Project Mercury director. These three astronauts would then be trained for the mission, without any of them knowing who would actually be the prime. Only a few days before the launch the astronaut to fly the mission would be named and an order for future mission assignments would follow from that decision. Designed to give all a voice in the selection, this approach also sought to avoid a leak to the media of the astronaut selected.

[CONFIDENTIAL] [DECLASSIFIED]

In reply refer to:
DA-1 (WJN:rfr)
Dec 14 1960

MEMORANDUM for Administrator

Subject: Astronaut Selection Procedure for Initial Mercury-Redstone Flights

1. The purpose of this memorandum is to document the procedure for Mercury-Redstone Astronaut Selection as discussed in your office December 12.

2. The first possible manned Redstone mission is MR-3; however, manned occupancy of MR-3 is, of course, contingent upon successful accomplishment of MR-1 and MR-2. Since capsule 7, for MR-3, arrived at the Cape December 8, the pilot should be chosen in the near future so that he can become fully familiar with the capsule systems and operational procedures. Capsule 7 is the only manned configuration with a mechanical-latching side hatch, interim clock timer, small windows, and control system which does not include the rate stabilization mode.

3. Since it is impractical to train all 7 Astronauts on the proper Procedures Trainer configuration, three men will be chosen as possible pilots and all three will begin working with the capsule 7 configuration. It is hoped

that the identity of the three men can be kept secure from the press. The first pilot and his alternate will not be selected until approximately one week before the launch date of the first manned Redstone. The identity of the two-man flight crew for this flight would thus not be available for announcement to either the Astronauts or the press until approximately a week before the flight. The assignments for the first two manned Redstone flights might be as follows:

	Astronauts
First manned Redstone	1,3
Second manned Redstone	2,3

[2]

4. An astronaut Flight Readiness Board consisting of five men will be established with Robert Gilruth serving as chairman. Individuals on this board will evaluate the following pertinent areas of Astronaut performance.

   A. Medical
      a. General health
      b. Reaction to physical stress
      c. Weight control

   B. Technical
      a. Proficiency on capsule attitude control simulators
      b. Knowledge of capsule systems
      c. Knowledge of mission procedures
      d. Ability to contribute to vehicle design and flight procedures
      e. General aircraft flight experience
      f. Engineering and scientific background
      g. Ability to observe and report flight results

   C. Psychological
      a. Maturity
      b. Motivation
      c. Ability to work with others
      d. Ability to represent Project Mercury to public
      e. Performance under stress

Expert witnesses in the various areas will be called before the Board. Based on evaluations by the Board, the actual selection of the three men and of the final two-man flight crew will be made by the Director of Project Mercury.

5. The Astronauts themselves will be asked to submit to the Board chairman their recommendations for the three best-qualified pilots, excluding themselves. This input will be known by the chairman only and will be used as an additional factor in the selection.

6. The Flight Readiness Board will meet either during the week of December 26 or January 2.

[Signed]
Able Silverstein
Director of Space Flight Programs

Enclosure:
Astronaut instruction sheet

Cc: AD/Dryden
AA/Seamans
STG (Gilruth)

[3]

ASTRONAUT INSTRUCTION SHEET

You are asked to submit a list of three Astronauts, excluding yourself, who in your judgment are best qualified for the first two manned Redstone flights. We assume you would rate yourself in the group, therefore please omit your name from the list.

#1. ________________________________.

#2. ________________________________.

#3. ________________________________.

Comments, if any:

Signed ________________.

Document I-33

Document Title: Jerome B. Wiesner, The White House, Memorandum for Dr. [McGeorge] Bundy, "Some Aspects of Project Mercury," 9 March 1961.

Source: Folder 18674, NASA Historical Reference Collection, NASA History Division, NASA Headquarters, Washington DC.

When President Eisenhower chose to use military test pilots as astronauts in 1958 to1959, it set in motion several discussions in various sectors about the signal it would send to the world of the U.S.'s peaceful intentions in space. The inauguration of John F. Kennedy as president in January 1961 brought to the nation's highest political office a different political party and a different philosophy on such matters. This memorandum sent by Presidential *science advisor Jerome Wiesner to National Security Advisor McGeorge Bundy, suggests that JFK revise that earlier decision and allow civilians to become astronauts. This plea became policy in 1962, when NASA chose its second groups of astronauts and for the first time civilians were selected for the position. The memorandum also discusses the then-controversial question of live television coverage on the initial Mercury suborbital launch.*

THE WHITE HOUSE

WASHINGTON
March 9, 1961

MEMORANDUM FOR DR. BUNDY

SUBJECT: Some Aspects of Project Mercury

We have an ad hoc panel which is making a technical review of the National Aeronautics and Space Administration project to put a man in an earth orbit, Project Mercury. The time is now nearing when man will be first introduced into the system in a sub-orbital launch using a modified Redstone booster. Although the interest of the panel is primarily in the technical details, two phases of the operation which fall mostly outside the technical area have caused them considerable questioning, and I would like to take this opportunity to bring them to your attention.

1. Many persons involved in the project have expressed anxiety over the mounting pressures of the press and TV for on-the-spot coverage of the first manned launch. Our panel is very concerned that every precaution should be taken to prevent this operation from becoming a Hollywood production, because it can jeopardize the success of the entire mission. The people in the blockhouse and in the control center are not professional actors, but are technically trained people involved in a very complex and highly coordinated operation. The effect of TV cameras staring down their throats during this period of extreme tension, whether taped or live, could have a catastrophic effect. Similarly, following a manned launch and recovery, the astronaut must be held in a confined area for a considerable time period so that the doctors can accomplish the debriefing which will produce the basic information on possible effects of space flight on man. The pressures from the press during this time period will probably be staggering, but should be met with firmness. The experience with the RB-47 pilots has proven that this can be accomplished. [2]

Our panel does not profess to be expert in the field of public relations, but the overriding need for the safety of the astronaut and the importance to our nation of a successful mission make them feel that the technical operation should have first consideration in this program. The sub-orbital launch will, in fact, be man's first venture into space. It is enough different from the X15 program to require special consideration. It is my personal opinion that in the imagination of many, it will be viewed in the same category as Columbus' discovery of the new world. Thus, it is an extremely important venture and should be exploited properly by the Administration.

2. Some members of the panel (and other individuals who have contacted me privately) believe that the decision by the previous Administration, that the astronauts should be military personnel, was wrong. They point out that NASA was created expressly for the purpose of conducting peaceful space missions, and the orbiting of a military astronaut will be identified by the world in general as a military gesture, and is sure to be seized upon by the U.S.S.R. for propaganda purposes.

My personal feeling is that any change in status (such as asking the astronauts to become civilians) at this late date will be recognized for what it is, an artificial maneuver. Nevertheless, it might be desirable for this Administration to review the past decision and perhaps lay plans by which astronauts selected for later manned space programs could be given the option to become civilians. It would seem to me that the following might be the appropriate group to discuss the situation: The President, The Vice President, Dr. Bundy, Mr. Webb and Dr. Dryden, Mr. Murrow, and Secretary Rusk.

/S/
Jerome B. Wiesner

Document I-34

Document Title: "Report of the Ad Hoc Mercury Panel," 12 April 1961.

Source: Folder 18674, NASA Historical Reference Collection, History Division, NASA Headquarters, Washington, DC.

A special President's Science Advisory Committee (PSAC) panel, under the chairmanship of Donald F. Hornig, was formed in February 1961 and charged with reviewing Project Mercury. By April 1961, the Space Task Group had concluded that Mercury was near the end of its development phase and that the first human flight could be planned. Several test flights of Mercury capsules on both Redstone and Atlas boosters were in the process being readied. On 10 April, foreign correspondents in Moscow reported rumors that the Soviet Union had already placed a man in space. At the same time, the Space Task Group heard rumors that the Hornig panel was recommending up to 50 more chimpanzee flights before launching a man into space. This recommendation ultimately did not find its way into the final report of the Ad Hoc Mercury Panel, although the panel did express concern about the limited information available about the likely impact of spaceflight on a human. But the same day that the panel submitted its report, the Soviet news agency Tass reported that Yuri Gagarin had been launched into orbit and successfully returned to Earth. Apparently, that answered the question of whether a human could fly in space and return to Earth in good health.

OFFICIAL USE ONLY

April 12, 1961

REPORT OF AD HOC MERCURY PANEL

I. Introduction

Project Mercury has reached a stage where manned suborbital flight is being planned within months and manned orbital flight within a year. Manned flight will involve great personal risk to the pilot and political risk to the country. The object of the panel, therefore, was to become as well acquainted with Project Mercury as possible with a view toward giving advice on the future conduct of the project.

In order to gain some understanding of the project, the panel spent an intensive five days visiting McDonnell Aircraft (where the capsule is being built), Cape Canaveral, and Langley Field. We were brief [*sic*] by McDonnell, the Space Task Group, representatives of Marshall Space Flight Center (Redstone), BMD (Atlas), and had two general discussions with NASA personnel. Subsequently, a sub-group of the panel with biomedical competence met with representatives of CIA, Air Force, and the Army, and spent two more days at Langley and a day in Washington.

We would like to express our gratitude for the excellent cooperation we received from everyone. Information was made available to us freely, and the discussions were frank and to the point. We were impressed by the magnitude of what has been accomplished and the competence which has been exhibited in organizing and executing the program. We naturally tend to focus on the areas about which we are not happy, particularly those which we feel might imperil the success of the mission, but it must be realized that these are a small number of items out of an enormous enterprise.

II. Purpose of Mercury Program

The objective of Project Mercury is to advance the state of the art of manned space flight technology. In order to achieve this objective, the following goals have been adopted:

1. Place a manned space capsule in orbital flight around the earth;
2. Investigate man's performance capabilities and ability to survive in true space environment; and [2]
3. Recover the capsule and the man safely.

Mercury is an initial step in manned space flight and rests on an article of faith – that man wants to venture into space and that he will be an essential part of future space missions. In this sense, it may be likened to the Wright Brother's [*sic*] first flight or Lindbergh's crossing the Atlantic. In a real sense, it is a national exploratory program. Its justification lies not in the immediate ends achieved but in the step it provides toward the future.

III. The Mercury Program

The Mercury Program is a large one and has several major sub-divisions, each involving great effort and the solution of complex problems. These include:

1. The development of an aerodynamically stable reentry vehicle, parachutes, reliable telemetry, control systems, life support system, escape mechanism, etc.

2. The adaptation of a booster to the capsule and escape systems.

3. The establishment of a world-wide net of tracking stations for voice, telemetry, and command communications with the capsule, and for communication with a control center which is in contact with computers to help digest the information received.

4. The selection and training of pilots (Astronauts) to fly the capsule and to back up the automatic devices.

5. The development of suitable test procedures to achieve the necessary reliability of all of the preceding.

6. The development of recovery methods and the organization of recovery and rescue operations over a large part of the globe.

The primary responsibility for the project rests with the Space Task Group of NASA under the direction of R. R. Gilruth, Director, C. J. Donlan, Associate Director for Research and Development, and W. C. Williams, Associate Director of Operations. It is being assisted by the Department of Defense in testing, tracking, recovery, transportations, medical and other supporting activities. All indications are that the various agencies are well [3] integrated into a working relationship to give the project the necessary support. It is essential, however, with such a complex organization that along with the responsibility, the NASA Space Task Group must have full authority over the entire operation at all times.

The program is behind its original schedule but each of its component parts has come along sufficiently well so that we did not ascertain particular bottlenecks which will eventually dominate the schedule. General comments are:

1. Complete capsules are just now being delivered from McDonnell. One of them (No. 5) was flown on Redstone (MR-2) with the chimpanzee. Two environmental test chambers, simulating high altitudes, have been put into operation and extended tests on the capsules are just beginning. There are still a number of problems to be worked out. For example, the impact bag which absorbs the landing shock and stabilizes the capsule in the water needs further development. There has been a limited amount of testing of the escape system in flight tests. The complete capsule was tested under maximum heating and acceleration on the MA-2 shot (2/21/61). (MA – Mercury Atlas).

Although failure of the Atlas-to-capsule interface occurred on MA-1 (7/29/60), stiffening the Atlas with a "belly-band" resulted in a completely successful test on MA-2 (2/21/61). Future shots will use an Atlas with a thicker upper skin.

2. The equipment installation at all of the major tracking stations is nearing completion. Stations ready to go include the control center at Canaveral, the computers at Goddard, the communications center at Goddard, the subsidiary center at Bermuda, the Atlantic ship, and Canary Islands. The mainland-Bermuda complex was tested on MR-2 (MR – Mercury Redstone) and MA-2 and the net as far as the Canary Islands will be tested on MA-3. Installation is continuing at other stations and checkouts are being made with the aid of aircraft-borne instrumentation, but the world-wide net will not be ready for full operation until about 5/1/61.

3. Pilots have been selected. They have been subjected to a training program including performance at high g and under weightless conditions. They have practiced the manual controls in simulators and have flown simulated missions with surprise emergencies occurring. They have practiced leaving the capsule in the water and under water. [4]

4. Recovery operations have been rehearsed and organization of the world-wide recovery and rescue system is proceeding.

The program is approaching the state where manned suborbital flight is contemplated in the near future. The question of our readiness will be discussed at length later in the report since there are still serious problems. Manned orbital flight is probably about a year away but a number of problems must still be solved before such a launch.

IV. Assessment of Risk and Probability of Success

1. The Reliability Problem

In the assessment of probable system performance, there are two distinct analyses to be made:

(a) Probability of mission success;

(b) Probability of astronaut survival.

Both of these depend on subsystem and component reliabilities, but in very different ways; e.g., a booster failure means mission failure but by no means implies an astronaut fatality or injury.

Thus an estimate of either of these probabilities must begin with the failure probabilities of the individual subsystems. Two remarks of somewhat opposing tendency are important here. The first is that subsystem failure probabilities are not really independent numbers. There are always interactions, or correlations, among subsystems and components such that the failure of subsystem "A" will make the failure of subsystem "B" more probable than before. In large missile systems, it is not feasible to assess these interactions numerically with any degree of confidence without a large number of launchings. However, it is well to remember they are there. The second remark is that except for the booster the system, its several subsystems and even the components themselves are provided with a generous degree of redundancy, both at the hardware level and in the provision of alternative modes of procedure. Thus, there is both an automatic control system and an essentially independent manual control system; there are regular and emergency oxygen supplies, two modes of egress, and the like. Such redundancy is a standard and effective way of creating over-all reliability with the use of individually less than perfect components. It is necessary to keep this consideration in mind when examining reliabilities of individual components. [5]

2. Subsystem reliabilities

The subsystems are common to both the orbital and ballistic missions, and hence at this point it is not necessary to make a distinction between the Redstone and Atlas missions. When the ultimate probabilities of mission success and astronaut survival are considered, the distinction is, of course, a very important one.

There is a considerable body of test data on components and subsystems to which the panel has had access. Also, both NASA and McDonnell perform continuing reliability analyses of the over-all system on the basis of these data. For present purposes, it seems undesirable to present such detailed analyses, even in summary form. What follows, then, represents a distillation into very general terms of the Panel's considered reaction to these data. Reliabilities are aggregated into three categories:

Class	Reliability Range
Class 1	95 – 100%
Class 2	85 – 95%
Class 3	70 – 85%

The following chart indicates the major subsystems and lists our judgment of the reliability of each. It should be emphasized that the numerical categorization in the chart is the result not of calculations but rather of the subjective judgment of the panel. Following the chart is a brief discussion of certain of its entries. Those to be discussed are marked by and asterisk.

Subsystem or Component	Reliability Category
Capsule structure and re-entry properties	Class 1
Separation mechanism and Posigrade Rocket	Class 1
Tower and Abort Rockets	Class 1
Voice Communications	Class 1
*Abort sensing instrumentation system	Class 1

[6]

Subsystem or Component	Reliability Category
Manual Control System	Class 1
Retro-rocket system	Class 1
Parachute Landing System	Class 1
Ground Environment system	Class 1
Recovery operation	Class 1
Pilot and Pilot training	Class 1
*Landing Bag	Class 2
*Environmental control system	Class 2
*Automatic Stabilization and Control System	Class 2
*Booster (Redstone or Atlas)	Class 3
*Telemetry	Class 3

The starred items require a few brief remarks, which follow:

Abort Sensing and Implementation System (ASIS): In light of the necessity to provide maximum safety to the pilot with 80% (approximately) booster reliability, critical attention must be focused on the abort sensing system. This system provides the warning of impending failure and automatic aborting of the flight to avoid danger to the pilot. Within itself it is completely redundant for reliability. Other systems, i.e., ground control and pilot over-ride provide further redundancy in an "after the fact" manner for separating of the pilot from the booster; however, the abort sensing system gives the earliest warning and therefore the maximum capability of safety to the pilot in the event of an abort. Viewed in this manner, it is imperative that this system have as high a reliability as possible.

The discussions during the ad hoc panel meetings left some questions on the reliability of the ASIS which were not included in the NASA summary. It has been flown open and closed loop on Atlas flights with no apparent failures to operate as designed. The slosh problem in the last (MA-2) Atlas/Mercury [7] flight showed roll oscillations which were near the initiating limits of the ASIS. Admittedly, this condition is not extraordinary to expect at this stage of development, but one of the suggested solutions to the roll rate problem may involve changing the roll rate limits on the ASIS. If the ASIS on the Redstone missile is ready for a manned flight and utilizes the same design philosophy as the Atlas ASIS, then the limit settings for abort should not be amenable to change. These functions should have been settled beyond any doubts by impending disaster criteria and not be changed to adapt to a missile fix. It is recommended that NASA probe again into the reliability of the ASIS to insure to themselves that the system reliability is adequate.

Landing Bag: This buffer against landing shock performs its function well. The steel binding straps, however, have been observed to fatigue under prolonged wave action and the capsule has been punctured when struck by the heat shield. Redesign and test are being vigorously pursued to eliminate these problems. This must be a Class 1 item before the date of the MR-3 manned ballistic mission and it seems likely that satisfactory solutions can be obtained by the present research program and engineering drop tests.

Environmental Control System: Due to the critical role of the environmental control system in the success of the Mercury program, a more detailed engineering review of this system was conducted with members of the NASA Space Task Group at Langley Field, Virginia during the days of 15 and 16 March 1961.

The idea of using a single gas, O_2, atmosphere, in both the suit and capsule to simplify the system appears to be reasonable from an engineering standpoint if it meets the biomedical requirements. The environmental control system is capable of operating completely automatically if required and still provide redundancy in many areas against failure. In the automatic mode the only single point of failure without backup appears to be with the emergency oxygen rate valve. However, with man functioning in the system, this valve can be manually operated.

From the limited drawings available for inspection, good mechanical designs practices appear to have been followed. This conclusion also is confirmed by the results of what testing has been done to date. To the best knowledge of the panel at the present writing, the complete unit incorporating the final design of the ECS has not been subjected to full environmental and vibration testing. In the absence of such testing, it is impossible a priori to categorize this critical subsystem as a class 1 item. Such tests should be performed so that any doubts in this area can be removed.

Automatic Stabilization and Control System: This system is not critical for suborbital missions; it is mandatory for the later orbital missions. Both the automatic and manual systems have in the past had peroxide corrosion [8] problems in the valves. It is probable that new drying methods and procedural improvements have corrected this condition. The automatic system is much more complex than the manual, and a Class 2 categorization of the system is probably fair. However, in the event of a failure of the ASCS, a functioning pilot can bring the capsule in under manual control from an orbital flight.

Booster: There is a good deal of flight data on both the Redstone and Atlas boosters. These indicate reliabilities of the order of 75 to 80%. However, the Redstone used in the Mercury program is a modified version and a vibrational problem was observed in the MR-2 flight. Several fixes were applied including a filter in the control system to eliminate control vane flutter and stiffening to dampen airframe vibrations in the control section of the booster. These fixes were tested in the MR-BD flight of 3/24/61 and appear to have been completely successful.

The relative unreliability of boosters is not per se a cause of alarm; booster failure will invalidate the mission, will of necessity reduce the probability of astronaut survival, but will not necessarily reduce it below an acceptable value.

Telemetry: Some failures or outages of telemetry are to be contemplated, most of which do not endanger the astronaut. Absence on the ground of biomedical data (particularly if a simultaneous outage of all three communication channels to the astronaut were to occur) could result in an unnecessary abort. This again results in a reduction, but not necessarily below acceptable limits, of astronaut survivability.

3. Redundant or Backup Systems

During the presentations a great deal of stress was placed on the many redundant features of the entire system. The basic need for alternate ways to bring the astronaut to safety in case of system failure centers around the desire to provide much more reliable over-all operation than can be assured from the presently available reliability of either the Atlas or Redstone boosters. In addition, many newly designed subsystems are involved, and there is no way to guarantee an acceptable reliability without an inordinate amount of testing, unless the backup or redundant system philosophy is adopted.

The following chart illustrates the multiple possibilities which are available to bring the astronaut to safety in case of a subsystem failure. [9]

Critical Functions or Events	Redundant Modes of Operation or Actuation
Accelerate to altitude	Normal booster operation – Abort by use of escape rockets
Initiation of abort	Radio command from Control Center or Blockhouse; direct actuation by astronaut; radio command by range safety; abort sensing and implementation system.
Release of escape rocket tower, and Separation from booster bolts.	Electrical exploding bolts; alternate electrically exploding bolts; direct activated exploding
Oxygen environment for astronaut	Capsule pressurization; space suit with separate oxygen system; emergency oxygen supply
Monitoring astronaut's condition	Telemetry of biomedical instruments; UHF voice link; alternate UHF voice link; HF voice link; manual key on telemetry link.
Attitude control of Capsule	Automatic stabilization control system with dual sets of jets; manual control system with separate set of jets; switch-over between the two systems.
Retro-fire	Three rockets when two are needed; two firing mechanisms and two power supplies.
Landing	Normal parachutes descent of capsule; emergency chute for the capsule, and in Redstone flight a personal chute for astronaut egress from capsule top hatch; and emergency side hatch
Recovery	Helicopter pickup in water plus numerous ground and sea pickup arrangements. [10]

In a similar way, the astronaut can be recovered from the capsule in a variety of ways in the event of a prelaunch emergency. Depending on the time, he can use the escape mechanism, the gantry can be moved into place, or rescue may be attempted with the remote controlled "cherry picker" egress tower or the armored rescue vehicle.

It must be emphasized that these alternate modes of operation for the main events in the flight are only illustrative of the many redundancies which are built into all of the systems, subsystems, and components. Of course, the redundant design philosophy has not proved to be easy. When a backup system is introduced, extra care must be exercised to insure that there is not some subtle common link in the two which can fail and thereby inactivate both the main and emergency system or that the emergency system is not inadvertently used at the wrong time.

In summary, the Mercury system is heavily dependent on the use of redundant systems and upon the reliability and decision-making ability of the astronaut to achieve the desired degree of over-all systems reliability. As far as the panel could learn, the Space Task Group has given ample attention to the interrelationships between the redundant systems and of the relationship of the astronaut to the system.

4. Fire Hazard

The atmosphere in both the capsule and suit is pure oxygen. Consequently the possibility of fire, with electrical switches or pyrotechnic devices as a source of ignition, has to receive careful attention. A number of precautions have been taken to minimize the risk of fire. These include: (a) All electrical switches are potted or hermatically [*sic*] sealed; (b) all squibs and shaped charges used in the vehicle have been installed to vent outward; (c) all combustible materials have been eliminated wherever this has been possible. Where this was not possible, materials have been chosen which are incapable of ignition from the hot surfaces of the capsule. It is important to observe, however, that the astronaut's suit is made of the combustible material; (d) the capsule can be depressurized to extinguish a fire if one should start. Despite these precautions, a certain hazard of fire remains. Particular attention is required to the period before launch when capsule and the astronaut's suit are being purged with pure oxygen at atmospheric pressure.

In particular, it was felt by the panel that an experiment should be performed in which the emergency hatch was blown off by its explosive bolts with an internal capsule atmosphere of oxygen. [11]

5. Possibility of Failure with no Redundant Backup

In a system which is heavily dependent upon redundancies to obtain acceptable reliability, it is necessary to single out the situations or devices for which there is no backup and in which a single failure would inevitably result in failure of the mission. Experience has shown that in all major systems, there are some operations for which it becomes virtually impossible to provide a backup. During the presentations, no mention was made of the non-redundant operations. A subsequent cursory analysis of the systems showed that there are several such. For example, three retro-rockets are provided to decelerate the capsule out of orbit. The entire package is held on by a single explosive bolt. There is a possibility that a stray current in the circuit beyond the main switch could fire the bolt prematurely and jettison the rocket package before it had performed its function and thus make it impossible to get out of orbit. Just such unexplained currents have plagued two of the Little Joe shots. Another possible difficulty centers around the necessity for releasing both the main and the emergency parachutes from the capsule upon impact with the water. There is a possibility that a premature spurious signal may make the release at high altitude and drop the capsule with catastrophic results.

The panel is concerned that steps may not have been taken to specifically tabulate the operations or functions in which a signal failure would lead to catastrophe. When such possibilities have been defined, then special testing, inspection, and check out procedures should be adopted in order to obtain the maximum possible reliability for the associated components.

6. Status of the Quantitative Reliability Studies

The recommendation of the preceding section that the single failure possibilities be critically analyzed serves to emphasize the value which a reliability analysis has in a program of this magnitude and complexity. From the presentations, it was learned that the McDonnell Aircraft Corporation had performed an extensive failure mode analysis and that a separate reliability study had been initiated at NASA Headquarters and, subsequently, had been transferred to the Space Task Group.

Through a misunderstanding, the questions which were asked by the panel about the McDonnell study were deferred until later in the briefing when the reliability studies would be presented in detail. The later presentation proved to be on the NASA study, and consequently, very little was learned about the failure mode analysis studies of McDonnell. Hence, no evaluation of their impact on the program can be made. [12]

When the NASA reliability studies were presented, it became apparent that as yet they had not played an important role in the design. The mean time to failure of each component which was the basic parameter in the analysis did not reflect the changes which had been made to correct obvious early difficulties. The results which are available from a reliability analysis for the Atlas orbiting mission in which the man is assumed to play no role. The analysis was in the process of being revised and results would not be available until approximately July 1,1961. In view of this situation, the panel was left in doubt as to how comprehensive has been the analysis of the possibilities of single mode failures, of simple correlated multiple failures, and of subtle failures in redundant subsystems which might preclude the use of either subsystem for the Atlas shots.

In view of this uncertainty, the panel wishes to express an opinion that an emphasis be placed on having the results of such a systematic analysis available prior to the first launchings of the manned Atlas vehicles. Further, the panel recommends that the Space Task Group review with the Marshall Space Flight Center the Redstone subsystem reliability data prior to first manned flight.

V. Medical Aspects of Project Mercury

1. General Comments

The major medical effort for the Mercury has followed the traditional aeromedical approach. Once the "mission" was determined, the philosophy emphasized selection of outstanding individuals to be the first astronauts. A training program was established to expose these men as realistically as possible to the anticipated stresses of space flight. Medical personnel provided specifications and requirements for the design and construction of life support systems for the ballistic and orbital flights and participated in the testing and training utilization of prototype systems; undertook ground simulation of anticipated stressing situations; developed a medical monitor system for ground control at Cape Canaveral and a series of stations along the intended orbital path; participated in requirements for and extensive flotilla of recovery ships and aircraft and provided medical contributions to recovery plans and debriefing of the astronauts. These efforts by the small dedicated medical staff of the Space Task Group have been exemplary.

Much less medical effort has been directed to understanding the unique features of stress anticipated during space flight. During the program, when a new physiological stress was identified, tests were designed to simulate the conditions. After the astronaut "took" the test, the assumption was that [13] he could endure it as a part of a combination of all the stresses in actual flight. The panel was disappointed to learn that no attempt was made to evaluate the degree of the physiological stress on the body. Thus, no penetrating medical analyses can be made of even those combined stresses which can be simulated in a ground environment. As a result, it is not known whether the astronauts are likely to border on respiratory and circulatory collapse and shock, suffer a loss of consciousness or cerebral seizures, or be disabled from inadequate respiratory or heat control. These uncertainties are awesome. Data from NASA and DOD aircraft and high altitude balloon flight programs demonstrate a demanding constellation of stresses, and yet measurements are not available which would provide assurances of physiological fitness and survivability characteristics of the pilots. When one must predict response in a more demanding situation apparent health and satisfactory performance are not enough. Essential observations which could provide the basis for extrapolation have not been made before, during, or after these flight programs nor during comparable ground simulation tests. How great a risk is being hazarded in the forthcoming Mercury flights is at present a matter for clinical impression and not for scientific projection.

The considered opinion, reluctantly arrived at by the panel, is that the clinical aspects of the Mercury medical program have been inadequate. We find that this opinion is also shared by several Mercury consultants, by individuals contributing to the simulation training program, and by other qualified observers.

2. Mercury Ballistic Program

The proposed ballistic flight (MR-3) has been scheduled for early May. NASA personnel state that from a medical standpoint, all essential studies are complete. Medical approval is based on experience which includes the apparent ability of pilots to adapt to the increasing stresses generated by the F and X series of aircraft, the balloon programs, the centrifuge trails in the Mercury profile and the successful flight of Ham in MR-2. The increased severity of the several known stresses of ballistic flight are recognized, but it is argued, the individual parameters involved are not greatly in excess of those already experienced.

The panel's uneasiness arises from incidents experienced for which little or no explanation is available. These include the unexplained but apparent medical deaths of three pilots in the F series of aircraft, experimental findings of temporal lobe epilepsy in monkeys at 5g (no comparable [14] detailed studies exist on man), loss of consciousness and seizures in qualified pilots during jet flights and disorientation experienced by an astronaut for two days following a centrifuge run, and lack of comparable animal data on the centrifuge for the profile flown by Ham. Further, although perhaps of less importance, vomiting by one of the early monkeys in ballistic flight and the presence of blood on Ham's harness have not been explained. Finally, the animal experimental program at Johnsville and elsewhere has been limited in scope. Data on maximum stress limits and physiological and neurological observations which would allow one to draw a series of medical graphs represents animal vs man leading to an estimation of man's position are not available.

3. Mercury Orbital Program

In contrast to the ballistic program, NASA personnel state that much more needs to be done prior to the first manned orbital flight. The combined stresses may be much greater than any heretofore experienced. Thus the requirement for ground and animal flight tests data is stringent. The panel is not aware of any firm programs which will accomplish the necessary medical studies, although brief references were made of plans to obtain metabolic information, blood pressure measurements, and electroencepholographic [*sic*] tracings during centrifuge and actual flight tests. We are concerned that these plans were not designed to assess the critical parameters in sufficient detail to permit predictions of astronaut reactions to prolonged orbital flight.

The current program is centered on a small in-house group of physicians. Funds are not available to provide for the extensive university support required or expand current work in DOD laboratories. While it is true that Project Mercury cannot be expected to provide the national effort in space medicine, certain problems must be vigorously and intelligently attacked to provide a minimum of clinical data. Certainly, all relevant information, including that obtained by the Soviet Union should be assembled and subjected to critical analysis.

The panel noted with approval plans to fly a second chimpanzee in orbit prior to man; however, it should be realized that this one additional flight can only provide minimum data, and consideration should be given to whatever animal flights including those in the DOD Discoverer series are necessary to insure the safety of man in space. [15]

VI. Manned Suborbital Flight

As with most development projects, it is desirable and often mandatory that the final mission capability be attained in a series of development steps. The Redstone manned flights provide such steps prior to orbiting a man. The MR-3 is the first in a series of proposed manned suborbital flights. These provide much of the actual flight training for the pilot and qualification of the equipment under realistic condition but with considerable reduction in the severity of flight conditions and consequent dangers which may be encountered when orbiting conditions are possible but not necessarily intended. In particular, the environmental control system of the capsule itself can be used to demonstrate its functional adequacy under limited ballistic flight conditions with reduced risk to the man compared to that of the later Atlas flights.

The Redstone mission is limited in range and the capsule will necessarily land in water (short of possible aborts on the stand). The pilot can commit errors without affecting his landing region dangerously or inadvertently leaving himself in orbit. In the same sense the basic systems, particularly the automatic stabilization and control system and the ground command and data links can be demonstrated for adequacy without undue severe consequences if there are failures. Therefore, if the Redstone booster reliability is equal to or better than that of the Atlas, its use can provide an invaluable step in the progression to an orbital mission.

In addition, in the earlier phases of the Mercury program, concern over the unknown factors involved in having a man perform specific duties under weightless conditions following high acceleration resulted in an approach commands. Training programs since that time have shown that man's tolerance for conditions in flight is considerably higher than early estimates. As a result, it appears that the man may be the most reliable single item in the capsule. The suborbital manned flight will give a better insight into whether this is the case by combining stresses which cannot be adequately simulated and testing the skill of the pilot under these conditions. For all of these reasons, the suborbital flight is a necessary prerequisite to later manned orbital flights.

Nevertheless, for the reasons mentioned in the preceding section, we are concerned that enough data has been accumulated to predict with certainty the margin of physiological safety for the astronaut.

Before further ballistic flights are undertaken, it must be seriously inquired in each case whether the objectives justify the repeated risk of a man's life. [16]

VII. Conclusions

1. The program is a reasonable step in attaining manned space flight. It represents the highest degree of technical advancement available at the time of its inception.

2. The system is a complicated one and is made so largely by the automatic devices, which are often duplicated, plus the alternate manual control and safety devices.

3. The system is not completely reliable and cannot be made so in the foreseeable future. It is not more unreliable then could have been predicted at its inception. The thought and organization which have gone into making it as reliable as possible have been careful and thorough and most of the problems have been thought through. There does not appear to be any shortage of funds for reliability and safety measures.

4. Manned Mercury flights will definitely be a hazardous undertaking, although related to such initial efforts as the flights of the Wright Brothers, Lindbergh flight, and the X-series of research aircraft.

5. A suborbital flight or flights are needed as a prelude to orbital flight. They will check out the pilot's performances, including his ability to orient the capsule in flight, adding elements which cannot be adequately simulated such as the anxiety and stress of a real flight and the extension of weightlessness to a five minute period, all under conditions where the risk is very much less than in orbital flight since descent in a reasonably accessible recovery area is assured under all conditions.

6. The presence of a man in the capsule will very greatly increase the probability of a successful completion of the mission over uninhabited or primate flights. One of the possible conclusions of the Mercury program is that the design philosophy of the automatic system to designing automatic mechanisms as a backup to the man.

7. We urge that NASA appoint a group of consultants to plan and implement a full-scale crash effort on the Johnsville centrifuge and at other appropriate laboratories to obtain essential measurements under as many kinds of combined stresses as possible. The measurements should be sufficient to permit correlations between man and primates with enough certainty to estimate the human margin of reserve during the anticipated stresses of space flight. Substantial data should be on hand prior to [17] committing an astronaut to the first Mercury flight. In view of the limited time available, and commitments of the Space Task Group Medical personnel to MR-3, we urge that additional qualified personnel be recruited to accomplish the studies.

8. We recommend consideration of including a chimpanzee in the forthcoming MA-3 flight. This is designed for an abort of the McDonnell capsule, complete with life support systems, from an Atlas booster just prior to capsule insertion into orbit.

9. We urge a considerable expansion of the scientific base of the medical program. Working consultants, additional in-house personnel and sufficient funds to permit implementation of a sound program, based on the resources and capabilities of several university laboratories and utilizing additional contracts with DOD and other government facilities, are essential if we are to insure reasonable programs toward orbital flight.

General Conclusion

The Mercury program has apparently been carried through with great care and there is every evidence that reasonable stops have been taken to obtain high reliability and provide adequate alternatives for the astronaut in the event of an emergency. Nevertheless, one is left with the impression that we are approaching manned orbital flight on the shortest possible time scale so that the number of over-all system tests will necessarily be small. Consequently, although it is generally assumed by the public that manned flight will not be attempted until we are "certain" to be able to return the man safely and that we are more conservative in our attitude toward human life than is the USSR, the fact seems to be that manned flight will inevitably involve a high degree of risk and that the USSR will have carried out a more extensive preliminary program particularly in animal studies than we will before sending a man aloft.

It is difficult to attach a number to the reliability. The checkout procedures on individual components and for the flight itself are meticulous. There appear to be sufficient alternative means by which the pilot can help himself if the already redundant mechanical system fails. However, there is no reliable current statistical failure analysis and although we feel strongly that such analyses should be certainly be brought up to date before the first orbital flight we see no likelihood of obtaining an analysis which we would really trust. One can only say that almost everything possible to assure the pilot's survival seems to have been done. [18]

The area of greatest concern to us has been the medical problem of the pilot's response to the extreme physical and emotional strains which space flights will involve. On this score the pilot training has been thorough and it has been demonstrated that a man can perform under the conditions of acceleration and weightlessness to which he will be subjected. Nevertheless, the background of medical experimentation and test seems very thin. The number of animals that will have undergone flights will be much smaller than in the USSR program. Consequently, we are not as sure as we would like to be that a man will continue to function properly in orbital missions although the dangers seem far less pronounced in a suborbital flight.

Altogether, the probability of a successful suborbital Redstone flight is around 75 percent. The probability that the pilot will survive appears to be around 90 to 95 per cent although the NASA estimates are somewhat higher. This does not appear to be an unreasonable risk, providing the known problems are taken care of before the flight, and those of our members who have been very close to the testing of new aircraft fell that the risks are comparable to those taken by a test pilot with a new high performance airplane.

It is too early to say anything as definite for the risks of orbital flight. Nevertheless, if the planned program of tests is carried through it seems probable that the situation at the time of the first flight will be comparable to that for a Redstone flight now – a high risk understanding but not higher than we are accustomed to taking in other ventures. [19]

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Document I-35

Document Title: MR-3 Technical Debriefing Team, NASA, "Debriefing," 5 May 1961.

Source: Folder 18674, NASA Historical Reference Collection, NASA History Division, NASA Headquarters, Washington DC.

At the conclusion of the suborbital flight of the first American astronaut into space on 5 May 1961, a NASA team debriefed astronaut Alan Shepard on the aircraft carrier U.S.S. Lake Champlain *soon after his recovery from his capsule's water landing. This transcript of his debriefing captured critical information about the mission, the performance of the spacecraft, the ability of the astronaut to function in space, weightlessness, and the success of the various systems that made the flight possible. It offers immediacy to the first American steps into space. It also set the precedent for debriefings after all future space missions. This interaction was followed by a more formal and extensive debriefing that took place upon return of the astronaut to the Langley Research Center.*

SECTION A [Enclosure 4, page A1-4]

CARRIER DEBRIEFING

IMMEDIATELY AFTER FLIGHT

MAY 5, 1961

1. The following is a transcription of a tape recording made by Astronaut Shepard aboard the aircraft carrier approximately one to two hours after flight. This tape recording constitutes an essential part of the planned debriefing of Shepard and covers the time period from his entrance into the capsule to his arrival aboard the aircraft carrier. The period of the flight between retrojettison and main chute deployment was not described aboard the carrier. A description of this part of the flight was made on the day after the flight and is included herein.

2. "This is the first flight debriefing, and before I go into the formal debriefing kit, I would like to say, as a general comment, that I quite frankly did a whole lot better than I thought I was going to be able to do. I was able to maintain control of the capsule fairly well throughout all of the manual maneuvers I made. I was able to follow the sequences fairly well throughout the entire flight, and, as a general comment, I felt that even though I did not accomplish every single detail that we had planned for the flight, I still did much better than I had originally thought I would.

3. "With that general comment as a start, I'll go into the first question of the debriefing kit which says 'What would you like to say first?' and I've just said it.

4. Question, No. 2 'Starting from your insertion into the capsule and ending with your arrival aboard the recovery ship, tell us about the entire mission.'

"Starting with foot over the sill back at Pad 5, I make these remarks. The preparations of the capsule and its interior were indeed excellent. Switch positions were completely in keeping with the gantry check lists. The gantry crew had prepared the suit circuit purge properly. Everything was ready to go when I arrived, so as will be noted elsewhere, there was no time lost in the insertion. Insertion was started as before. My new boots were so slippery on the bottom that my right foot slipped off the right elbow of the couch support and on down into the torso section causing some superficial damage to the sponge rubber insert – nothing of any great consequence, however. [Page A4-7] From this point on, insertion proceeded as we had practiced. I was able to get my right leg up over the couch support and part way across prior to actually getting the upper torso in. The left leg went in with very little difficulty. With the new plastic guard I hit no switches that I noticed. I think I had a little trouble getting my left arm in, and I'm not quite sure why. I think it's mainly because I tried to wait too long before putting my left arm in. Outside of that, getting into the capsule and the couch went just about on schedule, and we picked up the count for the hooking up of the face plate seal, for the hooking up of the biomedical connector, communications, and placing of the lip mike. Everything went normally.

5. "The suit purge went longer than usual because of the requirement of telemetry to change the potentiometers on the EKG cards; so, as a result, I got a fairly good long suit purge and comfortable one. The temperature was certainly comfortable during suit purge. Joe[1] seemed to have no trouble with the straps as he was strapping me in. Everything seemed to go as scheduled. I think we would have saved a little time at this point, since we were already in a very long suit purge, if Joe had tightened the straps up immediately rather than going out and coming back in again. However, at this point, he may have been getting a little bit tired, so it was probably just as well that the sequence went as we planned it according to the SEDR. As a result of this very long purge, I was surprised that the suit circuit oxygen partial pressure was only 95 percent.

6. "The oxygen partial pressure in the suit circuit apparently is not necessarily a function of the length of the purge. If it is, then there is a leveling off point so that 95 percent seems to be a fairly good endpoint for the present system that we are using. After suit purge, of course, the gross suit-pressure check showed no gross leaks; the suit circuit was determined to be intact, and we proceeded with the final inspection of the capsule interior and the safety pins. I must admit that it was indeed a moving moment to have the individuals with whom I've been working so closely shake my hand and wish me bon voyage at this time.

7. "The point at which the hatch itself was actually put on seemed to cause no concern, but it seemed to me that my metabolic rate increased slightly here. Of course, I didn't know the quantitative analysis, but it appeared as though my heartbeat quickened just a little bit as the hatch went on. I noticed that this heartbeat or pulse rate came back to normal again shortly thereafter with the [page A7-10] execution of normal sequences. The installation of the hatch, the cabin purge, all proceeded very well, I thought. As a matter of fact, there were very few points in the capsule count that caused me any concern.

8. "As will be noted by members of the medical team, it became apparent that we were going to hold first for lack of camera coverage as a result of clouds. At this point, I decided that I better relieve my bladder, which I did, and felt much more comfortable. It caused some consternation. My suit inlet temperature changed, and it may possibly have affected the left lower chest sensor. We can check back to see if the moment at which the bladder was relieved actually coincided with a loss or deterioration of good EKG signal from that pair. My general comfort after this point seemed to be good. Freon flow was increased from 30 to 45, and although

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[1] Joe Schmidt, NASA Suit Technician

I suspect body temperature may have increased slightly, I at no time really felt uncomfortable. I, of course, shifted around continuously to try to get proper circulation, particularly in the lower limbs, and found that normal upper torso and arm movements and following sequence items were such that proper circulation was provided. The couch fit was fine. The helmet fit and sponge support was fine for the static condition. I'll describe other deviations later.

9. "The parachute is definitely in the way of a yaw movement. When you make an attempt to yaw left, the wrist seal bearing on the right wrist bumps into the parachute, not to the point where it makes less yaw possible, but it certainly does interfere with it. It also, of course, interferes with the voice-operated relay sensitivity control and voice-operated relay shutoff switch which I did reach later in the flight using the 'window pole'. So then we had several holds during the count, but my general comfort was maintained, and I found as we did finally proceed down to the last part of the count that my pulse rate did appreciably increase.

10. "I felt no apprehension at any time, but I did find that if I thought that some people were a little slow in reporting that their panel was in GO condition, I started to get a little bit flustered. I think that I was anxious to go at this point after having been in the capsule for some time.[2] The transition from the freon flow to suit capsule water flow was made smoothly even though we were very late in the count at that time.

11. [Page A11-14] "The transfer from MOPIS circuitry to RF was made smoothly. I was able to transmit and get an RF check with the control center and with the chase planes as well as with the block house in plenty of time prior to T minus one minute, when, of course, attention did naturally shift to the umbilical and the periscope.

12. "Backtracking here slightly, I see that I have slipped by gantry removal at –55 which, as far as I was concerned, posed no problem to me. I was well tied in by that time, and at –45 the panel check posed no problem. I had no difficulty at any time with the CTC[3] on any of the check-off items – I think primarily due to his foresightedness in reading the check-off lists when he had the opportunity, rather than following the launch count document to the second. Escape tower arming at –22 was no problem – all you had to do was throw a switch, and, as all know, the escape tower did not fire. The T-15 panel check was satisfactory, the –5 status check was satisfactory, and I would say that the countdown right up to the point of umbilical pull indeed was satisfactory. This ties me back in where I was before, to the periscope.

13. "I noticed the umbilical go out and I saw the head of the boom start to drop away as the periscope retracted electrically. This fact was reported as well as main bus voltage and current over RF prior to lift-off. I had

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[2] About 4 hours by now.

[3] Capsule Test Conductor

the feeling somehow that maybe I would've liked a little more over RF with respect to the booster countdown steps. I remember hearing firing command, but it may very well be that although Deke[4] was giving me other sequences over RF prior to main stage and lift-off, I did not hear them. I may have been just a little bit too excited. I do remember being fairly calm at this point and getting my hand up to start the watch when I received the lift-off from the Control Center on RF. The time-zero relays closed properly, the onboard clock started properly, and I must say the lift-off was a whole lot smoother than I expected. I really expected to have to use full volume control on UHF and HF to be able to receive. I did <u>not</u> have to – I think I was legible to Tel 3[5] because all of my transmissions over UHF were immediately acknowledged without any repeats being requested.

14. "Again, insofar as the mission itself is concerned, lift-off was very smooth. I noticed no vibrations of any consequence at all during the period of about the first 30-45 seconds (I would say as a guess). [Page A14-17] I got an extra transmission in primarily to insure myself of a good voice link and also to let the people on the ground know I was in good shape. The 30-second scheduled transmission went according to schedule, right on time. I did start that a little bit early, I remember, as I wanted to again let people know that I was in good shape. It seemed to me then that somewhere about 45 seconds to a minute after lift-off, I started noticing an increase in vibrations at the couch. It was a gradual increase; there was not any concern. As a matter of fact I'd really been looking for an increase in sound levels and roughness just after one minute because, of course, going transonic, and because of the max q point, so I wasn't too upset by this. I think maybe if we look back at film (the pilot coverage film) we'll be able to see my helmet bouncing around vibrating. Actually there was [*sic*] vibrations there to the degree where it distorted some of the reading of the instruments. I made the voice report at one minute on schedule and from there on up to max q noticed the increase in the sound level and increase in vibrations.

15. "The cabin pressure, as we know, sealed properly at 5.5. It seemed to slow down a little bit at 6. As a matter of fact, I almost reported it as being sealed at 6, but it gradually came down to 5.5. A quick glance at the suit circuit absolute-pressure gauge confirmed this. After this, things really started to smooth out. The booster noises seemed to fade away, and booster vibrations got a lot smoother. As a matter of fact, I mentioned that over RF, so we'll have that on the record. There was a very definite transition in vibration, not a sharp one, but a gradual one, nonetheless noticeable. The report at 1 minute and 30 seconds was made on schedule. We, of course, included the main-bus and isolated-battery voltage at that time. I found that my scan pattern was not as good as it might have been, and I don't remember looking at the electrical panel as much I probably should have, paying more attention, of course, to the oxygen panel and the fuel panel.

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[4] Capsule Communicator in Mercury Control Center. [Astronaut Deke Slayton]

[5] Mercury Control Center

16. "At 2 minutes, normal periodic transmission was made, and, of course, I gave all systems 'GO' at that point. I remember feeling particularly happy at that point because the flight was proceeding very smoothly here, the capsule was working very nicely as far as I could tell. I also called out an additional acceleration of, I think, 5-1/2 g here.

17. "Cut-off as far as I could tell on the clock came exactly on schedule, right around 142 seconds, 2 minutes and 22 seconds on the count. The tower jettisoned. Immediately I noticed the noise in the tower jettisoning. I didn't notice any smoke coming by the porthole as I expected I might in my peripheral vision. I think maybe I was riveted on that good old 'tower jettison' green light which looked so good in the capsule. I threw the 'retrojettison' switch to disarm at this point as I noted over RF, and 'capsule separation' came on [page A17-19] green right on schedule at 2 minutes and 32 seconds. Aux damping at this point, I thought, was satisfactory. I don't remember reporting it specifically because I reported the periscope coming out, and I think at this point I was going to report it, but the turnaround maneuver actually started on ASCS.[6] I remember reporting the turn around maneuver, and at that point, at about 3 minutes, I went though hand control motions[7], as was noted, and I started switching to the manual control system. I switched of course to pitch first, pitched to retroattitude, and back to orbit attitude. The ASCS controlled in yaw and roll as I was doing this. I then switched next to manual yaw, and ASCS roll still continued to function. I switched then finally to manual roll. I was in the full manual system and found that controlling the capsule was just about the same as it been on the trainers.

18. "I did not pickup any noticeable noise of the jets. I think if I'd had time I might have been able to decrease the volume control of the voice radio circuits and picked it up but at this point I didn't have time to investigate it. I remember thinking that I did not hear the noise of the manual jets firing at this time.

19. "I controlled fairly close to orbit attitude on manual and then switched to the scope, and the picture in the scope certainly was a remarkable picture. Unfortunately, I had a filter in the scope to cut the sunlight down on the pad, and I did not feel that I had the time to reach it and change it on the pad. It was difficult for me to reach the filter-intensity knob with the suit on without bumping the abort handle with the wrist seal bearing of the left arm, so as a result I remember saying, 'Well, I'll leave the periscope filter in this position and try to remember to change it later on even though it may get me in trouble.' Of course, actually, it did, because I had in the medium gray filter which very effectively obliterated most of the colors. Clarifying that last remark, there is no question about being able to distinguish between cloud masses and land masses. This is very easy to do even with a gray filter, and I was able to distinguish the low

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[6] Automatic Stabilization and Control System

[7] A psychomotor test of positioning the hand controller at predetermined positions.

pressure area as described[8] in the southeastern part of the United States. As I think I mentioned over RF, Cape Hatteras was obliterated by cloud cover. The cloud cover of 3 to 4 tenths, low scattered on the east coast of Florida, was most apparent. The west coast of Florida and the Gulf were clear. I could see Lake Okeechobee. As I described, I could see the shoals in the vicinity of Bimini. I could see Andros Island. The Bahama Islands, Grand Bahama Island itself, and Abaco [page A19-21] were confusing because there was cloud cover there, just enough to confuse my view. I think if I had a little bit more time with a periscope here, though, I would have been able to definitely distinguish these islands, but the cloud cover was confusing to me at that point. I noticed also that I apparently had in a slow pitch rate because I noticed that I wasn't controlling the manual pitch too much at this point. I think I was paying too much attention looking out at the awe-inspiring sight in the periscope.

20. "The countdown to retrosequence helped me. It helped me come back to the next sequence which was to occur. The next sequence of course was retro. The onboard timer started retro essentially on schedule; the retrosequence and retroattitude lights came green, as expected. I went manually to retroattitude, and I wasn't quite as happy with the pitch control here as I was with yaw and roll. Somehow I got a little bit behind with my pitch control, and I got down fairly close to 20 to 25 degrees rather than staying up around the 34 degrees. Of course, as we all know, the index of this particular capsule is at 45 degrees, but I don't think this added to the confusion; however, I think the confusion was my own here. Okay, with respect to retrofiring – there is no question about it, when those retros go, your transition from zero g of weightlessness to essentially $\underline{5g}$ is noticeable. You notice the noise of the retros and you notice the torque[9] of the retros. I think I did a fairly good job of controlling the retros outside of the pitch deviation which I mentioned, and I thought that I was able certainly to control them within reasonable tolerance.

21. "At the end of retros, the plan was to go to fly-by-wire, which I did. I switched to fly-by-wire, pulled manual, and then, at this point, the plan was to go to yaw and then roll fly-by-wire, but I noticed I was a little lower in pitch than I wanted to be at the end of retrofire itself, so I started back on the pitch – then , at this point, it was either a yaw or roll maneuver that I made, I'm not sure which one. I think it's probably yaw because that is the one I was supposed to make first – a fly-by-wire yaw maneuver – and1, about the time the retros were to have jettisoned, I heard the noise and saw a little bit of the debris. I saw one of the retropack retaining straps. I checked and there was no light at that time. Deke[10] called up and said he confirmed retrojettison, and about this time I hit the manual override and the light came on. This, as I recall, is the only item sequence-wise in the capsule that did not perform properly. I did not do the specific roll

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[8] In preflight weather briefing

[9] Misalignment Torques.

[10] Astronaut Donald K. (Deke) Slayton, Capsule Communicator in the Mercury Control Center.

[page A21-23] 20 degrees and back as we had planned, because it took a little extra time to verify that retropack jettison had occurred.

22. "I went down to reentry attitude on fly-by-wire, and I think I made the general comment already that as far as I am concerned, the trainers – all the trainers that we have – the procedures trainer as well as the ALFA trainer, are all pretty close to the actual case. I say this now, because on these I have a tendency to be able to control these trainers on the manual system better than I can with the fly-by-wire system. And I think it's just a matter, really of not using fly-by-wire very much. By that I mean that normally we're controlling retros manually and normally controlling reentry manually, and when you switch to fly-by-wire as we had been doing here, the first tendency is to over-control in rate – at least for me – because the microswitch distances for the high and low thrust jets are very small, and we've had trouble on this. With these microswitches, particularly capsule seven, you get high torque right away, whether you want it or not, and so I noticed the same thing on the capsule. The first thing I do is over- control and get a higher rate than I thought I should have gotten.

23. "On fly-by-wire I went to reentry attitude, and switched to ASCS which stabilized at about 40 degrees, then at this point, the periscope came in on schedule, and I remember reporting 'periscope in.' Then I got involved with looking out the windows for the starts and anything else that I could see. At this time in the flight, of course, this window looks generally at the horizon, at the moon and the stars.[11] There was nothing there at all – I couldn't see anything in the way of stars or planets out in that area, and I did move my head around. I got a little confused because I though I ought to get my head up to see the horizon out that window, but I never did get a horizon out that window at this point, and I think it was because of the attitude. We had figured out it was 15 degrees above the horizon as I recall, and I thought I ought to be able to see the horizon but I never did see it. Well, that, plus the fact that I was looking for the stars that I couldn't see out of that window, actually got me behind in the flight – this was the only point in the flight that I felt that I really wasn't on top of things. What happened here was that .05g came quickly, as I reported, and I started switching to manual control, and I thought I had time to get on to manual control, but I didn't. The g-build-up started sooner than I figured it would. I don't know whether it was just that [page A23-26] I was late because of being on the time, or whether we don't have the same time difference between .05g and g-build-up on our trainer that we actually had in flight – we can check this later. What I'm talking about is the time period between .05g and the g-build-up in reentry. As I can remember on the trainer, I would have time to go ahead and get on manual control and get set up before the g's built up, but I was surprised when the g's started building up as soon as they did. I wasn't ready for it, but I thought we were in good shape

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[11] The stars he was to look for.

because we were still on the ASCS when the .05g relay latched in. As a result, the roll[12] started on schedule. . . ." END OF RECORD.

24. (There is a portion of Astronaut Shepard's report missing from the tape recording at this part of the flight. During a later debriefing at GBI the next day, Shepard described this portion of the flight essentially as follows:)

25. The acceleration pulse during reentry was about as expected and as was experienced on the Centrifuge during training, except that in flight the environment was smoother. During the early part of g-build-up, Shepard switched to manual-proportional control on all axes. He allowed the roll put in by the ASCS to continue. He controlled the oscillations somewhat in pitch and yaw during g-build-up only. The oscillations during and after the g-pulse were mild and not uncomfortable. He arrived at 40,000 feet sooner than he expected and at that time switched to ASCS in all axes in order to give full attention to observing drogue chute deployment. The drogue came out at the intended altitude and was clearly visible through the periscope. The capsule motions when on the drogue chute were not uncomfortable. The snorkel opened at 15,000 feet which Shepard thought was late. The main chute came out at the intended altitude.

Astronaut Shepard's recording made on the carrier continues:

26. "As to the chute, I was delighted to see it. I had pushed all hand controllers in so that I noticed that all the peroxide had dumped on schedule. At this point I shifted to the R/T position of the UHF-DF switch. The UHF-select was still normal, and I think at this point I reached over and flipped off the VOX relay switch which was obviously, I realized after I had done a superfluous maneuver because the transmitters were keyed anyway. I was a little confused here, I guess. I felt that the carrier[13] was coming in and out for some reason, so I went over there and threw that VOX power switch off. [Page A26-29] In any event, after going to the R/T positions, shortly thereafter, I established contact with the Indian Ocean Ship[14] and gave them the report of the parachute being good, the rate-of-decent indicator being at about 35 ft/sec and everything looked real good. The peroxide was dumped, the landing bag was green, and, of course the 'Rescue Aids' switch was off at that point. They relayed back shortly after that, as I recall.

27. "CARDFILE 23, the relay airplane, came in first of all with a direct shot and then with a relay, so that I was able to get the word to the Cape prior to other sources that I was indeed in good shape up to this point. The opening shock of the parachute was not uncomfortable. My colleagues will recognize it was a reassuring kick in the butt. I think I made the hand

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[12] Programmed reentry roll rate of 10 to 12 degrees per second.

[13] The hum of the carrier frequency.

[14] This ship was being exercised for the MR-3 mission and had been positioned in the landing area.

controller movements after the main chute. I can't vouch for it. The exact times of these sequences I do not recall at this point but we can cross-check again. Altitude-wise, the drogue and main came out right on the money, as far as indicated altitude was concerned.

28. "I put the transmission through that I was okay prior to impact. I was able to look out and see the water, with the capsule swinging back and forth. It was not uncomfortable at all. As a matter of fact I felt no uncomfortable physiological sensations, really, at any point during the flight. Excited, yes, but nothing uncomfortable at all. Prior to impact, I had removed my knee straps; I had released my face plate seal bottle and had removed the exhaust hose from the helmet. Back to the impact now – the impact itself was as expected. It was a jolt but not uncomfortable. The capsule went over on its right-hand side, down pretty close to the water, and of course stayed at about 60° off the vertical. I reached down and flipped the 'Rescue Aids' switch at this time to jettison the reserve chute and to eject the HF antenna although I <u>did</u> leave my transmit switch in the UHF position. At this point, I could look out the left window and tell the dye marker package was working properly. The right window was still under water. I began looking around for any indication of water inside but did not find any. I had broken my helmet at the neck ring seal at this point, and I did no transmitting here. I left the Switch on R/T because I didn't want any discharge from the UHF antenna.

29. "The capsule righted itself slowly to a near vertical position, though I thought myself 'It is taking an awfully long time to get up there,' but it did get up there, and about the time it did get up [page A29-31] there, I started to relax a little bit and started to read off my instruments. I had made a report to CARDFILE 23 after impact over UHF that I was indeed all right, and it was relayed back to the Cape. Then, getting back to the point where the capsule was close to the vertical, I was going to get a read-off of the instruments at this time prior to shutting down the power. I got the main bus voltage and current, and I got a call from the helicopter and thought that communicating with him was much more important. So I did. I communicated with him and established contact with the chopper. I am not sure he heard me at first, but I was able to get through to him that I would be coming out as soon as he lifted the door clear of the water. In the meantime, I experienced very little difficulty in getting the cable from the door around the manual controller handle and tightened up so that when I called the helo and told him I was ready to come out and he verified that he was pulling me up and I told him I was powering down and disconnecting communications. The door was ready to go off. I disconnected the biomedical packs. I undid my lapbelt, disconnected the communications lead, and opened the door and very easily worked my way up into a sitting position on the door sill. Just prior to doing this, I took my helmet off and laid it over in the position in the – as a matter of fact, I put it over the hand controller.

30. "The helo was right there. I waited before grabbing the 'horse-collar' for a few minutes because I hadn't seen it hit the water. They dropped

it down in the water and pulled it back up again, and I grabbed it and got into it with very little difficulty, and shortly thereafter, was lifted right directly from a sitting position out of the capsule up toward the chopper. The only thing that gave me any problem at all, and it was only a minor one, was that I banged into the HF antenna but, of course, it is so flexible that it didn't give me any trouble. I got into the chopper with no difficulty at all, and I must admit was delighted to get there. Of course, the pickup of the capsule went very nicely. The sea conditions were such that they were able to get it up right away, and the next thing I knew we were making a pass on the flat top. My sensations at this time were very easy to describe and very easy to notice. It was a thrill, and a humble feeling, an exultant feeling that everything had gone so well during the flight.

31. "I have not used the script[15] here, so I will go over it now to be sure I have covered most of these items. Item 3 – the most outstanding impression of the flight in special sensory areas. I think [page A31-34] it is really very difficult to describe any one thing as being more outstanding than the other. It was all fascinating, and interesting, and challenging, and everything, all wrapped up into one. But I don't really remember noticing the weightless condition until I noticed a washer flying by. 'Well,' I thought, 'you are supposed to be making some comment on being weightless.' So I did think about it a little bit. Of course, as we had known before, in the backseat of the F-100's, it is a real comfortable feeling. Being strapped in like that, there is no tendency to be thrown around at all and no uncomfortable sensations. I guess the most outstanding impression that I had was the fact that I was able to do as well as I did. A very good flight.

32. "Major surprises? No major surprises. Some minor ones which I have described. I expected to be able to see the stars and planets, which I did not do. I think I could have found them with a little more time to look. The fact that I did not hear the jets firing – although I do remember now hearing the control jets working just after reentry, after I went back to ASCS. I remember hearing some of the high-thrust jets going at this time. In reference to the sky and stars, I have described the stars which I did not see and which I tried to see. I described the landing in the water; I described the check points; I remember mentioning over RF that I was able to see Okeechobee, also Andros and the Bimini Atoll which was (the latter) most apparent because of the difference in color between the shoals and the deep water.

33. "I did not describe the perimeter[16] too well because of cloud cover around the perimeter. The predicted perimeter cloud cover was most accurate. The clouds were such that the ones that had any vertical formation were pretty far away, and I didn't really notice much difference in critical cloud heights. I think had I been closer to them, I would have been able to notice this a little more. They were pretty far from the center

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[15] The debriefing form.

[16] The perimeter of the field of view through the periscope

of the scope where some distortion occurs. We talked about the horizon. Essentially, there was only the one haze layer between the cloud cover and the deep blue.

34. "Weightlessness gave me no problem at all. The last question: 'Describe any sound, smell, or sensory impressions associated with the flight experienced.' Sounds? Of course, the booster sounds, the pyros firing, the escape tower jettisoning and the retros firing. Of course all these sounds were new, although none of them were really loud enough to be upsetting. They were definitely noticeable. The only unusual smell in the capsule was a gunpowder smell after – it seems to me – after main chute deploy. I think this was after the main antenna can [page A34-35] went off. I don't remember smelling it before, but I did get it after main chute and, of course, I didn't get it until after I opened my face plate. It didn't appear to be disturbing to me, so I didn't close the face plate. No other sensory impressions that I noticed that I can recall at this time that we did not have in training. The g-load, the onset and relief of g were familiar during reentry and powered flight. They were not upsetting. They were not unusual.

35. "I am sorry that I did forget to work the hand controller under g-load during powered flight as we had discussed, but I thought that I was operating fairly well during powered flight. I think the fact that I forgot this is not too significant. Well, I think that's just about the size of it for now. We will continue this on a more quantitative basis later on. This is Shepard, off."

Document I-36

Document Title: Joachim P. Kuettner, Chief, Mercury-Redstone Project, NASA, to Dr. von Braun, 18 May 1961.

Source: Folder 18674, NASA Historical Reference Collection, NASA History Division, NASA Headquarters, Washington DC.

In 1958 Joachim P. Kuettner joined NASA's Marshall Space Flight Center at Huntsville, Alabama, and became the Center's Director of the Mercury-Redstone Project, overseeing efforts at the center for the first spaceflights of U.S. astronauts. Subsequently, he became Director of the Apollo Systems Office, responsible for the integration of the Apollo spacecraft and the Saturn V rocket for the lunar landing. The euphoria surrounding the flight of Alan Shepard on 5 May 1961 prompted him to prepare this bold memorandum to Center Director Wernher von Braun advocating a circumlunar mission using a spacecraft under development. He had found that with a follow-on space capsule, which became the Gemini spacecraft, it might be feasible to undertake the truly significant "space spectacular" of a circumlunar flight. Such an endeavor would steal the march on the Soviet Union and significantly advance U.S. prestige in the space race. At the time Kuettner made this proposal President John F. Kennedy had not yet made his famous Apollo landing speech. That would come only a week *later, and because of it this proposal was overcome by events. It would be revisited in the 1963 to1964 timeframe, however, but never adopted.*

M-DIR, Dr. von Braun

May 18, 1961

M-S&M-TSM

MERCURY PROJECT

[Section 2 only]

2. Circumlunar "Shortcut"

a. You will remember the proposal we discussed a few weeks ago, using C-1 and MERCURY hardware. This "Beat-Russia" proposal which you took along envisioned a trip around the moon within three years. You considered the capsule problem as the time-critical item and suggested possible use of the present MERCURY capsule (beefed-up)

b. In the meantime, I have done some "incidental" digging and exploring among "savvy" STG people (Cooper, Slayton, Grissom, Glenn, Dr. White, Dr. Voss, Gilruth, Williams, and Faget). I learned that a slightly scaled-up MERCURY capsule is already being developed by McDonnell for prolonged orbital flights. Chamberlin, one of Gilruth's Division Chiefs, carries the ball. (He is the only one I missed.)

c. There was very little deviation in the general reaction: It can be done with almost existing hardware if the astronaut is given enough room to stretch to full length and to do some regular body exercises in order to avoid muscular dystrophy under prolonged weightlessness. This means some additional room around his body so that he can move his extremities freely. There is no walk-around requirement. I will find out whether the scaled up capsule at McDonnell fulfills these conditions.

d. Some astronauts, like Cooper, would ride the present MERCURY capsule for a week without hesitation, but the doctors may object. The reaction to the whole idea of an early circumlunar flight of this type varied from friendly to most positive. There was no objection raised by anybody except that Williams doubted that C-1 can do the job, payload wise. (Of course, the plan was to augment C-1 by four solids such as SCOUTS or MINUTEMEN [handwritten: Or by a 3rd of the Minutemen)].

e. Since this is one of the few real possibilities to accomplish an important "first" without requiring excessive funding (most of the hardware is developed anyway), I would like to know if you are interested in pursuing this idea. We may look into the costs and get some more details on the scaled-up capsule.

Joachim P. Kuettner
Chief
MERCURY-REDSTONE Project

Enc:

Letters of Commendation

Copies to: M-S&M-TSM (Record copy)
M-S&M-DIR

Document I-37

Document Title: James E. Webb, Administrator, NASA, to James C. Hagerty, Vice President, American Broadcasting Company, 1 June 1961.

Source: Folder 18674, NASA Historical Reference Collection, NASA History Division, NASA Headquarters, Washington DC.

James C. Hagerty had served as President Dwight D. Eisenhower's press secretary between 1953 and 1961, and in that capacity he had dealt often with the media issues brought to the forefront by Soviet "space spectaculars." Upon his departure from Washington with the end of the Eisenhower administration he keenly understood the excitement of spaceflight and in that context tried, as this letter suggests, to play upon the public's interest in the astronauts to aid his new organization, ABC, by organizing a joint television special with the first two humans in space, Yuri Gagarin and Alan Shepard. NASA Administrator James E. Webb's instinct was probably correct in refusing this offer. Even if the Soviets were willing to allow Gagarin's appearance on ABC , the question at the time of this correspondence was, why would the U.S. want to allow the Soviet Union to upstage the 5 May success of Shepard's flight with the joint television appearance? Instead, Shepard spent several months making public and media appearances to bolster confidence in the American space effort vis à vis its rival, the Soviet Union.

June 1, 1961

Mr. James C. Hagerty
Vice President
American Broadcasting Company
7 West 66th Street
New York 23, New York

Dear Jim:

Since our discussion on May 19th I have given a good deal of thought to the proposal outlined in the letter you delivered to me on that date, that Alan Shepard and Yuri Gagarin appear together in New York City on a nation-wide telecast. I cannot see how Shepard's appearance would serve a useful purpose, and I believe it could be detrimental to the best interests of the United States.

Although, as I told you, your proposal involves national policy questions beyond my own direct responsibility, I feel that it is my duty to state my conviction that the whole plan is unwise.

The Mercury flight of Alan Shepard was performed before the eyes of the whole world. He reported his immediate experience and reactions at the press conference on May 8th in Washington. On June 6th Shepard and other members of the Space Task Group will give a full report on the results of the flight at a scientific and technical conference in Washington which will be widely reported and whose proceedings will be published. Further reporting could add nothing significant.

The free and open way in which we have proceeded to share our manned contrast to Soviet secrecy and their unsupported and conflicting descriptions of the Gagarin flight.

If, [2] as you have proposed, Gagarin would be free to tell his story in whatever manner he so desired, it is fair to assume it would not be in a full and complete factual framework but a rather in the same framework as previous reports.

Why then should we permit the Soviet Union to blunt the impact of the open conduct of our program by the use of a nation-wide telecast as a propaganda forum?

From past experience, the Russians might very well use Gagarin's appearance here in the United States to announce and to exploit, again without full facts, and to a large audience, another Russian manned flight, timed to coincide with his appearance here—perhaps a flight of two or three persons. In such a situation, to compare Shepard's sub orbital flight with that of Gagarin, or with some other Russian achievement, would be inconsistent with the reporting of the flight as only one step in the U.S. ten-year program for space exploration.

With regret that I cannot encourage your proposal, and with best wishes,
I am Sincerely yours,

[Signed]
James E. Webb
Administrator

Blind copy:
Mr. Lucius D. Battle, Director
Executive Secretariat
Department of State
Washington 25, D.C.

A
Webb:hhm
Cc: AD- Dryden
A- Phillips

Document I-38

Document Title: MR-4 Technical Debriefing Team, Memorandum for Associate Director, NASA, "MR-4 Postflight Debriefing of Virgil I. Grissom," 21 July 1961, with attached, "Debriefing."

Source: NASA Collection, University of Houston, Clear Lake Library, Clear Lake, Texas.

The second flight of the Mercury program, astronaut Gus Grissom's suborbital mission on 21 July1961, proved somewhat less successful than Alan Shepard's because of the loss of the capsule in the ocean. On Grissom's mission, an explosively actuated side hatch was used to blow open seventy 1/4-inch titanium bolts that secured the hatch to the doorsill. During the water recovery effort a premature explosion of the side hatch allowed the capsule to sink in 15,000 feet of water. Grissom vacated the spacecraft immediately after the hatch blew off and was retrieved after being in the water for about four minutes. Much of the debriefing for the mission, as shown in this memorandum, relates to this important mishap. How this incident took place has been a mystery ever since, with numerous theories abounding. Some thought Grissom panicked and prematurely hit the control to blow the hatch, either accidentally or on purpose to escape the capsule sooner. Others, especially test pilots who knew a steely-nerved Grissom, have publicly doubted that explanation. Some thought that seawater might have gotten into the system and somehow shorted it out. There is no definitive explanation, and recovery of his capsule from the Atlantic Ocean in 1999 did not yield any final answer to what happened during Grissom's flight.

NASA-Manned Spacecraft Center
Langely Field, Virginia
[7-21-61]

MEMORANDUM for Associate Director

Subject: MR-4 postflight debriefing of Virgil I. Grissom

1. The enclosures to this memorandum constitute Captain Grissom's complete debriefing of MR-4. The first enclosure is a general outline of the three sessions of the MR-4 debriefing. The second enclosure is an index of enclosures four, five and six which are Grissom's comments

relative to capsule engineering, operational procedures, and pilot performance. In these enclosures each answer by Captain Grissom is preceded by the question proposed except for enclosure four. The debriefing questionnaire used as a guide by the astronaut for this portion of the debriefing is included as enclosure three.

2. The basic concept of the debriefing was to allow the pilot to freely discuss the flight on board the recovery ship before entering into the direct question and answer sessions held at Grand Bahama Island and Cape Canaveral. An index was prepared which, it is hoped, will help direct the various systems' specialists to the information pertaining to their areas of interest.

3. To take full advantage of the information gained form the MR-4 pilot debriefing, it is suggested that a copy of this material be distributed to each branch of the Manned Spacecraft Center. It is requested that all comments on the debriefing be forwarded back to the Training Office.

MR-4 Technical Debriefing Team

[Signed]
Sigurd A. Sjoberg
Flight Operations Coordination

[Signed]
Robert B. Voas
Training Office

[Signed]
Helmut A. Kuehnel
Spacecraft Operations Branch

Enc: Debriefing
RGZ:srl
Copies to: All MSC Branches

[Debriefing: Only Paragraphs 11-13 provided]

11. Recovery – On landing, the capsule went pretty well under the water. Out the window, I could see nothing but water and it was apparent to me that I was laying pretty well over on my left side and little bit head down. I reached the rescue aids switch and I heard the reserve chute jettison and I could see the canister in the water through the periscope. Then, the capsule righted itself rather rapidly and it was apparent to me that I was in real good shape, and I reported this. Then I got ready to egress. I disconnected the helmet from the suit and put the neck dam up. The neck dam maybe had been rolled up too long, because it didn't unroll well. It never did unroll fully. I was a little concerned about this in the water because I was afraid I was shipping a lot of water through it. In fact, the suit was quite wet inside, so I think I was. At this point, I thought I was in good shape. So, I decided

to record all the switch positions just like we had planned. I took the survival knife out of the door and put it into the raft. All switches were left just the way they were at impact, with the exception of the rescue aids and I recorded these by marking them down on the switch chart in the map case and then put it back in the map case. I told Hunt Club they were clear to come in and pick me up whenever they could. Then, I told them as soon as they had me hooked and were ready, I would disconnect my helmet take it off, power down the capsule, blow the hatch, and come out. They said, "Roger," and so, in the meantime, I took the pins off both the top and the bottom of the hatch to make sure the wires wouldn't be in the way, and then took the cover off the detonator.

12. I was just waiting for their call when all at once, the hatch went. I had the cap off and the safety pin out, but I don't think that I hit the button. The capsule was rocking around a little but there weren't any loose items in the capsule, so I don't see how I could have hit it, but possibly I did. I had my helmet unbuttoned and it wasn't a loud report. There wasn't any doubt in my mind as to what had happened. I looked out and saw nothing but blue sky and water starting to ship into the capsule. My first thought was to get out, and I did. As I got out, I saw the chopper was having trouble hooking onto the capsule. He was frantically fishing for the recovery loop. The recovery compartment was just out of the water at this time and I swam over to help him get his hook through the loop. I made sure I wasn't tangled anyplace in the capsule before swimming toward the capsule. Just as I reached the capsule, he hooked it and started lifting the capsule clear. He hauled the capsule away from me a little bit and didn't drop the horsecollar down. I was floating, shipping water all the time, swallowing some, and I thought one of the other helicopters would come in and get me. I guess I wasn't in the water very long but it seemed like an eternity to me. Then, when they did bring the other copter in, they had a rough time getting the horsecollar to me. They got in within about 20 feet and couldn't seem to get it any closer. When I got the horsecollar, I had a hard time getting it on, but I finally got into it. By this time, I was getting a little tired. Swimming in the suit is difficult, even though it does help keep you somewhat afloat. A few waves were breaking over my head and I was swallowing some water. They pulled me up inside and then told me they had lost the capsule.

13. Before I end this debriefing, I want to say that I'll ever be grateful to Wally [Astronaut Walter Schirra] for the work he did on the neck dam. If I hadn't had the neck dam up, I think I would have drowned before anyone could have gotten to me. I just can't get over the fact that the neck dam is what saved me today.

Document I-39

Document Title: Robert R. Gilruth, Director, Space Task Group, NASA, to Marshall, NASA, (attention: Dr. Wernher von Braun), "Termination of Mercury Redstone Program," 23 August 1961.

Source: National Archives and Record Administration, Fort Worth, Texas.

A typical approach to flight research involves the slow and systematic advancement of the various parameters of the research project until the team completes the task at hand. As an example, Chuck Yeager in 1947 did not just kick the tires of his airplane and then fly the X-1 beyond the space of sound. He and several other research pilots worked with a team of aerospace engineers for months methodically advancing the X-1's flight regime until they were ready to make a supersonic flight. The Space Task Group, all of whom had enjoyed early experience in flight test, took the same approach with Project Mercury. After several missions without astronauts aboard, they then flew two suborbital missions with Alan Shepard and Gus Grissom on 5 May and 21 July 1961. They were quite prepared, and had planned for, a third suborbital mission but, as this memorandum makes clear, it would have been redundant of what had already been accomplished and was unnecessary to the systematic progression of the Mercury program. Accordingly, Space Task Group Director Robert Gilruth announced to his counterpart at the Marshall Space Flight Center, Wernher von Braun, that NASA Headquarters had approved cancellation of the third suborbital mission, so that NASA could move on to the orbital part of the research program. Because of this decision, Mercury would not need any additional Redstone rockets from the von Braun team, since orbital missions would be launched atop Atlas boosters.

Langley Field, Va.
August 23, 1961

From Space Task Group
To Marshall

Attention: Dr. Wernher von Braun

Subject: Termination of Mercury-Redstone Program

1. Approval has been received from NASA Headquarters to cancel the previously scheduled third manned suborbital flight and to terminate the Mercury-Redstone program. The objectives of this program have been achieved.

2. In the near future, personnel from the Space Task Group will visit Marshall to discuss disposition of the remaining boosters and Ground Support Equipment incurred in those activities.

3. I wish to take this opportunity again to thank you and your staff for the fine team effort displayed in accomplishing the Mercury-Redstone program.

[Signed]
Robert R. Gilruth
Director

Copy to: NASA Hq- Attn: Mr G. M. Low, DM

Document I-40

Document Title: Abe Silverstein, Director of Space Flight Programs, NASA, Memorandum for Administrator, "Use of a Television System in Manned Mercury-Atlas Orbital Flights," 6 September 1961.

Source: Folder 18674, NASA Historical Reference Collection, NASA History Division, NASA Headquarters, Washington DC.

NASA officials recognized the general public's keen interest in the human spaceflight missions that took place during Project Mercury. They also recognized the propaganda value of these flights for the U.S. during the cold war rivalry with the Soviet Union. At the same time, they were engineers who made virtually all of their decisions on the basis of technical data. As this memorandum demonstrates, Edward R. Murrow, the most respected journalist in the U.S. and the new Director of the U.S. Information Agency, had requested a television hook-up from space for orbital Mercury missions. Murrow's request reflected a desire to show the world that the U.S. was second to none technologically, something many non-aligned peoples questioned at the time. Reviewing the necessary technical components of such a broadcast capability, NASA's Director of Space Flight Programs Abe Silverstein concluded that reconfiguring the Mercury capsule's power, communications, and weight structures at that time would be detrimental to the overall objectives of the program. When the Gemini program flew in 1965 to1966 it did incorporate television, and the broadcasts from the Moon during the Apollo program became legendary.

In reply refer to:

DM (RJW:vr)

SEP 6 1961

MEMORANDUM for Administrator

Subject: Use of a Television System in Manned Mercury-Atlas Orbital Flights

References: (a) Memo frm AA/Romatowski to D/Silverstein
Dtd 9/5/61, same subject
(b) Ltr frm USIA (Murrow) to A/Webb, dtd 8/29/61

1. In accordance with the request made in reference (a), I have prepared the following comments to be used as a basis for a reply to reference (b).

2. The use of a television system in the Mercury capsule has been studied throughout the history of the project. Initially, the weights involved were prohibitive; now, light-weight television systems are considered feasible. As a result, within the last few months the question of a television system for the Mercury capsule has again been raised.

3. Studies of present television systems indicate that a complete system (camera and transmitter) for the Mercury capsule would weigh less than twenty-five pounds. The corresponding power and antenna requirements,

plus the heat exchanger, however, increase the total capsule weight beyond acceptable limits.

Furthermore, the necessary redesign of the antenna and heat exchanger systems will require considerable testing and development before reliability and confidence is increased to that required for manned flight. In addition, the inclusion of a television system in the capsule communication link will raise R.F. compatibility problems which in the past required months of tests and developments to solve. For example, ground tests indicate that extraneous R.F. signals or even incompatible systems can cause an inadvertent abort or improper ground command during flight. [2]

4. There is no doubt that at this time a change in the communication system of this magnitude will compromise the Mercury schedule, the reliability of the entire system, and the safety of the pilot. The use of television in our manned flight program must await future flight projects when adequate booster capability will be available to carry the increased payload and when an integrated television-communication system can be designed, developed and suitably tested.

[Signed]
Abe Silverstein
Director of Space Flight Programs

Document I-41

Document Title: Dr. Robert B. Voas, Training Officer, NASA, Memorandum for Astronauts, "Statements for Foreign Countries During Orbital Flights," 7 November 1961.

Source: Folder 18674, NASA Historical Reference Collection, NASA History Division, NASA Headquarters, Washington DC.

The importance of the Mercury program to the larger cold war rivalry with the Soviet Union is demonstrated by this memorandum concerning the possibility of radio transmissions relating news about the missions to various foreign nations. One of the key aspects of the early space race involved persuading non-aligned peoples in the cold war of the superiority of the U.S. and its way of life over that offered by the Soviet Union's communism. Directly speaking to some of these peoples from space might help sway their opinions. At the same time, the desire to appear genuine, unscripted as to remarks, and non-propagandistic motivated this discussion of commentary by the astronauts. In the end, the Mercury Seven performed their roles quite well, making interesting remarks via radio that were heard around the world.

NASA Manned Spacecraft Center
Langley Air Force Base, Virginia
November 7, 1961

MEMORANDUM: For Astronauts

Subject: Statements for foreign countries during orbital flights

1. The undersigned has attempted to get guidance within the NASA organization on the policy to be pursued in making statements of possible political significance from the Mercury capsule. In pursuing this question, he was referred to Mr. Goodwin of NASA Headquarters. Mr. Goodwin made the following suggestions. These he apparently discussed with Mr. Lloyd and the Administrator and they have their approval.

    a. It is essential that any statements made by the Astronauts appear to be spontaneous, personal and unrehearsed. He felt that there was a general agreement that statements made by the Russian Cosmonauts were not effective and backfired. There was a general feeling that they were being used inappropriately for propaganda. He agreed strongly with our own feeling that any political statement would look out of place. Mr. Goodwin also thought that statements in a foreign language could be dangerous, because unless there was a good basis to believe they were spontaneous, they would appear to be contrived. Thus, if the Astronaut spoke in Hindustani during the flight, the inevitable question could be raised in the press conference following the flight, "How did the Astronaut come to know Hindustani?" Unless he could show that it was a course given in the high school or college which he attended, it would be obvious that this statement had been politically inspired. The one point at which a foreign language might effectively be used would be over the Mexican station. Here, a few words of Spanish, such as, "Saludos Amigos," might be quite appropriate and since simple Spanish phrases are known by many Americans, it would not appear contrived.

2. While Mr. Goodwin did not feel that either a political statement as such, or statements in foreign languages, would be useful, he did feel that descriptions by the Astronaut in English of the terrain over which he was passing and personal statements of how he felt and reacted to the situation would be highly desirable and effective if released to foreign personnel. The primary requirement here on the Astronaut would be to be familiar enough with the political boundaries, to be able to relate his observation of the ground to the countries over which he is passing. This way, he could report, for example, "I see it is a sunny day in Nigeria," or "I can still see Zanzibar, but it looks like rain is on the way." To these observations related directly to the country should be added any personal observations such as, "I feel fine; weightlessness doesn't bother me a bit; it's just like flying in an aircraft, etc." In all such statements, care must be taken not to make them appear to be contrived, maudlin or too effusive. Rather, they should be genuine, personal and with immediate impact. Mr. Goodwin points out that the ideas and words expressed are more important to communication than using the actual language of the country. If the experience which the Astronaut is having can be expressed in personal, simple, meaningful terms, when translated, this will be far

more effective than a few words in a foreign language which, in the long run, might appear contrived.

3. Mr. Marvin Robinson of Mr. Lloyd's office is preparing a set of very short statements which might be made over each of the range stations. These statements are designed to strengthen the position of the nation in the use of these facilities. These statements will be forwarded through channels and can be considered by the Astronauts for use during the flight. The best use of such statements might be to have the Astronaut extract the general meaning, but to make the statement in his own words and in his own way at the proper time.

4. In summary, it appears desirable for the Astronaut

   a. To learn to recognize the political boundaries of the countries over which he passes in terms of the geographical features which will be visible to him from orbit, and

   b. To take any time available to him during the flight to describe his view of the earth and his personal feelings in simple, direct, terms.

Dr. Robert B. Voas
Training Officer

RBV.ncl

Document I-42

Document Title: Telegram, NASA—Manned Spacecraft Center, Port Canaveral, Florida, to James A. Webb and others, NASA, Washington, DC, "MA-6 Postlaunch Memorandum," 21 February 1962.

Source: Source: Folder 18674, NASA Historical Reference Collection, NASA History Division, NASA Headquarters, Washington, DC.

The Mercury Atlas 6 flight carrying John Glenn was the first astronaut-carrying orbital flight of the Mercury spacecraft and thus a milestone for the American space program. Despite the dramatic achievement of Glenn's flight, the engineers conducting the program were primarily interested in evaluating the performance of the vehicle and using that information for upcoming flights. This is an initial telegram from the launch site to NASA Administrator James Webb immediately after the launch reported on the performance of the Atlas launch vehicle and Mercury spacecraft.

[Handwritten note: "MA-6 Postlaunch Memo"] [DECLASSIFIED]

FROM: NASA – MANNED SPACECRAFT CENTER
PORT CANAVERAL, FLA

TO: NASA HEADQUARTERS
WASHINGTON DC
ATTN: MR JAMES A WEBB, A

NASA HEADQUARTERS
WASHINGTON DC
ATTN: MR D BRAINERD HOLMES

DIRECTOR, OFFICE OF MANNED SPACE FLIGHT
NASA – MANNED SPACECRAFT CENTER
LANGLEY AFB, VA
ATTN: MR ROBERT R GILRUTH, DIRECTOR

INFO
HQ SPACE SYSTEMS DIV
LOS ANGELES CAL
ATTN: LT COL R H BRUNDIN, SSVM

ZEN
NASA LOD
GCMSFC
TITUSVILLE FLA

PMFO 24 CONFIDENTIAL.

SUBJECT: MA-6 POSTLAUNCH MEMORANDUM.

1.0 GENERAL-

THE MA-6 VEHICLE, SCHEDULED FOR LAUNCH AT 07:30 EST, FEB. 20, 1962, WAS LAUNCHED AT 09:48 EST. THE THREE-ORBIT

[signed]
Walter C Williams
Associate Director

[2]

MISSION WITH ASTRONAUT JOHN GLENN ABOARD THE CAPSULE WAS ACCOMPLISHED AS PLANNED, AND ALL TEST OBJECTIVES WERE ACCOMPLISHED. MALFUNCTIONS WERE INDICATED FROM CAPSULE INSTUMENTATION IN THE INVERTER COLD-PLATES, IN THE AUTOMATIC

CONTROL SYSTEM, AND IN THE LANDING BAG DEPLOYMENT SYSTEM. CONFIRMATION OF THE EXISTENCE AND NATURE OF THESE INDICATED MALFUNCTIONS WILL REQUIRE A THOROUGH EVALUATION OF DATA. THE LANDING BAG PROBLEM RESULTED IN A DECISION TO REENTER WITHOUT JETTISONING THE RETROPACK. THE LANDING OCCURRED WITHIN VISUAL RANGE OF THE DESTROYER NOA STATIONED APPROXIMATELY 45 NAUTICAL MILES UP RANGE OF THE CENTER OF THE THIRD ORBIT LANDING AREA. LANDING OCCURRED AT APPROXIMATELY 1943Z AND THE SHIP WAS ALONGSIDE FOR RETRIEVAL AT APPROXIMATELY 1959Z. MERCURY NETWORK OPERATION WAS HIGHLY SATISFACTORY FOR THE MISSION. THE ONLY MAJOR PROBLEM OCCURRED AT APPROXIMATELY T-12 MINUTES AS A RESULT OF POWER SOURCE FAILURE AT THE BERMUDA COMPUTER.

2.0 MAJOR TEST OBJECTIVES.-

(A) EVALUATE THE PERFORMANCE OF A MAN-SPACECRAFT SYSTEM IN THREE-ORBIT MISSION.

(B) EVALUATE THE EFFECTS OF SPACE FLIGHT ON THE ASTRONAUT.

(C) OBTAIN THE ASTRONAUT'S OPINIONS ON THE OPERATIONAL SUITABILITY OF THE SPACECRAFT AND SUPPORTING SYSTEMS FOR MANNED SPACE FLIGHT.

3.0 LAUNCH OPERATIONS

THE 390 MINUTE COMBINED COUNT BEGAN AT 23:30 EST, [3] FEB. 19, 1962. A TOTAL HOLD TIME OF 227 MINUTES WAS USED DURING THE COUNT. THE INDIVIDUAL HOLDS WERE AS FOLLOWS:

04:00 EST – T-120	90 MINUTES PLANNED HOLD.
05:30 EST – T-120	55 MINUTES TO CHANGE GE RATE BEACON.
07:25 EST – T-60	40 MINUTES TO REMOVE AND REPLACE A CAPSULE HATCH BOLT.
08:20 EST – T-45	15 MINUTES TO TOP OFF THE FUEL TANK AND MOVE THE SERVICE TOWER.
08:58 EST – T-22	25 MINUTES TO COMLETE LOX TANKING. A MAIN LOX PUMP FOILED AND TANKING WAS ACCOMPLISHED WITH THE TOPPING PUMP.
09:39 EST – T-6:30	2 MINUTES TO VERIFY MERCURY COMPUTER IN BERMUDA.

4.0 WEATHER. –

WEATHER IN THE LAUNCH AREA WAS INITIALLY UNSATISFACTORY FOR REQUIRED CAMERA COVERAGE BECAUSE OF LOW OVERCAST. BY APPROXIMATELY 09:00 EST, A CLEARING TREND WAS EVIDENT AND BY LAUNCH TIME CONDITIONS WERE ENTIRELY STATISFACTORY AS FOLLOWS:

CLOUDS – 2/10 ALTO CUMULUS

WIND – 18 KNOTS FROM 360 DEGREES WITH GUSTS TO 25 KNOTS

VISIBILITY – 10 MILES

TEMPERATURE – 70 DEG. F.

WEATHER AND SEA CONDITIONS IN ALL ATLANTIC RECOVERY AREAS WERE REPORTED SATISFACTORY PRIOR TO LAUNCH. THE CONDITIONS REPORTED BY THE RANDOLF IN THE THIRD ORBIT LAND AREA JUST PRIOR TO CAPSULE LANDING AREA AS FOLLOWS: [4]

CLOUDS – 2/10

WINDS – 14 KNOTS FROM 119 DEGREES

WAVE HEIGHT – 2 FT

5.0 TRAJECTORY AND EVENTS.-

(A) <u>FLIGHT-PATH CONDITIONS AT SECO</u>	<u>PLANNED</u>	<u>ACTUAL</u>
INERTIAL VELOCITY, FT/SEC	25,715	25,709
INERTIAL FLIGHT-PATH ANGLE, DEGREES	0	-.05
ALTITUDE, NAUTICAL MILES (PERIGEE)	87	86.7 N.M.
ALTITUDE, NAUTICAL MILES (APOGEE)	144	141.0 N.M.

<u>(B) EVENTS</u>	<u>PLANNED TIME</u>	<u>ACTUAL TIME</u>
BOOSTER ENGINE CUTOFF	00:02:11.3	00:02:11
ESCAPE TOWER JETTISON	00:02:34.1	00:02:33
<u>(B) EVENTS</u>	<u>PLANNED TIME</u>	<u>ACTUAL TIME</u>
SUSTAINER ENGINE CUTOFF (SECO)	00:05:03.8	00:05:04
CAPSULE SEPARATION	00:05:04.8	00:05:05
CAPSULE SEPARATION	00:05:04.8	00:05:05
CAPSULE TURNAROUND COMPLETED	00:05:35.0	APPEARED NORMAL
START OF RETROFIRE	04:32:58	04:33:08
RETROPACK JETTISON	04:33:58	NOT AVAILABLE
START OF REENTRY (.05G)	04:43:53	NOT AVAILABLE
DROGUE CHUTE DEPLOYED (21,000 FT)	04:50:00	04:49:17

MAIN CHUTE DEPLOYED (10,000 FT)	04:50:36	NOT AVAILABLE
LANDING	04:55:22	NOT AVAILABLE

[5]

6.0 BOOSTER PERFORMANCE. –

VERNIER, SUSTAINER, BOOSTER IGNITION AND TRANSITION TO MAISTAGE WERE NORMAL. LIFT-OFF WAS CLEAN AND ALL EVENTS OCCURRED AS PLANNED. THERE WAS NO ABNORMAL DAMAGE TO THE STAND.

7.0 CAPSULE SYSTEMS PERFORMANCE.-

PERFORMANCE OF THE CAPSULE SYSTEMS WAS SATISFACTORY WITH THE FOLLOWING EXCEPTIONS:

(A) BOTH INVERTERS (150 AND 250 UA) REACHED TEMPERATURES ABOVE 200 DEG. F., PROBABLY AS A RESULT OF INVERTER COLD-PLATE MALFUNCTION, OR FREEZING OF WATER IN THE LINES SUPPLYING THE COLD PLATES.

(B) THE AUTOMATIC CONTROL SYSTEM AFTER 1 ORBIT WAS NOT ABLE TO MAINTAIN THE FINE YAW CONTROL (ORBIT MODE) BUT THE WIDE TOLERANCE PORTION OF THE SYSTEM FUNCTIONED SATISFACTORILY (ORIENTATION MODE). THE FLY-BY-WIRE SYSTEM HAD A MINOR MALFUNCTION LATE IN THE FLIGHT CAUSING LOSS OF CONTROL OF ONE OF THE ONE-POUND THRUSTERS. THE HORIZON SCANNER SYSTEM APPEARED TO HAVE PROBLEMS PROVIDING THE PROPER GYRO REFERENCE ON THE DARK SIDE OF THE EARTH DURING THE SECOND AND THIRD ORBIT.

(C) AN INTERMITTENT INDICATION THAT THE LANDING BAG WAS DEPLOYED WAS EVIDENT FROM CAPSULE INSTUMENTATION, AND THE STATUS OF THE LANDING BAG COULD NOT BE CONFIRMED. THIS PROBLEM RESULTED IN A DECISION TO REENTER WITHOUT JETTISONING THE RETROROCKET PACKAGE. EXTENSIVE EVALUATION OF CAPSULE [6] SYSTEMS DATA WILL BE REQUIRED TO CONFIRM THE EXISTENCE AND ESTABLISH THE NATURE OF THE INDICATED MALFUNCTIONS.

8.0 ASTRONAUT PERFORMANCE

ASTRONAUT JOHN GLENN PERFORMED WELL AND REPORTED FEELING WELL THOUGHOUT THE MISSION. NORMAL VALUES OF HEART RATE, RESPIRATION RATE AND BLOOD PRESSURE WERE REPORTED BY THE [7] MONITORING STATIONS FOR MOST OF THE FLIGHT. ALL PHYSIOLOGICAL SENSORS OPERATED PROPERLY AND DATA WERE OF GOOD QUALITY.

9.0 THE MONITORING OF THE FLIGHT FROM TELEMETRY AND AIR/ GROUND

VOICE INFORMATION WAS EXCELLENT, PROVIDING THE MERCURY CONTROL CENTER WITH ALL THE INFORMATION REQUIRED TO GIVE THE PILOT TECHNICAL ADVICE AND ASSISTANCE. DURING ALL PHASES OF THE FLIGHT THE FLOW OF DATA TO AND FROM THE NETWORK SITES AND THE CONTROL CENTER WAS RAPID AND ADEQUATE, SO THAT BOTH GROUND PERSONNEL AND FLIGHT CREW WERE CONTINUALLY IN AGREEMENT AS TO STATUS OF TRAJECTORY, CAPSULE, SYSTEMS, AND PILOT. OF PARTICULAR SIGNIFICANCE IN PROVIDING REAL TIME INFORMATION TO THE CONTROL CENTER WAS THE RELAYING OF AIR/

GROUND VOICE FROM ALL SITES WHICH HAVE POINT-TO-POINT VOICE. THE PROBLEMS ENCOUNTERED WERE WELL COORDINATED WITH THE PILOT, AND THIS DEFINITELY AIDED IN THE ULTIMATE SUCCESSFUL COMPLETION OF THE MISSION. [8]

10.0 NETWORK PERFORMANCE.-

NETWORK PERFORMANCE WAS HIGHLY SATISFACTORY FOR THIS MISSION. THE COMPUTER CONTROLLED NETWORK TESTS WERE CONDUCTED DURING THE COUNTDOWN AND CONFIRMED NETWORK READINESS WITH THE EXCEPTION OF RADAR DIFFICULTIES DETECTED AT CAPE CANAVERAL AND BERMUDA. THESE DIFFICULTIES WERE CORRECTED PRIOR TO LAUNCH. A TWO-MINUTE HOLD IN THE COUNTDOWN WAS REQUIRED AT T-2 MINUTES AS A RESULT OF POWER SOURCE FAILURE AT THE BERMUDA COMPUTER AT APPROXIMATELY T-12 MINUTES. DURING LAUNCH AND RADAR HANDOVER WITH BERMUDA, AN UNIDENTIFIED C-BAND RADAR ATTEMPTED CAPSULE TRACK. THIS CAUSED INTERFERENCE WITH THE BERMUDA ACQUISITION PHASE BUT ACQUISITION WAS ACHIEVED ANYWAY. TELETYPE AND VOICE COMMUNICATIONS WITH NETWORK SITES, AND RELAY OF AIR-TO-GROUND COMMUNICATIONS TO MERCURY CONTROL CENTER WERE EXCELLENT. EXCELLENT PERFORMANCE WAS ALSO OBTAINED FROM TRACKING SUBSYSTEMS INCLUDING RADAR, ACQUISITION, TELEMETRY, COMMAND CONTROL, AND AIR/GROUND VOICE.

11.0 RECOVERY.-

RECOVERY FORCES WERE POSITIONED TO PROVIDE A RECOVERY CAPABILITY IN THE END OF ORBIT LANDING AREAS, THE ATLANTIC

ABORT LANDING AREAS, AND IN CONTINGENCY RECOVERY AREAS ALONG THE ORBIT GROUND TRACK. RECOVERY READINESS WAS SATISFACTORY IN ALL RESPECTS AT LAUNCH. [9]

THE LANDING OCCURRED WITHIN VISUAL RANGE OF THE DESTROYER NOA, STATIONED APPROXIMATELY 45 NAUTICAL MILES UPRANGE OF THE CENTER OF THE THIRD ORBIT LANDING AREA. THE NOA SIGHTED THE PARACHUTE DURING CAPSULE DESCENT AT A RANGE OF ABOUT 5 MILES AND ESTABLISHED COMMUNICATIONS WITH THE ASTRONAUT. THE SHIP REPORTED THAT LANDING OCCURRED AT APPROXIMATELY 1943Z AND THE SHIP WAS ALONGSIDE FOR RETRIEVAL AT APPROXIMATELY 1959Z. THE ASTRONAUT REMAINED IN THE CAPSULE DURING PICKUP AND THE CAPSULE WAS ABOARD AT ABOUT 2004Z. THE ASTRONAUT THEN LEFT THE CAPSULE THROUGH THE SIDE HATCH AFTER FIRST ATTEMPTING A TOP EGRESS WITHOUT SUCCESS. FOLLOWING INITIAL DEBRIEFING ON THE NOA THE ASTRONAUT WAS TRANSFERRED BY HELICOPTER TO THE AIRCRAFT CARRIER RANDOLF FOR FURTHER TRANSFER TO GRAND TURK. HE ARRIVED AT GRAND TURK AT ABOUT 0145Z. WALTER C. WILLIAMS, ASSOCIATE DIRECTOR.

SCP-4

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CCK

COPY TO: NASA Hq – Attn.: Mr. G. M. Low, MS

Goddard SFC – Attn: Dr. H. J. Goett

J. C. Jackson

Flight Operations Div
Data Coordination
Mercury Project Office (6)
Preflight Operations Div
Mercury Atlas Office
E. H. Buller

Document I-43

Document Title: R. B. Voas, NASA, Memorandum for Those Concerned, "MA-6 Pilot's Debriefing," 22 February 1962, with attached, John Glenn, NASA, "Brief Summary of MA-6 Orbital Flight," 20 February 1962.

Source: NASA Collection, University of Houston, Clear Lake Library, Clear Lake, Texas.

Mercury Atlas-6's flight carrying John Glenn on a three orbit mission around Earth proved enormously successful for the U.S. despite several technical problems. In this debriefing, Glenn describes what took place while in Earth orbit. He describes the problem with his low-rate attitude thrusters and his manual correction of the problem, as well as his capsule's reentry with its retrorocket pack attached in case the heatshield had come loose during the mission. This debriefing, analysis of the capsule, and review of the telemetry and other data from this mission led to more rigorous testing of the capsules and procedures used on the three following Mercury orbital flights.

PRELIMINARY

[2-22-62]

MEMORANDUM for Those Concerned

Subject: MA-6 Pilot's Debriefing

The enclosure to this memorandum is an edited transcript of the pilot's debriefing aboard the destroyer Noa and at Grand Turk on February 20, 21, and 22. This transcript is released in a PRELIMINARY form in order to aid in the writing of the postlaunch report. A more finished, edited, and index text of the postflight debriefing similar to the documents on the pilot's debriefings for the MR-3 and 4 flights will be issued at a later date. Request for clarification of any of this material should be sent to the Training Office.

The format of the enclosure is as follows:

1. Astronaut's brief narrative account of the flight.
2. Specific questions keyed to a chronological review of the flight.
    a. Prelaunch

   b. Launch and powered flight
   c. Zero G phase
   d. Reentry
   e. Landing
   f. Recovery

3. Miscellaneous questions covering the pilot's evaluation of capsule systems.
4. Description by John Glenn of the special astronomical, meteorological and terrestrial observations.
5. Discussion of the predominant sensations during launch and powered flight.
6. Miscellaneous discussion of flight activities by the astronaut. (This section was taken from recordings of several hours of discussion with personnel at Grand Turk. Time has not permitted organizing this material under appropriate headings.

[Signed]
R.B. Voas

[2]

Brief Summary of MA-6 Orbital Flight*

By John H. Glenn, Jr

[*Based on recorded debriefing onboard the destroyer Noa shortly after the MA-6 mission on February 10, 1962.]

There are many things that are so impressive, it's almost impossible to try and describe the sensations that I had during the flight. I think the thing that stands out more particularly than anything else right at the moment is the fireball during the reentry. I left the shutters open specifically so I could watch it. It got a brilliant orange color; it was never too blinding. The retropack was still aboard and shortly after reentry began, it started to break up in big chunks. One of the straps came off and came around across the window. There were large flaming pieces of the retropack – I assume that's what they were – that broke off and came tumbling around the sides of the capsule. I could see them going on back behind me then making little smoke trails. I could also see a long trail of what probably was ablation material ending in a small bright spot similar to that in the pictures out of the window taken during the MA-5 flight. I saw the same spot back there and I could see it move back and forth as the capsule oscillated slightly. Yes, I think the reentry was probably the most impressive part of the flight.

Starting back with highlights of the flight: Insertion was normal this morning except for the delays that were occasioned by hatch-bolt trouble and by the microphone fitting breaking off in my helmet. The weather cleared up nicely and after only moderate delays, we got off.

Lift-off was just about as I had expected. There was some vibration. Coming up off the pad, the roll programming was very noticeable as the spacecraft swung around to the proper azimuth. There also was no doubt about when the pitch programming started. There was some vibration at lift-off from the pad. It smoothed out just moderately; never did get to very smooth flight until we were through the high q area. At this time – I would guess a minute and fifteen to twenty seconds – it was very noticeable. After this, it really smoothed out and by a minute and a half, or about the time cabin pressure sealed off, it was smooth as could be.

The staging was normal, though I had expected a more sharp cutoff. It felt as though the g ramped down for maybe half a second. For some reason, it was not as abrupt as I had anticipated it might be. The accelerometers read one and a quarter g's when I received a confirmation on staging from the Capsule Communicator. I had been waiting for this message at that point because I was set to go to tower jettison as we had planned, in case the booster had not staged. At this time, I also saw a wisp of smoke and I thought perhaps the tower had jettisoned early. The tower really had not jettisoned at that time and did jettison on schedule at 2+34. As the booster and capsule pitched over and the tower jettisoned, I had a first glimpse of the horizon; it was a beautiful sight, looking eastward across the Atlantic.

[2]

Toward the last part of the insertion, the vibration began building up again. This I hadn't quite expected; it wasn't too rough but it was noticeable. Cutoff was very good; the capsule acted just as it was supposed to. The ASCS damped and turned the spacecraft around. As we were completing the turnaround, I glanced out of the window and the booster was right there in front of me. It looked as though it wasn't more than a hundred yards away. The small end of the booster was pointing toward the northeast and I saw it a number of times from then on for about the next seven or eight minutes as it slowly went below my altitude and moved farther way. That was very impressive.

I think I was really surprised at the ease with which the controls check went. It was almost just like making the controls check on the Procedures Trainer that we've done so many times. The control check went off like clockwork; there was no problem at all. Everything damped when it should damp and control was very easy. Zero-g was noticeable at SECO. I had a very slight sensation of tumbling forward head-over-heels. It was very slight; not as pronounced an effect as we experience on the centrifuge. During turnaround, I had no sensation of angular acceleration. I acclimated to weightlessness in just a matter of seconds; it was very surprising. I was reaching for switches and doing things and having no problem.

I didn't at any time notice any tendency to overshoot a switch. It seemed it's just natural to acclimate to this new condition. It was very comfortable. Under the weightless condition, the head seemed to be a little farther out of the couch which made it a little easier to see the window, though I could not get up quite as near to the window as I thought I might.

The rest of the first orbit went pretty much as planned, with reports to the stations coming up on schedule. I was a little behind at a couple of points but most of the things were going right according to schedule, including remaining on the automatic control system for optimum radar and communications tracking. Sunset from this altitude is tremendous. I had never seen anything like this and it was truly a beautiful, beautiful sight. The speed at which the sun goes down is very remarkable, of course. The brilliant orange and blue layers spread out probably 45-60 degrees each side of the sun tapering very slowly toward the horizon. I could not pick up any appreciable Zodiacal light. I looked for it closely; I think perhaps I was not enough night adapted to see it. Sunrise, I picked up in the periscope. At every sunrise, I saw little specks, brilliant specks, floating around outside the capsule. I have no idea what they were. On the third orbit, I turned around at sunrise so that I could face into the sun and see if they were still heading in the same direction and they were. But I noticed them every sunrise and tried to get pictures of them.

[3]

Just as I came over Mexico at the end of the first orbit, I had my first indication of the ASCS problem that was to stick with me for the rest of the flight. It started out with the yaw rate going off at about one and one-half degrees per second to the right. The capsule would not stay in orbit mode, but would go out of limits. When it reached about 20 degrees instead of the 30 degrees I expected, it would kick back into orientation mode and swing back with the rate going over into the left yaw to correct back into its normal orbit attitude. Sometimes, it would cross-couple into pitch and roll and we'd go through a general disruption of orbit mode until it settled down into orbit attitude. Then yaw would again start a slow drift to the right and the ASCS would kick out again into orientation mode. I took over manually at that point and from then on, through the rest of the flight, this was my main concern. I tried to pick up the flight plan again at a few points and I accomplished a few more things on it, but I'm afraid most of the flight time beyond that point was taken up with checking the various modes of the ASCS. I did have full control in fly-by-wire and later on during the flight, the yaw problem switched from left to right. It acted exactly the same, except it would drift off to the left instead of the right. It appeared also that any time I was on manual control and would be drifting away from the regular orbit attitude for any appreciable period of time that the attitude indications would then off when I came back to orbit attitude. I called out some of these and I remember that at one time, roll was off 30 degrees, yaw was off 35 degrees, and pitch was off 76 degrees. These were considerable errors and I have no explanation for them at this time. I could control fly-by-wire and manual very adequately. It was not difficult at all. Fly-by-wire was by far the most accurate means of control, even though I didn't have accurate control in yaw at all times.

Retrorockets were fired right on schedule just off California and it was surprising coming out of the Zero-g field that retrorockets firing felt as though I were accelerating in the other direction back toward Hawaii. However, after retrofire was completed when I could glance out the window again, it was easy to tell, of course, which way I was going, even though my sensations during retrofire on automatic control. Apparently, the solid-on period for slaving just prior to retrofire brought the gyros back up to orbit attitude, because they corrected very nicely during that period. The spacecraft was just about in orbit attitude as I could see it from the window and through the periscope just prior to retrofire. So, I feel that we were right in attitude. I left it on ASCS and backed up manually and worked right along with the ASCS during retrofire. I think the retroattitude held almost exactly on and I would guess that we were never more than 3 degrees off in any axis at any time during retrofire.

[4]

Following retrofire, a decision was made to have me reenter with the retropackage still on because of the uncertainty as to whether the landing bag had been extended. I don't know all the reasons yet for that particular decision, but I assume that it had been pretty well thought out and it obviously was. I punched up .05g manually at a little after the time it was given to me. I was actually in a small g-field at the time I pushed up .05g and it went green and I began to get noise, or what sounded like small things brushing against the capsule. I began to get this very shortly after .05g and this noise kept increasing. Well before we got into the real heavy fireball area, one strap swung around and hung down over the window. There was some smoke. I don't know whether the bolt fired at the center of the pack or what happened. The capsule kept on its course. I didn't get too far off the reentry attitude. I went to manual control for reentry after the retros fired and had no trouble controlling reentry attitude through the high-g area. Communications blackout started a little bit before the fireball. The fireball was very intense. I left the shutters open the whole time and observed it and it got to be a very bright orange color. There were large, flaming pieces of what I assume was the retropackage breaking off and going back behind the capsule. This was of some concern, because I wasn't sure of what it was. I had visions of them possibly being chunks of heat shield breaking off, but it turned out it was not that.

The oscillations that built up after peak-g were more than I could control with the manual system. I was damping okay and it just plain overpowered me and I could not do anymore about it. I switched to Aux. Damp as soon as I could raise my arm up after the g-pulse to help damp and this did help some. However, even on Aux. Damp, the capsule was swinging back and forth very rapidly and the oscillations were divergent as we descended to about 35,000 feet. At this point, I elected to try to put the drogue out manually, even though it was high, because I was afraid we were going to get over to such an attitude that the capsule might actually be going small end down during part of the flight if the oscillations kept going the way they were. And just as I was reaching up to pull out the drogue on manual, it came out by itself. The drogue did straighten the capsule out in good shape. I believe the altitude was somewhere between 30,000 and 35,000 at that point.

I came on down; the snorkels, I believe, came out at about 16,000 or 17,000. The periscope came out. There was so much smoke and dirt on the windshield that it was somewhat difficult to see. Every time I came around to the sun – for I had established my roll rate on manual – it was virtually impossible to see anything out through the window.

The capsule was very stable when the antenna section jettisoned. I could see the whole recovery system just lined up in one big line as it came out. It unreeled and blossomed normally; all the panels and visors looked good. I was going through my landing check off list when the Capsule Communicator called to remind me to deploy the landing bag. I flipped the switch to auto immediately and the green light came on and I felt the bag release. I was able to see the water coming towards me in the periscope. I was able to estimate very closely when I would hit the water. The impact bag was a heavier shock than I had expected, but it did not bother me.

Communications with the recovery ship Noa were very good. The Noa had me in sight before impact and estimated 20 minutes to recovery which turned out to be about right. When the destroyer came alongside, they hooked on with the Shepard's hook and cut the HF antenna. During the capsule pickup, I received one good solid bump on the side of the ship as it rolled. Once on deck I took the left hand panel loose and started to disconnect the suit hose in order to hook up the hose extension prior to egressing through the upper hatch. By this time I was really hot- pouring sweat. The capsule was very hot after reentry and I really noticed the increase in humidity after the snorkels opened. I decided that the best thing at that point was to come out the side rather than through the top. I am sure I could have come out the top if I had had to, but I did not see any reason to keep working to come out the top. So I called the ship and asked them to clear the area outside the hatch. When I received word that the area was clear, I removed the capsule pin and hit the plunger with the back of my hand. It sprung back and cut my knuckles slightly though the glove. The noise of the hatch report was good and loud but not uncomfortable.

In summary, my condition is excellent. I am in good shape; no problems at all. The ASCS problems were the biggest I encountered on the flight. Weightlessness was no problem. I think the fact that I could take over and show that a pilot can control the capsule manually, using different control modes, satisfied me most. The greatest dissatisfaction I think I feel was the fact that I did not get to accomplish all the other things that I wanted to do. The ASCS problem overrode everything else.

Document I-44

Document Title: Robert C. Seamans, Jr., Associate Administrator, NASA, Memorandum for Robert R. Gilruth, Director, Manned Space Flight, NASA, "Astronaut Activities," 31 May 1962.

Source: Folder 18674, NASA Historical Reference Collection, NASA History Division, NASA Headquarters, Washington DC.

In 1962 the Space Task Group moved from the Langley Research Center in Hampton, Virginia, to found the Manned Spacecraft Center (MSC) in Houston, Texas. This change placed the human spaceflight program of NASA on a more formal and permanent footing. Also in 1962, NASA selected its second class of astronauts who would be involved in the Gemini and Apollo programs. With these changes came the institutionalization of a structure for managing the astronauts, the creation of policies regarding what they could and could not do as a part of their outside activities, and a formalization of crew assignments and other duties. This memorandum discusses the management structure for the astronauts. In September1962, MSC Director Robert Gilruth selected Deke Slayton, one of the Mercury Seven, to coordinate astronaut activities. The effort became even more structured in November 1963 when Slayton assumed the position of Director of Flight Crew Operations. In that capacity, he became responsible for directing the activities of the astronaut office, the aircraft operations office, the flight crew integration division, the crew training and simulation division, and the crew procedures division. Working directly with Gilruth, Slayton closely managed the astronauts and oversaw their activities.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

WASHINGTON 25, DC

May 31, 1962

MEMORANDUM

To: Robert R. Gilruth, Director, MSC

From: Associate Administrator

Subject: Astronaut Activities

With our recent announcement concerning additional astronaut selection, it seems timely to restate my understanding of your responsibilities for astronaut activities and to suggest some guidelines for your consideration.

1. Current and future NASA astronauts are employees of the Manned Spacecraft Center and, therefore, are under your direction. In executing this responsibility, it is a sound procedure to have a key member of your operations group as astronaut supervisor. This individual should be held responsible for day-to-day direction of astronaut activities in the same fashion as any other NASA line supervisor accounts for the activities of personnel reporting to him. This responsibility includes supervision of non-project activities covered in the paragraphs following.

2. In connection with astronaut personal appearances, I know you understand that Mr. Webb, Dr. Dryden, and I are under constant demands to make these individuals available. As in the past, we will continue to restrict such appearances to occasions that have a minimum effect on the program assignments of the astronauts and which, in addition, advance the overall

objectives of the National program for space exploration. As you know, Mr. Webb has assigned the responsibility for planning and approving astronaut appearances to Dr. Cox. I believe it is essential that a close tie is maintained between your office and that of Dr. Cox's on these matters. I believe the most satisfactory organizational arrangement to implement such activities is to have one of Dr. Cox's staff work continuously with an individual in Houston in order to best schedule such appearances.

3. As is the case with other employees of your Center, you are responsible for controlling the extra-program activities of the astronauts, particularly in such areas as newspaper and journal articles and press appearances. Unlike those of other personnel, however, the [2] press relations of the astronauts present a special circumstance because of the status they have assumed as public figures. As in the case of public appearances, Headquarters is under constant pressure for articles, messages, endorsement of causes, etc., by the astronauts. It is necessary, therefore, that activities of this sort by the astronauts also be closely coordinated with Dr. Cox, and that major activities be specifically approved by him. This approval, obviously, would not apply to day-today press contacts which are related directly to their mission, but rather to significant interviews, articles, or statements which might relate to or reflect on national policy.

Consequently, I wish you would discuss this matter further with Dr. Cox in order that we may agree upon an individual for this assignment and upon his position in your organization. With this position designated, I believe we will have an effective relationship between the astronaut supervisor, and Dr. Cox's office in Headquarters.

We have learned a great deal in the last year about the technical and non-technical problems which face us in manned space flight projects. We are in full agreement that, as Director of the Manned Spacecraft Center, it is your responsibility to direct NASA astronauts in order to maximize their individual and combined contribution to our programs. As in the past, Mr. Webb, Dr. Dryden, Dr. Cox, and I will be happy to discuss any particular question with you and provide whatever guidance you feel is needed.

[Signed]
Robert C. Seamans, Jr.
Associate Administrator

Document I-45

Document Title: W. J. North, Senior Editor, E. M. Fields, Dr. S. C. White, and V. I. Grissom, National Aeronautics and Space Administration, Manned Spacecraft Center, "MA-7/18 Voice Communications and Pilot's Debriefing," 8 June 1962.

Source: NASA Collection, University of Houston, Clear Lake Library, Clear Lake, Texas.

On 24 May 1962 Scott Carpenter flew Mercury Atlas-7 on a three-orbit flight that paralleled the John Glenn mission of the previous February. During Carpenter's second orbit he took manual control of the spacecraft and made changes to the capsule's orientation by movements of his head and arms. He also over-used his attitude control jets and ran short of fuel. This and a mis-timed reentry burn resulted in his spacecraft overshooting the planned landing point by 250 miles. This caused major delays in the water recovery of Carpenter and his Aurora 7 capsule and a nationwide concern for the astronaut's safety. Many people criticized Carpenter's performance on this flight. Chris Kraft, senior flight controller and later director of the Manned Spacecraft Center, blamed Carpenter for the poor reentry and worked to ensure that he never flew in space again. Others were more charitable, concluding that monitoring fuel consumption should be done by Mission Control. This debriefing presents Carpenter's assessment of what had taken place. It was only the beginning of several reviews of less than stellar in-flight performance that embarrassed the astronaut and eventually led to his departure from NASA in 1965.

[CONFIDENTIAL] [DECLASSIFIED]

[Only Section 3 of report provided]

[3-1]

3.0 SHIPBOARD DEBRIEFING

3.1 Introduction

The following is an essentially unedited transcript of the self-debriefing of Astronaut Carpenter which he conducted shortly after arriving onboard the recovery aircraft carrier, Intrepid. This shipboard debriefing consists of the pilot's general impressions of the flight from lift-off to the beginning of the retrosequence. From that point through normal egress of the pilot from the spacecraft, the pilot describes his activities in considerable detail.

3.2 Shipboard Debriefing

I would like to give a good debriefing at this point while the events of the flight are still fresh in my mind. I will be able to cover only the high-points. I can not really do the flight justice until I review the voice tape to refresh my memory.

As a whole, I was surprised that the sensations at lift-off, and throughout the launch phase, were as slight as they were. In retrospect, it was a very, very short period. As a matter of fact, the whole flight was very short. It was the shortest five hours of my life.

My general impression of the flight right now is that I am happy to be back. I feel that I brought back some new information. I hope that the pictures turn out because they are photographs of truly beautiful sights. I think that the MIT film was properly exposed. I hope it brings back some worthwhile information. I realize now that a number of the MIT pictures were taken while the spacecraft was in a 90° roll attitude and the filter in the camera was not oriented properly. So there are a few pictures that may be of no value.

I feel badly about having squandered my fuel and I feel badly about the error in impact. I know that there was an error in pitch and I think there was an error in yaw in the gyro attitude presentation from somewhere in the second orbit on. Because the control fuel supply was low, I did not want to evaluate the ASCS problem until just prior to retrofire when I thought it would probably clear up. I thought for some time that the problem in pitch might have been just a scanner error. Now, as I look back at it, it seems to me that that was wishful thinking, [3-2] because I aligned the gyros correctly and the spacecraft was holding orbit attitude when I first selected ASCS. Later, however, when I would recheck attitude the spacecraft would be pitched way down, about 20°. So ASCS was holding orbit attitude in yaw and roll but pitch attitude was not right. It did not agree with the window and it did not agree with the periscope. I say 20° down when I think of the periscope, but when I think about what I saw in the window when the ASCS was holding retroattitude and indicating 34°, I would say that it might be something like 30° down. I noticed the same problem on the second orbit, or maybe it was the very beginning of the third orbit. I also noticed this prior to retrofire.

I think that one reason that I got behind at retrofire was because, just at dawn on the third orbit, I discovered the source of the fireflies. I felt that I had time to get that taken care of and prepare for retrofire properly, but time slipped away. It really raced during this period, as it did through the whole flight. I really needed that time over Hawaii. The Hawaii Cap Com was trying very hard to get me to do the preretrograde checklist. I had previously been busy with the fireflies. Then was busy trying to get aligned in attitude so that I could evaluate ASCS. I got behind. I had to stow things haphazardly. I think everything was stowed, but not in the planned places. Food crumbling gave me a bad problem because I couldn't use that bag for the camera. As it was, I had to carry the camera with me and almost dumped it in the water.

At retrofire I still had the problem in pitch attitude. I did not have any confidence in ASCS just prior to retrofire. So I told the California Cap Com that the ASCS was bad and that I was committing to a fly-by-wire retrofire. By this time, I had gone through part of the preretro checklist. It called for the manual fuel handle to be out as a backup for the ASCS. I selected the fly-by-wire control system and did not go off of the manual system so that attitude control during retrofire was accomplished on both the fly-by-wire and manual control systems.

I feel that attitude control during retrofire was good. My reference was divided between the periscope, the window, and the attitude indicators. At retroattitude as, indicated by reference to the window and the periscope, the pitch attitude indicator read -10 degrees. I tried to hold this attitude on the instruments throughout retrofire but I cross-checked attitude in the window and the periscopes. I have commented many times that you can not divide your [3-3] attention between one attitude reference system and another, and do a good job in retrofire on the trainer. But that was the way I controlled attitude during retrofits on this flight. I did not notice any gross errors in attitude that persisted throughout retrofire. There was some wandering, but I feel that it was balanced out pretty well.

The initiation of retrofire was just a little bit late, although retrosequence came on time. I got the countdown from the California Cap Com. I waited one more second, which was 99:59:59 and did not get retrofire. I punched the manual retrofire button and one or two seconds after that I felt the first retrorocket fire.

I expected a big boot from the retrorocket. But the deceleration was just a very gentle nudge. The sound of the rockets firing was just audible. Retrorocket Two fired on time, Retrorocket Three fired roughly on time. Each rocket gave me a sensation, not of being pushed back toward Hawaii as reported by John Glenn, but of being slowed down in three increments. So that by the time the retroacceleration was over, I felt that there was just enough deceleration to bring the spacecraft to a stop. I felt that, if I looked down, I would see that the obvious motion that I had seen through the window and the periscope before retrofire had stopped. But, of course, it had not.

I put three 'arm' switches on at this time. Retropack jettison occurred on time and the periscope came in on time. At this time I noticed my appalling fuel state, and realized that I had controlled retrofire on manual and fly-by-wire. I went to rate command at this time, and tried manual <u>and</u> rate command, and got no response. The fuel gauge was reading about 6 percent, but it was empty. This left me with 15 percent on the automatic system to last out the ten minutes to .05g and to control reentry.

If the California Cap Com had not mentioned the retroattitude bypass switch, I think I would have forgotten it, and retrofire would have been delayed considerably longer. He also mentioned an Aux Damp reentry which I think I would have chosen in any case, but it was a good suggestion to have. He was worth his weight in gold for just those two items.

The period prior to the .05g was a harried one, because I did not know whether the fuel was going to hold out. The periscope [3-4] was retracted. The attitude indicators were useless. The only attitude reference I had was the window. I did not have much fuel to squander at this point holding attitude. I did use it, gingerly, trying to keep the horizon in the window so that I would have a correct attitude reference. I stayed on fly-by-wire until .05g. At .05g I think I still had about 15 percent reading on the autofuel gage.

I began to get the hissing outside the spacecraft that John Glenn mentioned. I feel that the spacecraft would have reentered properly without any attitude control. It was aligned within 3 or 4 degrees in pitch and yaw at the start of the reentry period. My feeling is that the gradual increase of aerodynamic damping during the reentry is sufficient to align the spacecraft properly.

Very shortly after .05g I began to pick up the oscillations on the pitch and yaw rate needles. At this time I think roll rate was zero, or possibly one or two degrees. The spacecraft oscillated back and forth about zero, just the way the trainer would do at a -.1 (-.1 damping coefficient set into the trailer computer) reentry. From this I decided that the spacecraft was in a good reentry attitude and I selected Aux Damp.

I watched the rate indicator and the window during this period because I was beginning to see the reentry glow. I was beginning to see a few flaming pieces falling off the spacecraft, although the window did not light up as John Glenn reported. It was just a noticeable increase in illumination. I did not see a fiery glow prior to peak g as John Glenn did.

I noticed one thing during the heat pulse that I had not expected. I was looking for the orange glow. I also saw a long rectangular strap of some kind going off in the distance. It was at this time that I noticed a light green glow that seemed to be coming from the cylindrical section of the spacecraft. It made me feel that the trim angle was not right, and that some of the surface of the recovery compartment might be ablating. I think it must have been the berylium [*sic*] vaporizing. The fact that the rates were oscillating evenly strengthened my conviction that the reentry was at a good trim angle. The green glow was really brighter than the orange glow around the window. [3-5]

I heard Cape Cap Com up to the blackout. He told me that black-out was expected momentarily. I listened at first for his command transmission, but it did not get through. So I just talked the rest of the way down.

Acceleration peaked at about 6.7g. At this time, oscillations in rate were nearly imperceptible. Aux Damp was doing very, very well. The period of peak g was much longer than I had expected. I noticed that I had to breathe a little more forcefully in order to say normal sentences.

The accelerometer read 2.5 to 3g when the spacecraft passed through a hundred thousand feet. At around 80 or 70 thousand feet, we may have run out of automatic fuel. I do not remember looking at the fuel gage but the rates began to oscillate pretty badly, although the rate needles were still on scale.

I put in a roll rate earlier and after we got down around 70 or 80 thousand feet, I took the roll rate out. So I did have fuel at that point. I took the roll rate out at a point where the oscillations carried the sun back and forth across the window. My best indication of the amplitude of the oscillation was to watch the sun cross the window, and try to determine the angle through which the spacecraft was oscillating. I remember calling off about 40 or 50 degrees. This was around 60,000 feet. At about 50,000 feet, the amplitude of the oscillations increased. I could feel the deceleration as we would go to one side in yaw or pitch. I would feel the spacecraft sort of stop, and then the rate would build up in the other direction. I felt that I had a pretty good indication of the variation in attitude from this change in acceleration. I switched the drogue fuse switch on at about 45 thousand feet. At about 40 thousand feet, I began to feel that the spacecraft oscillations were going past 90 degrees. I would feel a deceleration as the spacecraft would go past the vertical. I knew from the amplitudes that I had previously extrapolated, that the spacecraft attitude had reached at least 90 degrees. Then the spacecraft would apparently slip past 90 degrees. I am convinced that the attitudes were diverging, and that there were times when the spacecraft was 30 or 40 degrees small end down. This I remember occurring two or three times. Each time it was worse. I reported that the oscillations were getting too bad and said, "I'm going to have to chance the drogue now." I did deploy the drogue parachute manually at around 25,000 feet. [3-6]

Although I did not make a concerted effort to deploy the drogue parachute when the spacecraft was properly aligned in attitude, I think that it did come out when the spacecraft was in normal attitude, because there was no marked snap on deployment. There was a sudden shock, but I do not think that it dragged the spacecraft around from bad yaw or pitch angle. The spacecraft moved maybe 10 or 20 degrees. I could see the drogue pulsing and vibrating. It was visible against a cloudy sky. I saw no blue sky at this time. All was gray. The drogue was pulsing and shaking much more than I had expected. I watched the parachute for a while along with some other material that came out at this time.

After the drogue parachute was deployed, I operated the snorkel manually. The rate handle did come up but I reached over and pushed it up, too. I did not notice any more cooling at this time. I also did not notice the suit fan cutting down so I assume it continued to run.

I got the main fuse switch at 15,000 feet and waited for the main parachute to deploy. It did not, and I manually operated the main parachute deploy switch at about 9,500 feet. It was just a little below 10,000 feet. It came out and streamed. It was reefed for a little while. Boy! There is a lot of stress on that parachute! You can see how it is being tried. The parachute unreefed and it was beautiful. I could see no damage whatsoever.

Rate of descent was right on 30 feet per second. Incidentally, prior to retrofire the rate of descent indicator was reading about six or seven feet per second. I was convinced that the main parachute was good and selected the auto position on landing bag switch and the bag went out immediately. I went through the post reentry, post-10K, and post landing checklists and got everything pretty well taken care of.

The impact was much less severe than I had expected. It was more noticeable by the noise than by the g-load. There was also a loud knock at impact. I thought "We have a recontact problem of some kind." I was somewhat dismayed to see water splashed on the face of the tape recorder box immediately after impact. My fears that there might be a leak in the spacecraft were somewhat confirmed by the fact that the spacecraft never did right itself on the water. It continued to stay in a 60 degree attitude on the water. [3-7] The direction of list was about halfway between pitchdown and yaw left. That is the attitude it maintained on the water.

I got everything disconnected and waited for the spacecraft to right itself. We do not have a window in the egress trainer, but the level of the water on the window seemed to be higher than I had expected. The list did not change.

I knew that I was way off track. I had heard the Cape Cap Com transmitting blind that there would be an hour before recovery. I decided to get out at that time and went about the business of egressing from the spacecraft.

Egress is a tough job. The space is tight and egress is hard. But everything worked properly. The small pressure bulkhead stuck a little bit. Pip pins and initiators came out very well. I easily pushed out the canister with my bare head. I had the raft and the camera with me. I disconnected the hose after I had the canister nearly out.

I forgot to seal the suit and I did not put the neck dam up. I was aware at this time that the neck dam was not up. It should have been put up right after impact, but I had forgotten it. I think one of the reasons I did not was that it was so hot. However, it wasn't nearly as hot as I expected it to be. I think after impact I read 105 on the cabin temperature gage. I was much hotter in orbit than I was after impact. I did not notice the humidity. I felt fine.

I climbed out. I had the raft attached to me. I placed the camera up on top of the recovery compartment so that I could get it in the raft with me if the capsule sank. I did not want to take it with me while I inflated the raft.

I slid out of the spacecraft while holding on to the neck. I pulled the raft out after me and inflated it, while still holding on, to the spacecraft. The sea state was very good. Later on the swells may have increased to eight or nine feet. But at impact the swells were only five or six feet. I got in the raft upside down. It was attached to the spacecraft.

The rest of the debriefing I can do later. This is the only part I really need to talk about now. The rest will come back in much clearer detail when I get the voice tapes.

Document I-46

Document Title: Richard L. Callaghan, NASA, Memorandum for Mr. James E. Webb, "Meeting with President Kennedy on Astronaut Affairs," 30 August 1962.

Source: Folder 18674, NASA Historical Reference Collection, NASA History Division, NASA Headquarters, Washington, DC.

From the beginning of NASA's human spaceflight effort the activities of the astronauts outside of their official duties had been a source of concern and contention. The public, of course, relished as much information as could be obtained about the Mercury Seven and NASA had facilitated the sale of their personal stories to Life *magazine as a means of both satisfying that thirst and as a form of insurance for the astronauts should any lose their lives in spaceflight. This decision faced numerous criticisms, however, and NASA had to explain and find more equitable approaches to the issue in later years. Moreover, companies sought endorsements and some entrepreneurs offered the astronauts gifts such as homes at no expense so they could use the fact that the astronauts lived in their housing developments as selling points for other* *buyers. It proved a prickly issue for NASA, much of it the result of the celebrity status of the Mercury Seven. As this memorandum demonstrates, concern for these issues rose all the way to the Oval Office and prompted comments by President John F. Kennedy. NASA worked to refine its policies in this regard, but never found a fully satisfactory solution that balanced the rights and privileges of the astronauts with government regulations on private activities.*

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

WASHINGTON 25, DC

August 30, 1962

MEMORANDUM For Mr. James E. Webb

Subject: Meeting with President Kennedy on Astronaut Affairs

On August 23, I called Pierre Salinger about 5:30 p.m. to advise him of the discussion Mr. Lingle, Mr. Johnson and I had with Alfred Friendly. It occurred to me that such a call might serve to remind him of our interest in having the reaction of the White House that Mr. Lingle and I sought in our meeting with Salinger nearly two weeks ago. Salinger commented that since meeting with Lingle and me, he had had a long talk with the President and others in the White House about a revised policy relating to the affairs of the astronauts. He stated that "the President tends to agree with you (NASA) and Bundy (McGeorge) agrees with me." He expressed no particular interest in the reaction of Mr. Friendly but indicated that he would try and set up a meeting in a few days to get together with us again. Within a half hour, he called back and said "bring Mr. Webb and Bill Lloyd down tomorrow morning at 10:30 and we'll meet with the President and settle this once and for all." I told him that you were out of town but that I would attempt to bring Mr. Lingle and Mr. Lloyd. This was satisfactory to him.

I checked with Dr. Seamans to determine whether he wished to go to the White House but he felt that Mr. Lingle could handle the problem satisfactorily. We attempted to contact you Friday morning but you were somewhat ahead of your itinerary and were apparently enroute [*sic*] from Norton to Medford. Lingle, Johnson, Lloyd and I discussed the proposed meeting with Dr. Seamans prior to going to the White House.

The White House meeting lasted some 30 minutes. The President at the outset stated generally that he felt the astronauts should be permitted to continue to receive some money for writings of a personal nature inasmuch as they did seem to be burdened with expenses they would not incur were they not in the public eye. He felt there should be stricter control of their investments. He cited the proffer of the homes in Houston as an example of the type of situation that should be avoided in the future. Salinger was rather restrained in presenting his own views and seemed satisfied to take his cue from the President. Mr. Lingle prefaced his remarks by expressing the hope that no firm decision would be made at this particular meeting as to the [2] specifics of the policy inasmuch as no member of the NASA group at the meeting was prepared to delineate in a positive way your views. It was made clear to the assembled group that you wished to have the policy reflect White House desires and that you intended to make it clear to the astronauts that any policy decisions would embrace White House attitudes.

The President showed no disposition to criticize NASA's existing policy. Such observations as were made by Salinger, Bundy, and Ted Sorensen ran to a need for tightening up in the implementation of our policy rather than to a need for changing the policy in any drastic measure. It was the consensus that the refinement of NASA's policy should be achieved through discussions with the Department of Defense and that NASA policy should serve as a model to which a Department of Defense policy would conform. The development of such a policy by the Department of Defense seemed to be left within Salinger's hands.

Without detailing the discussion further, the following portrays my impression of the conclusions reached at the meeting with the President.

1. The President leaves to your discretion the preparation of such refinements in NASA's proposed policy revisions as are necessary to:
    a. Permit the continued sale by the astronauts of their personal stories, whether through a LIFE-type contract or otherwise.
    b. Extend the prohibition against commercial endorsements.
    c. Provide reasonable supervision of the astronauts' investments (although this need not be a specifically stated part of the policy, the astronauts are to understand that such supervision is inherent in the policy).
    d. Serve generally as a model of administration policy.
2. Within the framework of its policy NASA should attempt to:
    a. Make available to all news media at debriefings and press conferences a more comprehensive presentation of the official aspects of space missions in which the astronauts participate.
    b. Afford to the press additional access to NASA personnel (including the astronauts), NASA installations, and NASA facilities to the extent that such access does not impede the agency's programs or activities.
    c. Edit more stringently the material made available by the astronauts for publication.
    d. Restrict extravagant claims by publishers who attempt to overemphasize the exclusive nature of material received from the astronauts for publication.

[Signed]
Richard L. Callaghan

Document I-47

Document Title: Dr. Walter C. Williams, Deputy Director, NASA Manned Spacecraft Center, NASA, "Project Review," 3 October 1963.

Source: NASA Collection, University of Houston, Clear Lake Library, Clear Lake, Texas.

The Mercury program officially ended with the flight of Faith 7, Gordon Cooper's orbital mission on 15 and 16 May 1963. Within days of that flight those working on the Mercury began assessing their efforts and developing lessons-learned for the future. This review culminated in a large meeting in Houston on 3 to 4 October 1963, where the leading figures of the program discussed the Mercury project and its accomplishments. This document presents the perspective of Walt Williams, Robert Gilruth's assistant for space operations at the Manned Spacecraft Center.

MERCURY PROJECT SUMMARY CONFERENCE

MUSIC HALL, HOUSTON, TEXAS

October 3 and 4, 1963

PROJECT REVIEW

Address by Dr. Walter C. Williams, Deputy Director, NASA Manned Spacecraft Center

[Note: This review also included a slide presentation. The slides are not provided.]

I think that, perhaps, in reviewing a program such as this, the first step to take is to look at where we started and, principally, what were the objectives and what were our guidelines, and I think you'll find that this group that started five years ago, under Dr. Gilruth, stayed quite closely to these.

[Slide 1]

Let's look at the objectives first (first slide, please). I'm not sure this is exactly the same slide that was used five years ago, but I'm certain that the words are. Objectives were to place a manned spacecraft in orbital flight around the earth, to investigate man's performance capabilities and his ability to function in space, and, obviously, recover the man and spacecraft safely. And we hope, as we move along in these next two days, to show how these objectives were reached.

[Slide 2]

Some of the guidelines in establishing this project are shown on the next slide. We knew, or the team knew, that to do this program at any reasonable length of time, wherever possible, existing technology and off-the-shelf equipment would have to be used, wherever practical, and I think, although it was expected to find much equipment on the shelf, I think many of our problems were really finding which shelf this equipment was on, because, in almost every area, because of the design constraints, some new development had to be undertaken to meet the new requirements that [2] a manned spacecraft would place on a system. Obviously, we wanted to use as simple an approach because this, indeed, would give the most reliable approach. The simplicity, again, is a relative term. Because of the question about man's ability to perform, it was required that this spacecraft be capable of fully automatic flight as well as a flight were the man participated as part of the system. Well, when you automate the system and, indeed, then provide redundancy in the automation, you come out with a rather complex system. The existing launch vehicle would be employed; yes, we felt that we should use a launch vehicle that was well along in its development as a weapons system for this job, and we had some interesting experiences along the way in developing and working with the Space Systems Division in converting from a weapons systems to a man-mated booster and, of course as always, we felt this should be a progressive and logical test program and we will discuss that progression.

We were able, or the team at that time was able, to give some detailed requirements for the spacecraft, in a general sense, and these are shown in the next slide.

[Slide 3]

We knew that the state-of-art of the large rockets, the reliable launch escape system was required. We did feel, even though there was a question mark about the pilot's performance, that he should be able to manually control the spacecraft attitude, and I think it's well-known how much this paid off during the life of the program. Obviously, it had to have a reliable retrorocket system, but it was also a question that this spacecraft [3] should be deorbited by retrorockets, that it just wasn't a short life-time orbit; that the spacecraft would truly be in space flight. The zero-lift shape for reentry was chosen as the least difficult and still meet the mission objectives that we had in mind, and obviously, we had to provide a water-landing capability because, even though we would have good—take on the task of providing land capability for the end of successful missions, the vehicle still had to be amphibious in order to cover the abort cases.

Well this – this was about the way the program got started five years ago. Concepts were available; in fact, considerable research-and-development work had been done on these concepts, but there lay ahead the job of translating these concepts into real hardware, into systems that could be used in manned flight. There was the detailed mission planning that was yet to be done. There was the defining and implementing the world network. There were many of these things. Developing the recovery techniques. All of this was still ahead.

[Slide 4]

Scheduling, I think, is about the best way to describe the progress of the flights and of the program since these are, indeed, tangible milestones. And, although there were many schedules, and you could call them success schedules, or the like, this is the actual schedule as the flying occurred. I realize there's a lot of detail here, but I'd like to talk about this overall schedule first. In accomplishing this, in the period of about 45 months of activity, some 25 flights were made which was an activity of a major flight in something less than every 2 months. [Slide 5] [4] To do this, at various states, three launch vehicles were used and two launch sites. The Little Joe was a research-and-development booster used for the development, testing primarily the escape system; these tests were at Wallops Island. The Redstone booster was used for the ballistic flights to help qualify the spacecraft systems and the crew for orbital flight. And, of course, the Atlas was used for orbital flights. It is interesting to note that one of the first major flights was the BJ-1 up there, which was the Big Joe, which qualified the heat-protection system and verified that this concept was proper. Dr. Gilruth talked about the team getting right to work and I can talk a little about this one because I had nothing to do with it. I think this was an amazing job done in something less than a year from project go-ahead. This was a major activity and it involved a ballistic reentry of a full-scale Mercury like spacecraft.

[Slide 6]

And, so, the first year or so we were concerned with these development flights and it was about the end of 1960 really that the heavy activity in qualifying the actual hardware for the manned orbital flights began and I'd like to look at an expanded scale there and it's on this next slide, on the right side, please. This, I think, was the peak of our highest activity in Mercury. We began with our – really, we should start with the Mercuy-Redstone 1 which was our first full-boosted flight of our production spacecraft. We had problems; we fired the escape tower when it was a premature cutoff, but we won't go into this today. But, then, the program moved along rather rapidly on the ballistic program between December and May when Al Shepard made his flight and followed by Grissom's [5] flight that summer. Meanwhile, the Atlas was also moving along; we had a failure back in July, that Dr. Dryden referred to, which cost us about six months in our Atlas program and it was not until the following February, after suitable modifications had been made to both the spacecraft adapter and the launch vehicle, that we were able to resume the Atlas flights. The first of these qualified our production spacecraft for the reentry heating case. That was followed by another Atlas failure, MA-3, which was an electronic failure, but, by then, we had the team really working together; we solved these problems and made our first orbital flight of a Mercury spacecraft in September and within four or five months of that, we had John Glenn's flight following the flight of Enos in orbital flight. This, to me – to anyone planning schedules – The flight program for this time should look at this one, because there were periods here of major activities, at least once a month, and in a research-and-development program, I feel that this is about the limits of human tolerance. Everybody was working terribly hard on this period; it was a rough one.

Now, this is about all of the detail (will you take those slides off)—detail of the program that I can go into at this time (hold that one).

[Slide 7]

I would like to talk now a little, because we will describe all of this in much more detail – I would like to talk about how we managed this program, because I think this was one of the important things we learned. As you know, this program started on – go-ahead was given on October 7, 1958 and a small organization, the Space Task Group, was set up to handle [6] it. The overall management, of course, was the responsibility of NASA Headquarters, but the project management rested in Space Task Group. And of course, it was recognized from the beginning that this had to be a joint effort of many organizations and of many people, because it was an extremely complex program and it would be probably involve more elements of Government and industry than any similar development program that had been undertaken. So, the task was that of establishing an overall plan that would best fit the program and accomplish the objectives at the earliest date, pulling all of these varied groups together, and the scheme that we used to pull people together and pull organizations together is best shown in this next slide, where we might look at this at three levels: At the policy level, which was the overall management of level where general policy decisions were reached and carried out as to how the two organizations would work together; the next level down which was the approval review and direction level; and then, a third level of implementation where we used a system of working teams, with the specialists and design people from each of the various units concerned with any particular problem, and these were action committees and decisions could be reached at their meetings, with formal documentation to follow at a later date, and teams were set up as required wherever there were interfaces to be solved and common problems involving more than one organization. And I might add, and I think this is very important, teams were set up as they were needed; they were dissolved when they were no longer needed. We did not have committees for the sake of committees.

[7] [Slide 8]

And, I think a matter—To put some names and numbers into a chart such as this, I'd like to show the next slide which shows an arrangement we used in the launch vehicles. The manner whereby NASA could get Atlas launch vehicles for the space program was reached in an agreement at the level of NASA Headquarters and the Department of Defense, and this was spelled out in a working agreement. Then, it became the task of NASA Space Task Group and the then Air Force Ballistic Missiles Division to translate this policy into a launch vehicle we could use and then we brought together at the working level members of Space Task Group, members of the Ballistic Missiles Division, as well as their contractors and our contractors, and out of this evolved the details of things, such as the automatic abort system, the structural interface, the launch complex modifications, the launch countdown, that were required. Now, another bit of management arrangement that was established that also worked very well, and this fell primarily in the operational support area and in the network areas, was the fact that NASA, as such, had very little resources to carry out the program of this nature. For example, for recovery, we didn't have a navy. It's this type of resource I am addressing myself to. We did not have a range; so, in order to effectively provide this support from the Department of Defense, and arrangement was made whereby a Department of Defense Representative for Project Mercury Support was appointed and he was the NASA, the single point contact within the

Department of Defense framework for all Department of Defense support. Also, NASA provided such [8] a single point of contact, so that these two could meet; there was a logical place for the requirements to focus, a logical place for them to go, and logical place for them to be implemented. And rather than many parts of NASA trying to work with many parts of the Department of Defense, we had this single point, and I think, and I don't think, I know, in the operating end of it at least, this contributed greatly to the success.

[Slide 9]

I'd like to show how this worked; for example, in the case of our network and that's on the next slide. Again, we had this type of thing; we had our DOD representative, NASA single point of contact and this is for the establishment of the network. At this level, we reached agreement of what parts of the national ranges would be used which would be modified, where new stations had to be implemented and who would operate new stations, how would we work on the existing ranges. At the direction level, we had our Space Task Group and an element of the Langley Research Center which handled the Western Electric contract on the network that provided the detailed implementation, working directly with the Mercury Support Planning Office and the National ranges. And here, again, we had to break out working teams and these involved not only the obvious units shown there, but for example, our spacecraft contractor had to work with this people so that they would be compatible with the range. And, I think that it was arrangements like this that allowed us to move on as we did and I must say that it was also, as Bob Gilruth pointed out, the dedication of a large number of people that allowed these arrangements to work extremely well.

[9] Now, in these types of systems and at this point in time which was the development phase, we used this arrangement of working teams. As we moved into the operating phase, however, we had to go to a more functional type organization, with direct lines of command, and here again, having this single point within DOD helped considerably. I'll not show the entire operating organization, but I'd like to show an element of it in this next slide to give some idea of how organizations were intermingled in this line of command. This is essentially the blockhouse organization and our total operating complex. [Slide 10] The operations director was a NASA man; however, reporting to him was the launch director from the Air Force's Space Systems Division. In turn, there was a launch vehicle test conductor who was a General Dynamics/Astronautics and in turn, had his associate contractors, reporting to him and, meanwhile, the spacecraft test conductor was a NASA man who, in turn, had his contractors reporting to him. And, I think any part of this organization you would find similar intermingling – intermingling of the Services as well, intermingling of the Civil servants, military personnel, and contractor personnel, but I think that the important thing is that it did work; there were direct-line responsibilities and I think we learned a lot out of that.

Now, I think it's interesting to talk a little about the resources we used. (May I have the next slide, please?) [Slide 11] Manpower reached a total, and this, of course, has to be estimates, even though we've got rather small numbers shown, of about 2,000,000 people. The direct NASA effort, [10] Space Task

Group, never reached a peak of over 650 people on the program and I would say this was reached probably at the time of the Glenn flight [Slide 12]. Supporting NASA work was another 700 people. Obviously a large element was the industrial support of prime, subcontractors, and vendors and we had, of course, many people from the Department of Defense, the largest portion of this 18,000 being the Navy's recovery forces. And I think it's interesting in looking at a map, which spots only the major contractors and the Government agencies and universities involved, without going into the subs and vendors, and as you can see, fairly well covered the country, even at this level.

I think, perhaps, to, we should talk a little about the program cost and I'd like to have the next slide [Slide 13]. These figures, I might point out, are different from those that are in the chronology that is part of the handout for this conference. The chronology figures were not complete and left out some of the essential elements. These figures and this total of $384,000,000 is the best that we can come up with for now; it's our estimate of determinations of contracts and it's not a fully audited figure, but it's the best we have at this time and I think this represents a reasonably correct figure. I think the only thing of real interest here is that the two largest items of this was the development of the spacecraft itself and its operation and the implementation of the world network. These items, like this network, are things that normally aren't thought of as the cost of a program – one will concentrate mostly on the [11] flight hardware, but, as can be seen, this, indeed, was a large part of the total cost of Mercury. However, I may add that, although we're charging all of it to Mercury here, it is an investment in our National capability; it will be used in Gemini, it will be used in Apollo. The operations figure is primarily the cost of the recovery forces.

Now, this, in a nutshell, is about what Mercury consisted of. We will try to fill in detail in the next two days. I think we ought to, before I close though, just summarize what it appears to me we learned in Mercury. One, of course – we did, indeed, accomplish our objectives and we found that man does have a place in space, man can function as part of the spacecraft system or the total flight system and can be effective. I think we learned some very—Very obviously, we learned a lot about spacecraft technology and how a spacecraft should be built, what its systems should be, how they should perform, where the critical redundancies are that are required. I think we learned something about man-rating boosters, how to take a weapons system development and turn it into a manned transportation system. I think, in this area, we found primarily, in a nutshell, that this was a matter of providing a malfunction detection system or an abort system, and, also, we found very careful attention to detail as far as quality control was concerned. I think that some of the less obvious things we learned – we learned how to plan these missions and this take a lot of detail work, because it's not only planning how it goes, but how it doesn't go, and the abort cases and the emergency cases always took a lot more effort than the planned missions. These are things that must be done [12]. We learned what is important in training crews for missions of this type. When the crew-training program was laid down, the program had to cover the entire gamut because we weren't quite sure exactly what these people needed to carry out the missions. I think we have a much better focus on this now. We learned how to control these flights in real time. This was a new concept on a worldwide basis. I think we learned, and when I say we, I'm talking of this as a National asset, not

NASA alone, we learned how to operate the world network in real time and keep it up. And I think we learned a lot in how to manage development programs of this kind and to manage operations of this kind.

I thank you very much.

*Oral presentation transcribed by occ; typed by rhd.

Document I-48

Document Title: Christopher C. Kraft, Jr., "A Review of Knowledge Acquired from the First Manned Satellite Program," No date, 1963

Source: Folder 18674, NASA Historical Reference Collection, NASA History Division, NASA Headquarters, Washington DC.

Christopher C. Kraft, Jr. joined the NACA in 1944 and became a member of the Space Task Group upon its inauguration in 1958 and a close associate of STG Director Robert Gilruth. He served as Senior Flight Director for all of the Mercury missions. Because of his unique perspective on Mercury, his review of the program is especially valuable as an historical document.

NASA FACT SHEET #206

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER
HOUSTON 1, TEXAS

A REVIEW OF KNOWLEDGE ACQUIRED FROM THE FIRST MANNED SATELLITE PROGRAM

By

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NASA Manned Spacecraft Center

SYNOPSIS

With the completion of the Mercury program, science has gained considerable new knowledge about space. In more than 52 hours of manned flight, the information brought back has changed many ideas about space flight. Design problems occupied the first and major portion of the Mercury program. The heat shield, the shape of the Mercury spacecraft, the spacecraft systems, and the recovery devices were developed. Flight operations procedures were organized and developed and a training program both ground and flight crew was followed. Scientific experiments were planned with Man in the loop. These included photography, extra spacecraft experiments, and observation or self-performing types of experiments.

But the real knowledge of Mercury lies in the change of the basic philosophy of the program. At the beginning, the capabilities of Man were not known, so the systems had to be designed to function automatically. But with the addition of Man to the loop, this philosophy changed 180 degrees since primary success of the mission depended on Man backing up automatic equipment that could fail.

[2]

INTRODUCTION

As the first manned space flight project of the United States, Project Mercury in its various aspects have [*sic*] been discussed in great detail by almost all members of the project. The purpose of my discussion today will not be to repeat the technical details of Project Mercury, but to outline and discuss some of the significant contributions the program has made to the area of space technology.

It is important to note that 52 hours of manned orbital flight, and less than five hours of unmanned orbital flight by the Mercury spacecraft have produced a large book of new knowledge. The hours spent on the ground development and training, the preparations for flights, and the ballistic flights cannot be calculated, but it contributed heavily to the knowledge we ultimately gained in space flight.

The three basic aims of Project Mercury were accomplished less than five years ago from the start of the program. The first U.S. manned space flight program was designed to (1) put man into Earth orbit (2) observe his reactions to the space environment and (3) bring him back to Earth safely at a point where he could be readily recovered. All of these objectives have been accomplished, and some have produced more information than we expected to receive from conducting the experiment.

The whole Mercury project may be considered an experiment, in a certain sense. We were testing the ability of a man and machine to perform in a controlled but not completely known environment.

The control, of course, came from the launch vehicle used and the spacecraft systems included in the vehicle. Although we knew the general conditions of space at Atlas insertion altitudes, we did not know how the specific environment would affect the spacecraft and the man. Such conditions as vacuum, weightlessness, heat, cold, and radiation were question marks on the number scale. There were also many extraneous unknowns which would not affect the immediate mission but would have to be considered in future flights. Such things as visibility of objects, the airglow layer, observation of ground lights and landmarks, and atmospheric drug effects were important for future reference.

The program had to start with a series of design experiments. We had little criteria for the space vehicle. If we could find that a certain type of heat shield could make a successful reentry and a certain shape of spacecraft, we would have the basis for further design of systems.

A series of flight tests and wind tunnel tests were conducted to get the answers to some of the basic questions. First, would the ablation [3] principle work in our application? Could we conduct heat away from the spacecraft body by melting the fiberglass and resin material? How thick would the shield have to be for our particular conditions? What temperatures would be encountered and for what time period would they exist? Early wind tunnel test proved in theory that the saucer shaped shield would protect the rest of the spacecraft from heat damage. The flight test on the heat shield must prove the theory. In February 1961, we made a ballistic flight in which the spacecraft reentered at a sharper angle than programmed and the heat shield was subjected to great than normal heating. The test proved the heat shield material to be more than adequate.

The Mercury spacecraft did not start with the familiar bell shape. It went through a series of design changes and wind tunnel tests before the optimum shape was chosen. The blunt shape had proven best for the nose cone reentry. Its only drawback was the lack of stability. We next tried the cone-shaped spacecraft, but wind tunnel testing proved that heating on the afterbody would be too severe, although the craft was very stable in reentry. After two more trial shapes, the blunt bottom cylinder on cone shape came into being. It was a complete cycle from the early concepts of manned space-craft, but it was only the first of a series of changes in our way of thinking of the flight program and its elements.

A second part of design philosophy thinking came in connection with the use of aircraft equipment in a spacecraft. We had stated at the start of the program that Mercury would use as much as possible the existing technology and off-the-shelf items in the design of the manned spacecraft. But in many cases off-the-shelf equipment would just not do the job. Systems in space are exposed to conditions that do not exist for aircraft within the envelope of the atmosphere. Near absolute vacuum, weightlessness and extremes of temperatures makes equipment react differently than it does in aircraft. We had to test equipment in advance in the environment in which it was going to be used. It produced an altered concept in constructing and testing a spacecraft. Although aircraft philosophy could be adapted, in many cases, aircraft parts could not perform in a spacecraft.

The third part of the design philosophy, and perhaps the most important one in regard to future systems is the automatic systems contained in the Mercury spacecraft. When the project started, we had no definitive information on how Man would react in the spacecraft system. To insure that we returned the spacecraft to Earth as planned, the critical functions would have to be automatic. The control system would keep the spacecraft stabilized at precisely thirty-four degrees above the horizontal. The retrorockets would be fired by an automatic sequence under a grogramed [*sic*] or ground command. The drogue and main parachutes would deploy when a barostat inside the spacecraft indicated that the correct altitudes had been reached. The Mercury vehicle was a highly automatic system and the man essentially was riding along as a passenger, an observer. At all costs, we had to make sure that the systems worked.

[4] But we have been able to take advantage of Man's capability in space. It started from the first manned orbital flights. When some of the thrusters became inoperative on John Glenn's flight, he was able to assume manual control

of the spacecraft in order to fly the full three orbits planned in the mission. When a signal on the ground indicated the heat shield had deployed, Glenn bypassed certain parts of the retrosequence manually and retained the retropack after it had fired. In this way, he insured that the heat shield would stay in place during reentry and the spacecraft would not be destroyed by excessive heating. When oscillations built up during reentry, Glenn utilized his manual capability to provide damping using both the manual and fly-by-wire thrusters. The pilot's role in manned space flight was assuming a more important aspect.

Carpenter's flight again emphasized the ability of the pilot to control the spacecraft through the critical reentry period. Excess fuel was used in both of these orbital flights. Schirra's task was to determine if Man in the machine could conserve fuel for a long flight by turning off all systems in drifting flight. It was a task that could not be accomplished by a piece of automatic equipment in the confined area of the Mercury spacecraft. Schirra also was able to exercise another type of pilot control. It was the fine control necessary to adjust pressure suit air temperature to produce a workable environment. When we flew the mechanical man in MA-4, we did not have the capability of making fine suit temperature adjustments or to realize the problems we might encounter in the suit design. Man could analyze and correct suit temperature, thus pointing out necessary design parameters to follow in future programs.

The MA-4 and MA-5 flights were probably the most difficult of the orbital missions. They had to be flown using only one automatic control system. We had no man along with the ability to override or correct malfunctions in the systems. One of the flights ended prematurely due to malfunctions that we could not correct from the ground. In both cases, a man could have assumed manual control and continued the flight for the full number of orbits. It is no hypothesis or theory; it has been borne out by facts. With this design criteria in mind, the Cooper flight was a fitting climax to the Mercury program. Not only did it yield new information for other spacecraft program, but it demonstrated that Man had a unique capability to rescue a mission that would not have been successfully completed with the automatic equipment provided.

Man serves many purposes in the orbiting spacecraft. Not only is he an observer, he provides and redundancy not obtainable by other means, he can conduct scientific experiments, and he can discover phenomenon not seen by automatic equipment.

But most important is the redundancy, the ability of another system to [5] take over the mission if the primary system fails. Duplicate systems are designed to prevent bottlenecks in the operation of the systems. The single point failure caused the false heat shield signal in Glenn's flight. After the mission was successfully completed, we conducted an intense design review to see if there were any more of these single points in the spacecraft that needed redundancy of design for safe operation. We found many areas where the failure of one component could trigger a whole series of unfavorable reactions. This type of problem had been brought about by the design philosophy originally conceived because of the lack of knowledge of Man's capability in a space environment.

The Mercury program taught us not to stack the components on top of each other. It forces limited access, and the failure of one component during checkout makes it necessary to pull out other functioning systems to replace the malfunctioning part. For instance, in the MA-6 flight the short life carbon dioxide absorber in the environmental control system had to be replaced since checkout took longer than had been planned. This replacement required eight major equipment removals and four revalidations of unrelated subsystems for a total delay of 12 hours. All of these problems of course resulted from weight and space constraints brought about by payload limitations.

For the Gemini and Apollo spacecraft, the equipment will be modular and replaceable, allowing the substitution of alternate parts without tearing out whole subsystems.

We depend quite a bit on the automatic systems for retrosequence but man has proven that he can and does play an important role in the reentry process. The only manned flight in which the automatic system for reentry was used completely was at the end of Walter Schirra's six orbits. In all other flights, the astronaut took over and performed at least one part of the reentry manually because of some malfunction which had occurred during the flight.

As we move into the Gemini and Apollo programs, a maneuvering capability has been built into the spacecraft to allow changes in flight path both while in orbit and during reentry into the atmosphere.

The translation engines provided will allow modifications to the orbit for rendezvous with other vehicles in orbit. Also, by use of an offset center of gravity, the spacecrafts will have and L/D capability not provided in the Mercury vehicle. This will allow the onboard computers to select a particular landing point at any time during the flight and after retrofire or atmospheric reentry the vehicle can be maneuvered within a given footprint to reach this desired landing area. The astronauts will provide the necessary back-up to these complex systems and can at any time assume manual control of the system so that a proper and safe landing can be assured.

[6] Our experience with the Mercury network changed our thinking about the operation of this worldwide tracking system for manned flights. In the initial design of the network, we did not have voice communication to all the remote sites.

But we soon found that in order to establish our real time requirement for evaluating unusual situations, we needed the voice link. When we started the program, the determination of the orbital ephemeris was a process that could take several orbits to establish. We could not tolerate such a condition in a manned flight so we set up a worldwide network which would maintain contact with the astronaut approximately 40 minutes out of every hour. But continuous voice contact with the astronaut has proven unnecessary and in many cases undesirable. While we retain the capability to contact an astronaut quickly, we have tried to reduce the frequency of communications with the spacecraft.

In designing and modifying a spacecraft, it is also possible to learn something more than tangible changes or hardware design. We learned about the reliability requirement and the very important need to check details carefully. It is a requirement that cannot be designed into a system on the drawing board. It actually consists in developing a conscientious contractor team that will take care to follow procedures and deliver a reliable product. Then it takes a careful recheck by the government team to insure that reliability has actually been built into the product. The smallest mistake in a man rated system can bring totally unexpected results. The unexpected is the rule in the unknown, and if Man is going to live in the region beyond our atmosphere, he is going to live under rules or not at all. We have been aware of these new rules from the start of the satellite program, but they have not been brought to our attention so vividly as they have in the manned flight program.

If an unmanned satellite malfunctions we cannot get it back for examination. We can only speculate on the causes and try to redesign it to eliminate the source of the supposed trouble. It is necessarily a slow process of elimination. Here again, if a manned craft malfunctions, it can be returned to the ground by the proper action of the pilot. We knew what had failed in Gordon Cooper's flight, but we did not know why the system had failed until we got the spacecraft back for investigations and tests. Knowing why something occurred will give us the tools to improve spacecraft of the future.

AEROMEDICAL EXPERIMENTS

While we can redesign the equipment to accomplish the mission, we cannot redesign the man who must perform in space. Aeromedical experiments for new knowledge about space must simply answer one question. Can Man adapt to an [7] environment which violates most of the laws under which his body normally operates? The answer to the question at the end of the Mercury program seems to be an unqualified yes, at least for the period of one to two days.

The crushing acceleration of launch was the first concern. We knew he would be pressed into his couch by a force equal to many times the weight of his own body. It was not definitely known whether he would be able to perform any piloting functions under these high "g" forces. The centrifuge program was started and the astronauts tested under this stress proved that Man was not as fragile or helpless as we might have supposed. In addition to being able to withstand heavy acceleration, a method was developed of straining against the force and performing necessary pilot control maneuvers.

Weightlessness was a real aeromedical unknown and it was something that the astronauts could not really encounter on the ground. The ability to eat and drink without gravity was one serious question we had to answer. In the weightless condition, once the food is placed in the mouth, normal digestive processes take over without being affected by the lack of gravity.

The next problem was the effect of weightlessness on the cardiovascular system, that is the heart and blood vessel system throughout the body. All types of reactions were possible in theory. In actual flight, a small and temporary amount of pooling of blood in the veins of the legs has occurred, but it is not serious nor does it appear to affect the performance of the pilot. For all pilots weightlessness has been a pleasant experience. All the senses such as sight and hearing perform normally during space flight. There has been no hallucination, no blackout or any other medical phenomena which might have an effect on Man in space. We even experimented with drifting flight and whether the astronaut would become disoriented when he could not distinguish up from down or have the horizon of Earth for a reference. But each time the answer seemed to be that a man could adapt as long as his basic needs for breathing oxygen and pressure were supplied.

Perhaps the greatest contributions to the program have come in the area of development of aeromedical equipment. Blood pressure measuring systems were developed that would automatically take readings and transmit them by telemetry to the ground. The biosensors were designed to pick up other information such as pulse rate and respiration rate. There were numerous small changes that were made to these systems to increase the accuracy of the data that we got back from the man in space. The in-flight studies of the test pilot's reaction are probably the most complete medical records we have tried to keep on an individual. Their value has been to demonstrate that man functions normally in the space environment.

Related to the aeromedical studies in the environmental equipment that provides life support for the astronaut. We started with the basic Navy pressure suit for aircraft flying and modified it for performance in the spacecraft. We found it was desirable to eliminate as many pressure points as possible and have tailored the suits on an individual basis for each [8] astronaut. There are two areas in life support which presented new problems to be overcome. First, there was the problem of circulation of air. In the absence of gravity, the normal rules of air circulation are cancelled, and the carbon dioxide breathed out by the astronaut would suffocate him. The air in the cabin would also have to be forced through the air conditioning system to keep the cabin area from overheating.

Secondly, there is the problem of the air supply itself and its possible effect on the spacecraft pilot. For conserving weight, a single gas system was desirable. But it was not known if breathing pure oxygen over long periods of time could have harmful effects. The Mercury flights and other research in a pure oxygen environment have proven that no injury to the body's system has been produced by using a one gas system.

SCIENTIFIC EXPERIMENTS

Man's role as a scientific observer and experimenter in space was another unknown in the program. Much of it was based on the ability of man to exist in space. It had to first be determined that he would be able to function normally and then the scientific benefits of the program could be explored. Man as an observer has proven his capabilities from the first orbital flight. The brightness, coloring, and height of the airglow layer was [*sic*] established. It was something a camera could not record nor could an unmanned satellite perform this mission. Man in space has the ability to observe the unknown and to try to define it by experiment. The particles discovered at sunrise by John Glenn were determined by

Scott Capenter, to be coming from the spacecraft, and this analysis was confirmed by Schirra and Cooper.

We can send unmanned instrumented vehicles into space which can learn much about the space environment and the makeup of the planets. However, the use of Man to aid in making the scientific observations will be invaluable. The old problem of what and how to instrument for the unknown can benefit greatly from Man's capability to pick and chose the time and types of experiments to be performed. We have learned much from the Mercury program through this quality of choice and we will continue to learn if man continues to be an important part of the system.

If we have learned more about space itself, we have also learned about Man's capabilities in space. Many experiments have been conducted which have yielded valuable information for future programs. Aside from aeromedical experiments, Man has been able to distinguish color in space, to spot object at varying distances from the spacecraft, to observe high intensity lights on the ground, and to track objects near him. These observations provide valuable information in determining the feasibility of the rendezvous and navigation in Gemini and Apollo.

[9] Pictures taken with infrared filters have aided the Weather Bureau in determining the type of cameras to use in their weather satellites. Special pictures have also been taken for scientific studies such as geological formations, zodiacal light, and refraction of light through the atmosphere.

CONCLUSION

The manned space flight program has changed quite a few concepts about space, added greatly to our knowledge of the universe around us, and demonstrated that Man has a proper role in exploring it. There are many unknowns that lie ahead, but we are reassured because we are confident in overcoming them by using Man's capabilities to the fullest.

When we started the manned space program five years ago, there was a great deal of doubt about Man's usefulness in space. We have now come to a point which is exactly one hundred eighty degrees around the circle from that opinion. We now depend on Man in the loop to back up the automatic systems rather than using automatic systems alone to insure that the mission is accomplished.

We do not want to ignore the automatic aspects of space flight altogether. There must be a careful blending of Man and machine in future spacecraft which provides the formula for further success. By experience, we have arrived at what we think is a proper mixture of that formula. Man is the deciding element; but we cannot ignore the usefulness of the automatic systems. As long as Man is able to alter the decision of the machine, we will have a spacecraft that can perform under any known condition, and that can probe into the unknown for new knowledge.

--END--

Document I-49

Document Title: Manned Spacecraft Center, NASA, "Project Development Plan for Rendezvous Development Utilizing the Mark II Two Man Spacecraft," 8 December 1961.

Source: Folder 18674, NASA Historical Reference Collection, History Division, NASA Headquarters, Washington, DC.

The development plan for the Mercury Mark II spacecraft underwent a number of modifications throughout 1961. The plan was extensively revised up until 27 October 1961. A key question was the selection of a booster to launch the spacecraft; NASA's preference was a modified Titan II ICBM. The Air Force wanted to develop a Titan III, but NASA was wary of this plan, fearing that the development would take too long. The Air Force countered that NASA's requirements for modifications to the Titan II would lead to what was almost a new booster. These issues were solved by November and it was decided by 5 December that NASA would get the Titan II boosters it desired. On 6 December, Robert Seamans approved the project development plan and identified the development of rendezvous techniques as the project's primary objective. Brainerd Holmes asked for $75.8 million from current Fiscal Year 1962 funds to start the project and Seamans approved that request on 7 December. The final plan was approved the next day.

PROJECT DEVELOPMENT PLAN

FOR

RENDEZVOUS DEVELOPMENT

UTILIZING THE

MARK II TWO MAN SPACECRAFT

Manned Spacecraft Center
Langley Air Force Base, Virginia

December 8, 1961

CLASSIFIED DOCUMENT – TITLE UNCLASSIFIED [DECLASSIFIED]

This material contains information affecting the national defense of the United States within the meaning of the espionage laws, Title 18,U.S.C., Secs. 793 and 794, the transmission or revelation of which in any manner to unauthorized person is prohibited by law.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

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PART I – PROJECT SUMMARY

This project development plan presents a program of manned space flight during the 1963 – 1965 time period. The program provides a versatile system which may be used for extending the time of flight in space and for development of rendezvous techniques, but may be adapted to the requirements of a multitude of other space missions at a later date. A two man version of the Mercury spacecraft would be used in conjunction with a modified Titan II booster. The Atlas-Agena B combination would be used to place the Agena B into orbit as the target vehicle in the rendezvous experiments. This use of existing or modified versions of existing hardware minimizes the necessity for new hardware development.

The proposed plan is based on extensive usage of Mercury technology and components for the spacecraft. Therefore, it is proposed to negotiate a sole-source cost-plus-fixed-fee contract with McDonnell Aircraft Corporation for the Mark II Mercury spacecraft.

The launch vehicle procurement will involve a continuation of present arrangements with the Air Force and General Dynamics-Astronautics for the Atlas launch vehicles, and the establishment of similar arrangements with the Martin Company for the Modified Titan II launch vehicles, and with the Lockheed Aircraft Corporation for the Agena stages.

A Project Office will be established to plan, direct and supervise the program. The manpower requirements for this office are expected to reach 179 by the end of Fiscal Year 1962.

The estimated cost of the proposed program will total about 530 million dollars.

PART II – JUSTIFICATION

Upon completion of Project Mercury the next step in the overall plan of manned space exploration is to gain experience in long duration and rendezvous missions. It is believed that the program presented here would produce such information and that it would compliment other programs now underway while not interfering with their prosecution.

PART III – HISTORY AND RELATED WORK

The plans for Project Mercury originally recognized the value to be obtained from 18-orbit missions. However, such missions were later deleted from the Mercury schedule due to systems and network limitations. Early in 1961 it was believed that Project Mercury had progressed to the point where 18-orbit missions might be considered once again. At this time, McDonnell was asked to study how such missions could be accomplished with only a minimum of modifications to the spacecraft being required. This study showed that the 18-orbit mission represents the maximum growth potential of the present Mercury capsule with reasonable modifications. Therefore, McDonnell was asked to study means of providing a more extensively modified spacecraft with an extended mission capability, including multiman occupancy and improved systems accessibility. The Martin Company was asked to provide information as to how the Titan II might be adapted to serve as the launch vehicle for these extended missions. Both the McDonnell and Martin studies have progressed to the point that capabilities for performing the missions have been shown. On the basis of these favorable reports the program plan presented here has been developed.

[5]

PART IV – TECHNICAL PLAN
(Description and Approach)

1.0 INTRODUCTION

Project Mercury is an initial step in a long range program of manned exploration of space. The initial objectives of Project Mercury have already been accomplished; therefore, it now becomes appropriate to consider the steps that should be taken to insure immediate continuation of manned space flights following the successful conclusion of this project. Therefore, a follow-on project, after Project Mercury, is proposed which will provide a continuing source of development information. In the execution of the proposed project, maximum use will be made of vehicle and equipment development which has already been accomplished for other programs.

2.0 MISSION OBJECTIVES

The present Mercury spacecraft cannot be readily adapted to other than simple orbital missions of up to about one day duration, with a corresponding limitation on the objectives of the mission. The proposed project will allow the accomplishment of a much wider range of objectives.

2.1 Long Duration Flights Experience will be gained in extending the duration of flights beyond the 18 orbit capability of the present Mercury spacecraft. It is recognized that for the longer missions a multiman crew is essential so that the work load may be shared, both in time and volume. There are many areas which require investigations so that the multiman crew may be provided with a suitable environment during the prolonged missions. This project will contribute to the development of the flight and ground operational techniques and equipment required for space flights of extended periods. These flights will also determine the physiological and psychological reactions and the performance capabilities of the new crew while being subjected to extended periods in a space environment.

2.2 Rendezvous The rendezvous and docking maneuver in space may be compared to aerial refueling in that it makes possible the resupply of a vehicle in space and thus extends its mission capabilities. This maneuver makes it possible to put a much larger "effective" payload in space with a given booster. Since most space projects are "booster limited" at present, the development of techniques for getting the most out of available boosters should undoubtedly be treated as of highest priority. As the frequency of manned orbital flights increases, there will be instances when orbital rescue, personnel transfer, and spacecraft repair will be highly desirable. To accomplish these missions develop[6]ment of orbital rendezvous techniques is mandatory. Among the problem areas which are involved in effecting a successful rendezvous and docking maneuver are the following:

2.2.1 Launch Window The second vehicle involved in the rendezvous must be launched very close to a prescribed time if the operation is to be economical in terms of waiting time and propulsion requirements. This requires a major simplification of the countdown procedure and high reliability of equipment.

2.2.2 Navigation Means must be developed for maneuvers in space, using information supplied by the navigation system.

2.2.3 Guidance and Control Guidance and control techniques must be developed for maneuvers in space, using information supplied by the navigation system.

2.2.4 Docking Rendezvous is not effective until the docking maneuver is accomplished. The space environment makes this operation quite a bit different from the same type of operation within the earth's atmosphere and hence considerable work in developing suitable techniques is to be expected.

2.3 Controlled Land Landings Experience has shown that the magnitude of the effort required to deploy adequate naval forces for the recovery of the Mercury spacecraft at sea is such that any means for avoiding, or at least minimizing, this effort would be highly desirable. The sea has proved to be a more inhospitable environment for recovery than was originally envisioned. If space flights are to be accomplished on anything like a routine basis, spacecraft must be designed to alight on land at specified locations. This requires that the landing dispersion be reduced to a very low figure, and a satisfactory method of touchdown developed.

2.3.1 Dispersion Control To effect control of the landing area, it is fundamental that an impact prediction be made available to the pilot and a means provided for controlling the spacecraft so the desired impact point can be reached.

2.3.2 Landing Impact The attenuation of the impact loads which might result from a land landing of the Mercury spacecraft has presented a very considerable problem. Although it is estimated that in many cases the landing accelerations would be within tolerable limits, the random nature of the landing process has made it impossible to consider a sufficient variety of conditions that could be encountered so as to have adequate assurance [7] of success. In order to guarantee safety in landing, the impact must be made at a relatively low velocity and in a selected area.

2.4 Training Although much can be accomplished by ground simulation training, there does not seem to be any real substitute for actual experience in space. Thus, a by-product of this project would be to provide a means of increasing the number of astronauts who have had actual experience in space. A two-manned spacecraft will be an excellent vehicle for this purpose.

2.5 Project Philosophy In general, the philosophy used in the conception of this project is to make maximum use of available hardware, basically developed for other programs, modified to meet the needs of this project. In this way, requirements for hardware development and qualification are minimized and timely implementation of the project is assured.

Another fundamental concept is that in the design of the spacecraft, all systems will be modularized and made independent of each other as much as possible. In this way, an evolutionary process of product improvement and mission adaptation may be implemented with a minimum of time and effort. Thus, it will be possible to use equipment of varying degrees of sophistication as it becomes available and as the mission requirements are tightened. It is important that a minimum of lead time can be obtained by making use of the latest hardware developments. This concept will make possible the attainment of mission and permits reasonable compromises to be made in the face of difficulties rather than excessive delays that otherwise might be required to meet the full objectives.

This project will provide a versatile spacecraft/booster combination which will be capable of performing a variety of missions. It will be a fitting vehicle for conducting further experiments rather than be the object of experiments. For instance, the rendezvous techniques developed for the spacecraft might allow its use as a vehicle for resupply or inspection of orbiting laboratories or space stations, orbital rescue, personnel transfer, and spacecraft repair.

[Parts V-VIII not included]

PART IX-PROJECT RESULTS

The results to be realized from successful accomplishment of the MK II program include the following:

1. Operational Techniques Rendezvous and docking techniques will become operational, making possible the assembly of vehicles in orbit for extended exploration of space. Techniques for reduction of landing dispersion, through the use of reentry lift and the paraglider landing concept, will be developed and optimized. The relative roles of onboard and ground-based intelligence and optimum man-machine relationships will be established.

2. Long Duration Flight Performance Man's reactions and ability to perform during long duration space flight will be determined. Hardware for sustaining man's physical well-being during such extended missions will be developed.

3. Training A group of pilots will be trained in the techniques required for rendezvous, reentry and controlled land landings. Ground operational forces will acquire experience in the launch, tracking and recovery procedures necessary for long duration and rendezvous missions.

[8]

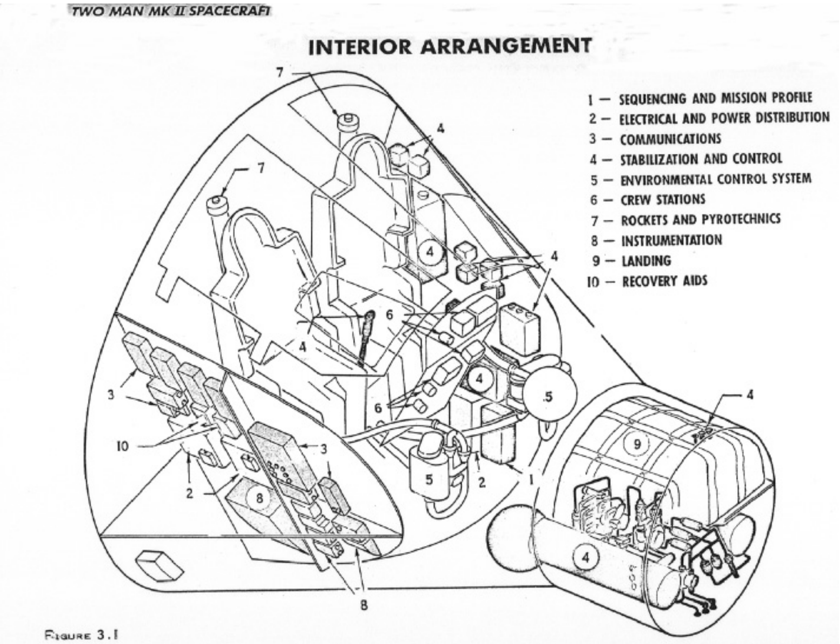
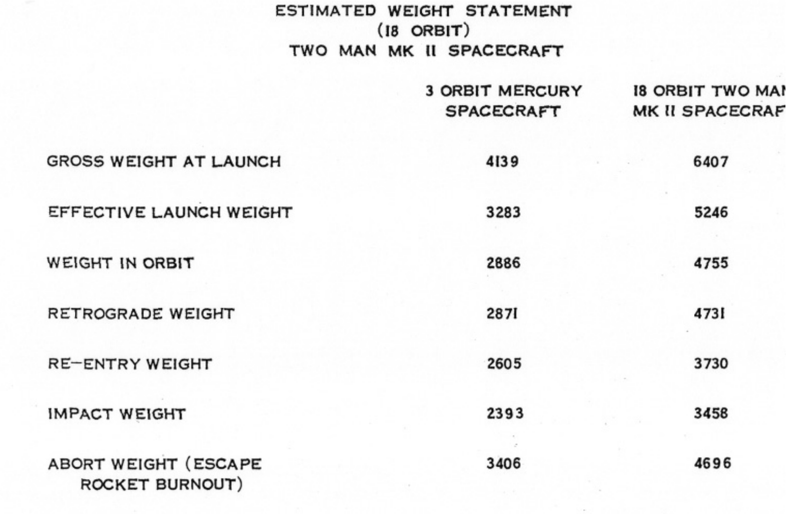


Figure 3.1

[9]



ESTIMATED WEIGHT STATEMENT
(18 ORBIT)
TWO MAN MK II SPACECRAFT

	3 ORBIT MERCURY SPACECRAFT	18 ORBIT TWO MA MK II SPACECRAF
GROSS WEIGHT AT LAUNCH	4139	6407
EFFECTIVE LAUNCH WEIGHT	3283	5246
WEIGHT IN ORBIT	2886	4755
RETROGRADE WEIGHT	2871	4731
RE–ENTRY WEIGHT	2605	3730
IMPACT WEIGHT	2393	3458
ABORT WEIGHT (ESCAPE ROCKET BURNOUT)	3406	4696

FIGURE 3.2

[10]

EVENTS REQUIRED TO COMPLETE A RENDEZVOUS MISSION WHEN SPACECRAFT LAUNCH OCCURS WITHIN THE LIMITS OF THE LAUNCH WINDOW

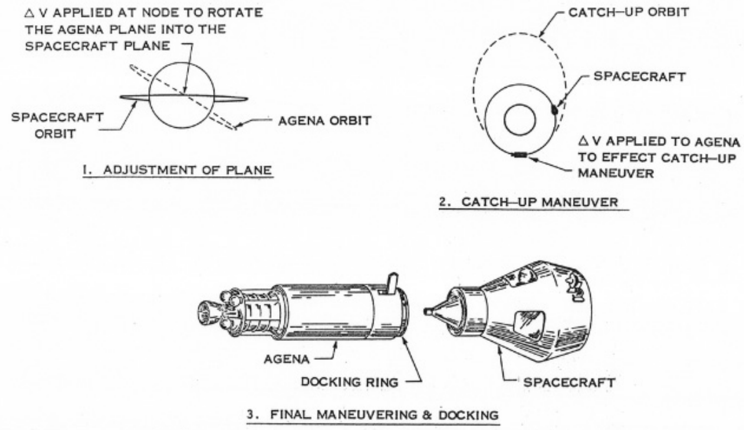


FIGURE 3.9

[11]

PARAGLIDER LANDING SYSTEM

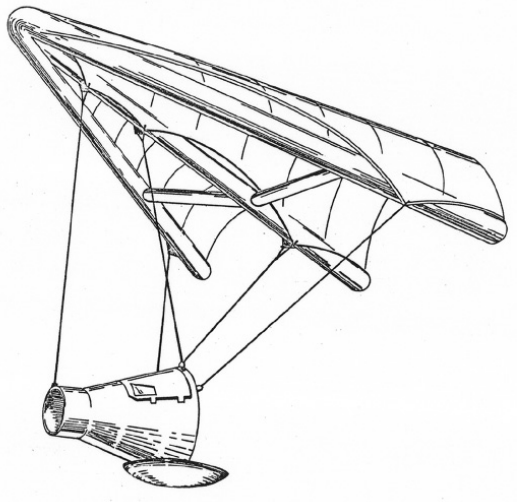
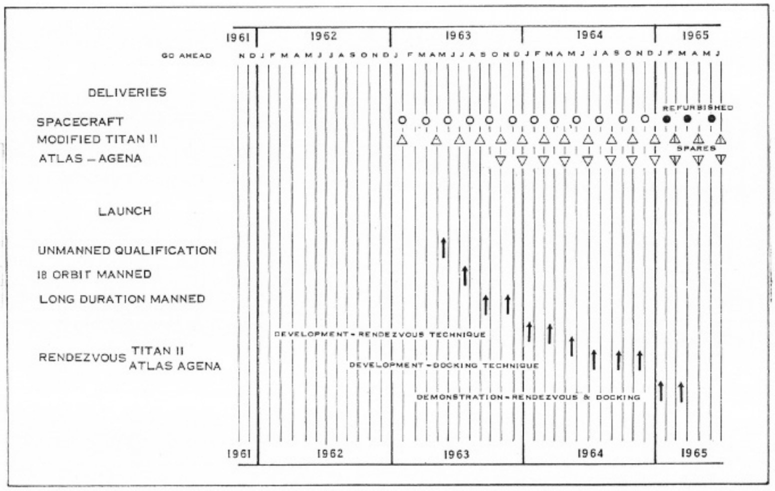


Figure 3.13

[12]

MK II LAUNCH PROGRAM



[13]

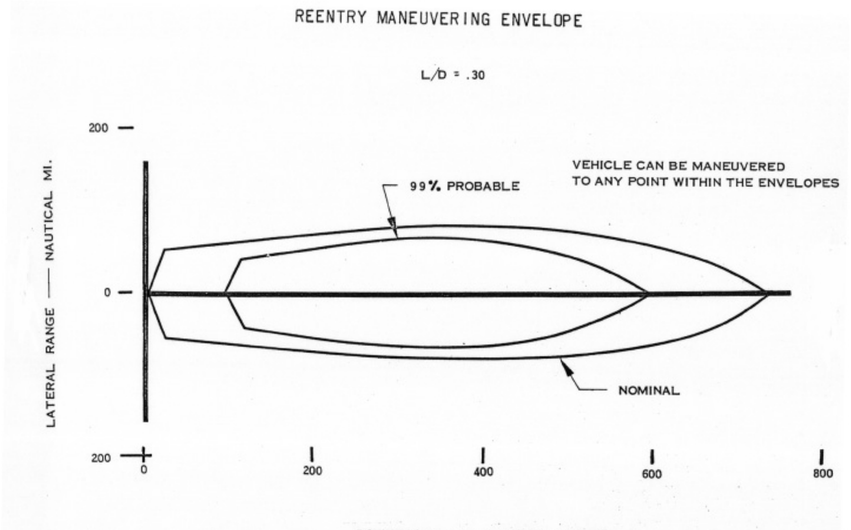


FIGURE 3.11

[14]

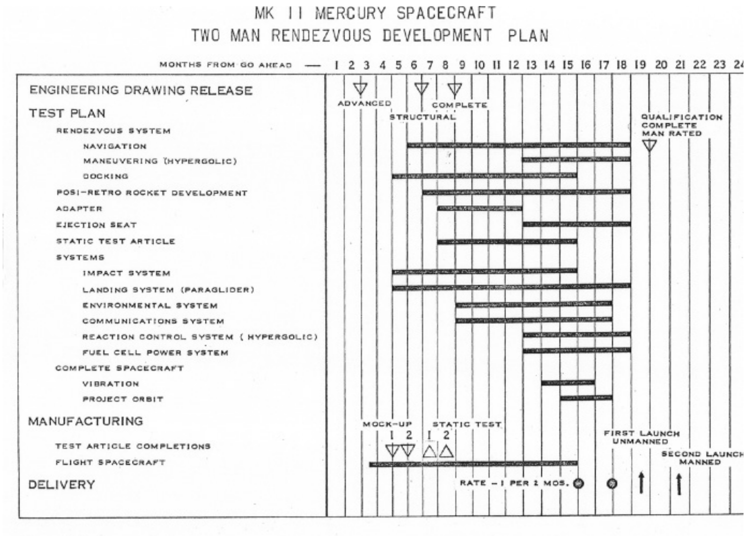
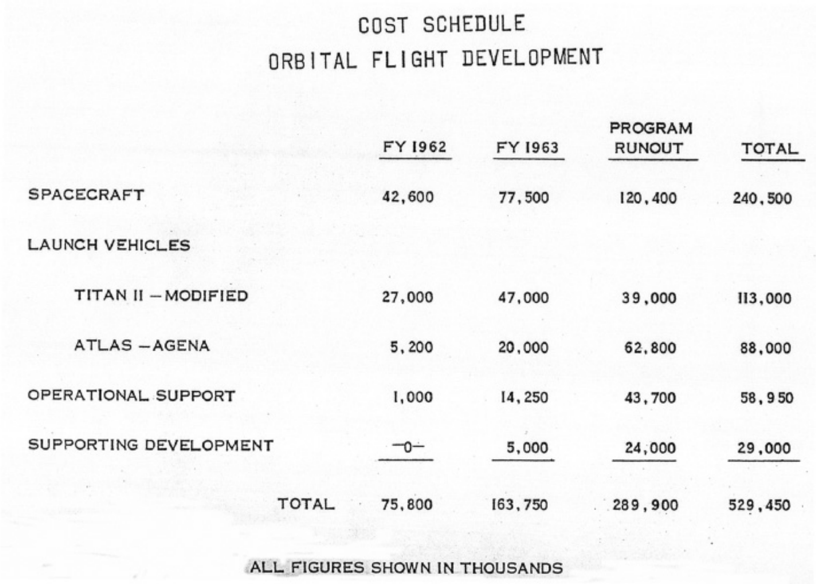


FIGURE 5.2



COST SCHEDULE
ORBITAL FLIGHT DEVELOPMENT

	FY 1962	FY 1963	PROGRAM RUNOUT	TOTAL
SPACECRAFT	42,600	77,500	120,400	240,500
LAUNCH VEHICLES				
TITAN II – MODIFIED	27,000	47,000	39,000	113,000
ATLAS – AGENA	5,200	20,000	62,800	88,000
OPERATIONAL SUPPORT	1,000	14,250	43,700	58,950
SUPPORTING DEVELOPMENT	–0–	5,000	24,000	29,000
TOTAL	75,800	163,750	289,900	529,450

ALL FIGURES SHOWN IN THOUSANDS

Document I-50

Document Title: Al Nagy, NASA, to George Low, NASA, 11 December 1961.

Source: Folder 18674, NASA Historical Reference Collection, NASA History Division, NASA Headquarters, Washington DC.

Document I-51

Document Title: D. Brainerd Holmes, Director of Manned Space Flight Programs, NASA, Memorandum for Associate Administrator, NASA, "Naming Mercury-Mark II Project," 16 December 1961.

Source: Folder 18674, NASA Historical Reference Collection, NASA History Division, NASA Headquarters, Washington DC.

In December 1961 NASA officials began considering what to call the new program planned to follow Mercury. Robert C. Seamans, Jr., NASA's Associate Administrator, wanted to run a competition to name the proposed Mercury Mark II, and offered a token reward of a bottle of good Scotch whiskey to the person suggesting the name finally accepted. In addition to others who recommended the name, Alex P. Nagy, an engineer in NASA's Office of Manned Space Flight, proposed "Gemini," a reference to classical mythology and quite appropriate for the two-astronaut spacecraft. NASA Headquarters officials selected Gemini from a host of *other names submitted, including "Diana," "Valiant," and "Orpheus," from the Office of Manned Spaceflight. On 3 January 1962, NASA announced the Mercury Mark II project had been renamed "Gemini."*

Document I-50

AP:lgs
December 11, 1961

George:

For the orbital flight development effort, I propose the name "PROJECT GEMINI."

This name, "the Twins" seems to carry out the thought nicely, of a two-man crew, a rendezvous mission, and its relation to Mercury. Even the astronomical symbol (II) fits the former Mark II designation.

[Signed: *Al*]
Al Nagy

Document I-51

In reply refer to:
MS

December 16, 1961

The Office of Manned Space Flight recommends the following names for the project currently referred to as Mercury-Mark II:

Diana [handwritten: *Huntress*]
Valiant
Gemini
Orpheus

These are not listed in any order of preference

[handwritten: *George M. Low*
for] D. Brainerd Holmes
Director of
Manned Space Flight Programs

Document I-52

Document Title: Flight Crew Operations Division, NASA, "Gemini Familiarization Package," 3 August 1962.

Source: NASA Collection, University of Houston, Clear Lake Library, Clear Lake, Texas.

The Project Gemini Familiarization Manual was a document published by the McDonnell Aircraft Company as a training aid for Gemini astronauts. The first section dealt with a mission description, while a second section related to Major Structural Assemblies. The remaining sections described the Cabin Interior Arrangement, the Sequence System, the Electrical Power System, the Environmental Control System, the Cooling System, the Guidance and Control System, the Communication System, and the Instrumentation System. This "Gemini Familiarization Package" served as a brief summary of the more extensive manual.

[CONFIDENTIAL] [DECLASSIFIED]

GEMINI FAMILIARIZATION PACKAGE

Prepared by the Flight Crew Operations Division
Crew Engineering
August 3, 1962

(This material contains information affecting the National Defense of the United States, within the meaning of the Espionage Laws, Title 18 US. C., Sections 798 and 794, the transmission or revelation of which in any manner to an unauthorized person is prohibited by law)

[1]

1.0 INTRODUCTION

The purpose of this familiarization package is to provide documentation describing the operation, system designs, and crew station arrangement of the two man Gemini spacecraft. These notes are complementary to the contractor furnished pilot's manual which deals primarily with the details of each display and control inside the spacecraft cockpit.

To best appreciate the significance of displays, controls, and manual operational procedures, one should have a thorough knowledge of the mission profile and system functions which are described in detail in the body of this document. First, however, the Gemini program objectives will be listed for reference and a summary description given of the guidelines used to divide crew tasks.

1.1 Program Objectives
- (a) Accomplish 14 day earth orbital flights.
- (b) Demonstrate rendezvous and docking in earth orbit.

(c) Provide for controlled land landing as primary recovery mode.
(d) Develop simplified countdown techniques to aid rendezvous missions (lessens criticality of launch window).
(e) Determine man's capabilities in space during extended missions.

1.1 Crew Tasks

The crew is used as a required integral part of Gemini. The Manned Spacecraft Center philosophy calling for increased crew usage and onboard command and control wherever logical is implemented in this program.

The Pilot-Commander has primary control of spacecraft operation during all phases of flight.

The Co-Pilot/Systems Engineer provides control backup to the pilot and manages operation of spacecraft and Agena systems.

[2]

1.2 Comparison of Mercury and Gemini

While there is similarity between Mercury and Gemini, there are several significant differences in operations and systems design. In summary, the major differences are as follows:

b. Manual Abort

All aborts will be initiated onboard by the pilot-commander who has launch vehicle system displays on the left hand console, and at least one backup indication of each malfunction situation; (visual, physical, audio, or redundant display).

c. Maneuvering Capability

Translation capability is provided in Gemini before docking by the OAMS (Orbit Attitude and Maneuver System) and after docking by Agena. Both these systems use similar hypogolic propellants.

d. Cryogenics

Super-critically stored hydrogen and oxygen are used in the environmental control system and for the fuel cells.

e. Range Control

Modest lift capability is provided during reentry by offsetting the spacecraft center of gravity.

Lift is controlled by rolling the spacecraft about the reentry vector. Greater reentry range and an increased heat load result from this feature which allows point return.

f. Paraglider

An inflatable paraglider and conventional landing gear provide for subsonic flight control and horizontal landing.

[3]

g. Extra-vehicular Operations

The Gemini hatch is designed to permit the crew to leave the spacecraft while in orbit. Specific experiments and extra-vehicular suit provisions have not been defined.

Document I-53

Document Title: Charles W. Mathews, Manager, Gemini Program, "Program Plan for Gemini Extravehicular Operation," 31 January 1964.

Source: Folder 18674, NASA Historical Reference Collection, History Division, NASA Headquarters, Washington, DC.

As the Mark II spacecraft was being designed and redesigned, one of the changes involved the addition of a large mechanical hatch that, in addition to facilitating entry and exit to the spacecraft and allowing the use of ejection seats, would also permit an astronaut to leave the spacecraft in orbit. But the idea was only discussed sporadically for the next few years, since it was not necessary for the Apollo program and it was planned that any extra-vehicular activity (EVA) experiments would be done late in the program. In January 1964, this preliminary plan for EVA operations was developed, but it was not enthusiastically received within NASA. At a press conference in July 1964, Gemini Deputy Manager Kenneth Kleinknecht had suggested that a limited EVA was possible during Gemini IV, but this remark had gone unnoticed. James McDivitt and Edward White, the primary crew for Gemini IV (called GT-4 in this document), and their backups Frank Borman and James Lovell, Jr., lobbied hard for the inclusion of the EVA mission in the Gemini IV flight and ultimately swayed opinions at NASA. An EVA on the Gemini IV mission was approved on 25 May 1965. The fact that the Soviet Union had carried out the first-ever EVA on 18 March 1965 was clearly a factor in that approval, but the intent to do EVAs during Project Gemini had been part of the program plan from the start.

PROGRAM PLAN

FOR

GEMINI EXTRAVEHICULAR OPERATION

January 31, 1964

Approved: ________[signed]_______
Charles W. Mathews
Manager, Gemini Program

[2]

I. PURPOSE

This program plan has been prepared by the Gemini Program Office to document the Objectives of Gemini extravehicular operation and to outline the program for achieving these objectives. It is intended for use as the basis for overall program control and coordination to ensure proper implementation of program requirements. The plan will be kept current by the Gemini Program Office and revisions will be issued as additional information is developed.

II. OBJECTIVES OF GEMINI EXTRAVEHICULAR OPERATION

A. General. The general objectives to the accomplished are as follows:
1. Evaluate man's capability to perform useful tasks in a space environment.
2. Employ extravehicular operation to augment the basic capability of the Gemini spacecraft.
3. Provide the capability to evaluate advanced extravehicular equipment in support of manned spaceflight and other national space programs.

B. Phase One. The objectives to be accomplished on the initial extravehicular missions are:
1. Demonstrate feasibility of extravehicular operation.
2. Establish confidence in Gemini systems for extravehicular operation.

[2]

3. Conduct preliminary evaluation of man's ability to perform in free space.

C. Phase Two. After completion of Phase One, the following objectives are to be accomplished:
1. Conduct detailed evaluation of man's ability to perform in free space.

2. Retrieve experimental data packages and equipment from the adapter section and from the Agena.
3. Conduct preliminary evaluation of advanced extravehicular equipment, including long term life support systems and maneuvering devices.

D. Phase Three. After completion of Phase Two, the following objectives are to be accomplished:

1. Evaluate equipment and man's capabilities to operate independent of the spacecraft.
2. Perform such advanced extravehicular experiments as are approved in the future.

III. IMPLEMENTATION

A. Mission Planning.

1. Mission planning is to be based on a step-by-step progression from the simplest to the more ambitious extravehicular tasks. For planning purposes the following mission scheduling shall be used:
   a. Phase One: GT-4 through GT-6
   b. Phase Two: GT-7 through GT-9
   c. Phase Three: GT-10 and up

[4]

2. Detailed flight activities planning is being done by the Flight Crew Support Division. Activities for a given mission will be determined on the basis of overall mission requirements and capabilities.

B. Task Assignments.

1. Crew Systems Division
   a. Equipment development and procurement
   b. Establishment of ground test program

2. Flight Crew Support Division
   a. Flight activities planning
   b. Astronaut training

3. Center Medical Operations Office
   Monitor progress of program to insure fulfillment of medical requirements.

4. Flight Operations Directorate
   Monitor progress of program to insure fulfillment of flight operations requirements.

5. Gemini Program Office
   Overall program direction

IV. EXTRAVEHICULAR EQUIPMENT

A. Portable Life Support System (PLSS).

1. Phase One. The Crew Systems Division (CSD) is developing a PLSS based on the Mercury 7500 psi oxygen bottle. This PLSS is being designed to provide open loop oxygen flow at 5 cfm for a total of 45 minutes. After allowing suitable [5] reserves and time for egress and ingress, this system will be limited to a maximum of 10 minutes outside the spacecraft.

2. Phase Two. In order to accomplish the Phase Two objectives, a PLSS which will provide 30 minutes useful time outside the spacecraft is required. Further study is needed to determine the type of system which will met this requirement. Development of the Phase Two PLSS is to be carried out by CSD.

2[*sic*] Phase Three. It is anticipated that the Phase Two PLSS will be used for egress and ingress during Phase Three operations. More advanced equipment to be used for longer duration periods outside would be stowed in the equipment adapter. This advanced equipment will be defined at a later date.

B. Pressure Suit.

1. A modified version of the Gemini Pressure suit will be used for extravehicular operation. The single wall pressure vessel concept will be retained. The following modifications will be incorporated:
   a. An overvisor for glare, ultraviolet, and thermal protection.
   b. Gloves modified to incorporate thermal protection.
   c. Redundant pressure sealing closure.
2. Development of the Gemini extravehicular suit is to be carried out by CSD.

[5]

C. Thermal Protection.

1. Phase One. The only thermal protection required for Phase One operations consists of local protection against the extreme temperatures of the spacecraft exterior. The gloves, boots, and knees are the primary areas affected.
2. Phase Two and Three. Present studies indicate that a thermal overgarment will be required for extravehicular missions of 30 minutes or more outside the spacecraft. Development of the thermal garment is to be carried out by CSD.

D. Meteoroid Protection.

1. Meteoroid protection will be required to provide a probability of .999 of no puncture of the pressure suit. On the basis of the present

MSC standard meteoroid environment, the following weight of soft goods padding will be required in a protective garment:
a. Phase One (10 minutes) - 2 lb.
b. Phase Two (30 minutes) – 3.5 lb.
c. Phase Three (1 hour) – 4.75 lb.

2. Development of a meteoroid protective garment is to be carried out by CSD.

E. Tether.

1. A tether incorporating a safety line and communications leads is being developed by CSD. Initial planning has been based on no biomedical instrumentation during the extravehicular operation. More recently CSD and Medical Operations have [6] specified minimum desired parameters to be monitored. Provisions for monitoring these parameters will be incorporated in the tether, if possible. The length of the tether is to be sufficient to allow ingress to the equipment adapter section.

F. Maneuvering Unit.

1. The Air Force has proposed an extravehicular unit (MMU) for use on later Gemini missions under Gemini/DOD Experiment 14C. If this experiment is approved, it is anticipated that the MMU would be used in the latter part of Phase Two and in Phase Three. The MMU would contain propulsion, control, communications, and life support systems. It would be furnished by the Air Force under an independent contract.

V. SPACECRAFT MODIFICATIONS

A. Spacecraft modifications will be incorporated to enable the astronaut to move about the exterior of the spacecraft and into the equipment adapter. These modifications are as follows:

1. Exterior handholds spaced approximately two feet apart from the cockpit to the adapter section interior. The handle configuration will be based on configuration studies by CSD as well as aerodynamic considerations.

2. Protective cover for the rough edge at the aft end of the adapter section. The astronaut must be able to proceed past this rough edge without the hazard of damage to the pressure suit or the tether.

Document I-54

Document Title: Edward Z. Gray, Director, Advanced Manned Missions Program, Office of Manned Space Flight, NASA, to Director, Gemini Program, NASA, "Gemini Lunar Mission Studies," 30 April 1964.

Source: Folder 18674, NASA Historical Reference Collection, NASA History Division, NASA Headquarters, Washington DC.

Document I-55

Document Title: Eldon W. Hall, Director, Gemini Systems Engineering, NASA, to Deputy Director, Gemini Program, NASA, "Circumlunar Missions," 29 June 1965.

Source: Folder 18674, NASA Historical Reference Collection, NASA History Division, NASA Headquarters, Washington DC.

Document I-56

Document Title: James E. Webb, Administrator, NASA, to Olin E. Teague, Chairman, Subcommittee on NASA Oversight, Committee on Science and Astronautics, House of Representatives, 10 September 1965.

Source: Folder 18674, NASA Historical Reference Collection, NASA History Division, NASA Headquarters, Washington DC.

In the spring of 1964 it appeared to many senior officials at NASA that the Apollo program was stalling and might not be able to make its deadline of a lunar landing by the end of the decade. The last Mercury flight had taken place in May 1963, and Gemini was not scheduled to fly for several months. The Saturn rocket project was having difficulties, and the Apollo spacecraft development effort was lagging behind schedule. Accordingly, Wernher von Braun suggested to a reporter for Missiles and Rockets *that in a contingency he thought Gemini might be reconfigurable for a flight around the Moon. This story, appearing on 18 May 1964, quoted von Braun as saying that Gemini could undertake a circumlunar flight "to salvage this country's prestige if the manned lunar goal proves impossible." Von Braun had voiced something that had been bubbling within NASA for some time, and thereafter pressure mounted to formalize and make public efforts to evaluate the possibility of a Gemini circumlunar flight. Throughout the summer of 1964, as these documents show, NASA undertook internal studies. They were only internal, for on 8 June, NASA Deputy Associate Administrator Robert C. Seamans told NASA Associate Administrator for Manned Spaceflight George Mueller that "any circumlunar mission studies relating to the use of Gemini will be confined to in-house study efforts." In reality, NASA leaders had bet the future of their Agency on the success of Apollo. They intended to make Apollo succeed and any serious effort to reconfigure Gemini as a "quick and dirty" lunar program would detract from that objective. The studies were at best halfhearted. In his 10 September 1965 memorandum to Representative Olin Teague (D-Texas), NASA Administrator James E. Webb said it well,: "Our main objective now is to see that our basic current responsibilities are met effectively . . . the Apollo system now being developed can meet our requirements for knowledge and capability better than the adoption of other courses of action."*

Document I-54

MT-1:JRS:saj

April 30, 1964

MG/Director, Gemini Program

MT/Director, Advanced Manned Missions Program

Gemini Lunar Mission Studies

As you are aware, we have been asked by Dr. Mueller to study the feasibility of using Gemini in a lunar mission and to develop suitable contingency plans to be available by mid-1966, should such a mission be feasible and should it be required. Mr. Taylor's office (MT-1), with the assistance of John Hammersmith from your office, has completed a preliminary review of the feasibility of using Gemini in a lunar mission, based on the work that has been done by your office, MSFC, MSC, and McDonnell Aircraft Corporation. This review has concluded that, although all of the studies are relatively shallow, there are several combinations of hardware which could be used to provide a Gemini lunar mission capability. Enclosure 1 [not included] contains the review results.

I believe that a study should be initiated to more thoroughly investigate the Gemini circumlunar mode, utilizing the Saturn IB with a Centaur as the injection stage, in either a direct ascent or an earth orbit rendezvous trajectory. These modes are summarized in Columns 1 and 3 of the Enclosure.

In addition, I think we should study the Gemini Lunar Orbit mode, as represented in Column 7 of the Enclosure. The purpose of such a study would be to more accurately determine the capability of each configuration, the key technical problems, relative costs, development schedules and key decisions points to provide a basis for possible contingency- type decisions in the 1965-66 time period.

As indicated during our telephone conversation on April 22, I believe these studies should be conducted by McDonnell Aircraft Corporation through existing contracts. These studies should be monitored by MSC, either under your or my jurisdiction. If required, I can make funds available for this study, which I believe will require approximately five (5) man-years of effort. We will be available to work with you in this study to whatever extent you desire.

Edward Z. Gray
Director, Advanced Manned
Missions Program,
Office of Manned Space Flight

Document I-55

[CONFIDENTIAL] [DECLASSIFIED]

UNITED STATES GOVERNMENT MEMORANDUM

DATE: June 29, 1965

TO: MG/Deputy Director, Gemini Program

FROM: MGS/Director, Gemini Systems Engineering

SUBEJCT: Circumlunar Missions

1. On Thursday, June 24, I attended a meeting at MSC in which representatives of Martin-Denver and MAC (including Messrs. McDonnell, Burke, and Yardley) presented a proposal for a circumlunar flight using the Gemini spacecraft and the Titan IIIC booster. In attendance at the meeting was Dr. Gilruth, Messrs. Low, Mathews, Kleinknecht, Evans, and Guild of MSC and myself.

2. In this proposal the Gemini spacecraft modified for circumlunar flight is launched into earth orbit with a GLV. The Titan IIIC launches a stripped down transtage that provides the propulsion for injection to circumlunar velocities after rendezvous with the spacecraft. The general arrangement and flight hardware are summarized in enclosure (1) (Figure 2.1-1 of Attachment C). [not included]

3. The principal changes to the Titan IIIC involve using a double transtage. The first provides propulsion during launch into earth orbit and contains the attitude control and an equipment module for use during rendezvous with the spacecraft. A Gemini Target Docking Adapter is mounted on top of the second transtage.

4. A significant number of changes are proposed for the spacecraft. Weight saving items are summarized in enclosure (2) and enclosure (3) (page 1-8 and Table 1.2-1 of Attachment C). The most significant changes to the spacecraft are summarized as follows:

   a. Addition of a Unified S-Band System.

   b. Additional OAMS tankage and TCA's substituted for the retrograde rockets.

   c. Additional heat protection using coated columbium and ablation shingles.

   d. Shortening of the R&R section by 20 inches.

   e. Use of three fuel cell sections.

   f. "Blow-down" RCS and independent pressurization of fuel and oxidizer.

[2]

5. Three flights are recommended:

   a. Heat Protection Qualification (Titan IIC – one transtage on ballistic trajectory);

   b. Spacecraft Qualification (manned, GLV in earth orbit);

   c. Manned Circumlunar Orbit.

6. The Martin schedule, enclosure (4) (last page of Attachment A) [not included], indicates completion by April 1967. The MAC schedule (not available) is even earlier using two refurbished spacecraft and a go-ahead by July 1.

7. No money estimates were presented by Martin or MAC; however, some preliminary estimates by GPO indicated $350M.

8. I think the proposal is feasible, but not within the time and effort indicated. The equipment and mission are too marginal to absorb changes and additions that will be required without extensive redesign and testing.

9. I personally would prefer to see us advance our earth orbital capability. With the same or fewer modifications to the spacecraft advocated in this proposal and additional Agena payloads, we could attain a significant lead in the design and operation of earth-orbital space stations. Gemini is ideally suited to the preliminary determination of problems and to the initial development of techniques and procedures leading to advanced manned earth-orbital missions. The time and money spent in additions or extensions of this type to an earth-orbital Gemini would be more than repaid in time and money saved in later, more expensive, and complicated programs.

[Signed]
Eldon W. Hall

Enclosures: 4 as stated [Not included]

Attachments:

A) "Configuration, Weight Summary, Performance, Transtage #2 Performance, EOR Operations, Mission Profile, and Related Schedules," by Martin-Denver (Unclassified)
B) "Rendezvous Concept for Circumlunar Flyby in 1967," by Martin-Denver, P-65-91, June 1965 (Proprietary)
C) "Gemini Large Earth Orbit (U)," by McDonnell, B743, Vol. I – Technical, June 19, 1965 (Confidential)

Document I-56

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON DC 20546

September 10, 1965

OFFICE OF THE ADMINISTRATOR

Honorable Olin E. Teague
Chairman, Subcommittee on NASA Oversight
Committee on Science and Astronautics
House of Representatives
Washington, DC 20515

Dear Mr. Chairman:

With reference to your request for my views on the possibility of a circumlunar flight, using a Gemini system, prior to the Apollo lunar landing, you will note that the enclosed statement, which was submitted to the Senate Committee on Aeronautical and Space Sciences on August 23, indicates that in the process of accomplishing the lunar exploration mission with Apollo, our program will give us experienced crews, operating know-how, and the ground and space equipment to undertake quite a number of other scientific and technological developments. The point is also made that our on-going and approved missions will require, for the next several years, the peak performance of the scientific, engineering, industrial and facilities complex that we have been expanding since 1961.

As indicated to the Senate Committee, we are not ready to recommend major new projects on the order of Gemini or Apollo. Our main objective now is to see that our basic current responsibilities are met effectively. I also feel that the Apollo system now being developed can meet our requirements for knowledge and capability better than the adoption of other courses of action.

The insertion in our program of a circumlunar flight, using the Gemini system, would require major resources. We are now proceeding with many complex, developmental tests, and operational efforts with too thin a margin or resources. Therefore, if additional funds were available, I believe it would be in the national interest to use these in the Apollo program.

As you will remember, I testified in 1961 that the USSR would most likely have the capability and therefore accomplish ahead of us each major milestone in space up to the lunar landing and exploration with manned vehicles. We have clearly stated over the past few years that they will do a lunar fly-by with men before we can accomplish this with the Apollo system. However, there is certainly no assurance that we could do this in advance of them with a modified Gemini system. Further, our main reliance for operating [2] at lunar distances and developing a thoroughgoing capability that can achieve preeminence in space, and hold it, is the large Saturn V/Apollo system. The fact that this has been under contract for several years; that full duration test runs have been made on each stage of the Saturn V booster; that we now have an eight-day Gemini flight behind us and will shortly have information from a 14-day flight; and the fact that the Apollo ground test equipment has largely been fabricated and the flight line equipment will shortly be constructed and delivered means that we have a growing competence that we and the world can see is considerably beyond anything the Russians have shown us, including Proton One. Therefore, I do not believe a decision not to make the substantial investment that would be required by a modified Gemini lunar fly-by will change the posture which our program has had for a number of years.

Sincerely yours,
[Signed]
James E. Webb
Administrator

Document I-57

Document Title: William C. Schneider, Deputy Director, Gemini Program, NASA, for Deputy Director, Apollo Program, "Gemini Support of Apollo," 25 June 1964 (signed for Schneider by LeRoy Day).

Source: Folder 18674, NASA Historical Reference Collection, NASA History Division, NASA Headquarters, Washington DC.

Document I-58

Document Title: Eldon Hall, Director, Gemini Systems Engineering, NASA, Memorandum for Deputy Director, Gemini Program, NASA, "List of Missions," 17 July 1964 (signed for Hall by John Hammersmith).

Source: NASA Historical Reference Collection, NASA History Division, NASA Headquarters, Washington D.C.

From the very beginning of the Gemini program, it had four major objectives that would support the Apollo effort to reach the Moon by the end of the decade. These included: (1) long duration spaceflight of up to two weeks in duration to demonstrate the human capability to survive such an extended stay in space; (2) rendezvous and docking with another orbiting vehicle; (3) engaging in extra-vehicular activity (EVA) or spacewalks; and (4) developing methods for entering the atmosphere and landing at pre-selected points on land. All of these were skills viewed as necessary for later Apollo missions, and all except the last were accomplished. These two memoranda outline the evolution of efforts on the Gemini missions aimed at satisfying these requirements. The first, signed for Gemini Deputy Director William Schneider by LeRoy E. Day, longtime engineer at NASA, shows a steady progress of achievements in support of the Apollo program, each more complex than the last. The second, signed for Gemini Director of Systems Engineering by Eldon W. Hall, another longtime NASA engineer, offers a shopping list of Gemini "desires" that never came to fruition, such *as propellant transfer in orbit and on-orbit assembly and repair. These initiatives were to be part of additional Gemini missions that were never approved. Both memos reflect what S[ch]neider and Hall were thinking about a year in advance of the first Gemini mission and about the many possibilities for the program.*

Document I-57

[CONFIDENTIAL] [DECLASSIFIED]

June 25, 1964

UNITED STATES GOVERNMENT MEMORANDUM

TO: MA/Deputy Director, Apollo Program

FROM: MG/Deputy Director, Gemini Program

SUBJECT: GEMINI SUPPORT OF APOLLO

As you know, one of the primary missions of Gemini is to provide support to Apollo, by developing orbital rendezvous techniques and obtaining data on the effects of long duration weightless flight. We have developed a set of missions which support these objectives. The missions and schedules are outlined below.

Enclosure 1 [not included] shows the launch schedule of Gemini and its relationship to Apollo launch schedules. Enclosure 2 [not included], Gemini Flight Mission Assignments, contains a summary of the Gemini missions.

Flights 4, 5, and 7 will provide experience in long duration orbital flight. A typical mission profile for these long duration flights is shown in Enclosure 3 [not included]. Many measurements and experiments will be performed to assess the effects of orbital weightless flight on man and machine for periods up to 14 days – more than adequate for the Apollo lunar expedition. Among the medical experiments, for example; M-1, Cardiovascular Reflex, will determine the feasibility of using inflatable cuffs to prevent cardiovascular deterioration – evidence of which was noted in Project Mercury flights MA-8 and MA-9. Among the engineering experiments, MSC-1, Electrostatic Charge will determine the buildup of electrostatic charge on spacecraft due to the firing of the rocket engines –a potential hazard due to the possibility of electrical discharge between rendezvous vehicles. These experiments and other are described in the Manned Space Flight document, Description of Gemini Experiments, Flights GT-3 through GT-7, April 13, 1964. In addition to these experiments, we also plan to conduct extravehicular activity to evaluate man's performance outside the spacecraft.

With Flight No. 6, we will establish the feasibility of rendezvous and provide experience for the visual manual docking mode, which is common to both Gemini and Apollo. This flight is outlined in Enclosure 4. The flight plan shown is one of the several proposed to date for this flight; however, the docking procedures shown in the addendum to the enclosure are typical.

[2]

Whereas radar computer guidance will be the primary onboard mode for the terminal rendezvous phase of Flight No. 6; the radar optical and optical guidance modes will be primary for Flights 8 and 9 respectively. The Gemini radar optical and optical guidance modes are very similar to the LEM Manual Alternate guidance modes outlined in Grumman Aircraft Engineering Corporation Report No. LED-540-3, Back-up Guidance Requirements, July 9, 1963. The basic feature of the terminal homing phase in these rendezvous maneuvers is that the LEM and Gemini essentially fly a collision course to their respective rendezvous target. This characteristic is achieved by keeping the inertial rate of the Line of Sight (LOS) to the target below a given threshold value. Following the LOS rate reduction, range rate with respect to the target is measured and thrust applied along the LOS direction until range rate is reduced to a pre-determined value appropriate to the range at which thrust was initiated. This procedure is repeated several times from the initial range of 20 NM down to the docking phase. A mission profile for Flight No. 8, employing radar optical guidance, is shown in Enclosure 5[not included]. The mission profile for Flight No. 9 will be basically the same; however, the optical sight will be used in place of the radar.

When viewed against the malfunctions encountered with the Automatic Stabilization Control System in Project Mercury, it is difficult to over-emphasize the vital importance of simulating and testing the manual alternate modes provided to accomplish critical maneuvers such as rendezvous. The success of Project Mercury was due in large part to its manual modes. Since the Gemini manual modes require the greatest degree of astronaut participation, they will also provide the greatest degree of astronaut training.

In NASA Project Apollo Working Paper No. 1083, Study of Earth Orbit Simulation of Lunar Orbit Rendezvous, July 24, 1963, it is concluded that it would be desirable to perform an earth orbit simulation of lunar orbit rendezvous since this will provide a realistic assessment of the guidance techniques and demonstrate the ability to perform the critical lunar orbit rendezvous maneuver. Enclosures 6 and 7[not included], taken from Working Paper No. 1083, show the close comparisons of earth orbit and lunar orbit rendezvous trajectories and closing times.

By Flights 10 and 11, or earlier, we plan to flight test the feasibility of the LEM lunar orbit direct rendezvous mode in earth orbit if possible. In this mode, the catch up or parking orbits are essentially by-passed and terminal rendezvous is initiated near first apogee as shown in Enclosure 8. In order to insure its successful completion, the astronauts should be ready to take over manual control of the spacecraft at any time should the automatic system falter. This will require a high degree of training and proficiency on the part of the astronauts. While it is true that Gemini does not employ the same guidance hardware as Apollo; Gemini may be in a unique position, based on present plans, to flight test direct rendezvous in earth orbit. In addition, in terms of schedules, Gemini is in a relatively good position to influence Apollo [3] rendezvous techniques with flight test results. Gemini's first rendezvous flight takes place approximately two years prior to the first manned Apollo flight and its first direct rendezvous flight takes place approximately two years prior to the first lunar rendezvous flight.

For Flight No. 12, we plan to simulate LEM abort maneuvers; either abort from an equiperiod transfer orbit as shown in Enclosure 7 or abort from a Hohmann transfer orbit as shown in Enclosure 9[not included].

In conclusion, we believe that Gemini missions as presently planned will make a very significant contribution to Project Apollo. However, in order to insure the most effective Gemini Program, we would appreciate your comments on our mission plans as outlines herein especially with regard to the Apollo support areas of Flights 8 through 12.

L.E Day

[handwritten: *for*] William Schneider
Deputy Director, Gemini Program

Enclosure: 9 as stated [not included]

Copy to:
MSC-DD/Low
MSC-GPO/Mathews
M/Mueller
MGO/Edwards
MGS/Hall
MGS/HUFF
MGT/DAY

Document I-58

[FOR INTERNAL USE ONLY]

July 17, 1964

UNITED STATES GOVERNMENT MEMORANDUM

TO: MG/Deputy Director, Gemini Program

FROM: MGS/Director, Gemini Systems Engineering

SUBJECT: List of missions

The following is a quick list of missions (or important experiments), which would be accomplished with a follow-on Gemini program. Certain items may require up-rated GLV launch capability or up-rating of spacecraft performance.

Also enclosed is an equally quick vehicle layout of some of these suggestions. Improved quality will follow.

1. Land landing demonstration.

2. Propellant transfer.
3. Extended duration research (medical, physical, environmental).
4. Apollo rendezvous simulations.
5. Apollo DSIF check out.
6. Rendezvous with empty Apollo Command Module.
7. Rendezvous with LEM.
8. Apollo chaser.
9. Minimum space station.
10. Extended duration at low g's (G-can).
11. MOL-rendezvous – joint Air Force mission.
12. Space assembly and repair.
13. Satellite rendezvous – OAO – photographic adaptor.
14. Satellite recovery (like OSO).
15. Satellite chaser (no velocity match).
16. Space escape, personnel reentry (dummy tests).
17. Spacecraft assembly and checkout for orbital launch of unmanned mission.
18. Gemini deep space guidance and navigation.
19. Gemini circumlunar.
20. Gemini lunar orbit.
21. 3-seat rescue craft.
22. Control of upper stage reentry to reduce hazards.
23. 1-man Gemini and telescope.

[Signed: John L. Hammersmith]
[for] Eldon W. Hall

Document I-59

Document Title: E. C. Welsh, National Aeronautics and Space Council, Executive Office of the President, Memorandum for the President, "Space Rescue," 21 May 1965.

Source: Folder 18674, NASA Historical Reference Collection, NASA History Division, NASA Headquarters, Washington DC.

Document I-60

Document Title: Bill Moyers, Special Assistant to the President, The White House, Memorandum for James Webb, Administrator, NASA, and Robert McNamara, Secretary of Defense, 29 May 1965, with attached: Joseph A. Califano, Jr., Special Assistant to the Secretary and Deputy Secretary of Defense, Memorandum for Mr. Valenti/Mr. Busby, Special Assistants to the President, 29 May 1965, with attached: Cyrus Vance, Office of the Secretary of Defense, Memorandum for Mr. Bill Moyers, The White House, "Comments on Need for Space Rescue," 29 May 1965.

Source: Folder 18674, NASA Historical Reference Collection, NASA History Division, NASA Headquarters, Washington DC.

Document I-61

Document Title: James E. Webb, Administrator, NASA, Memorandum to the President, "Space Rescue," 2 June 1965.

Source: Folder 18674, NASA Historical Reference Collection, NASA History Division, NASA Headquarters, Washington DC.

The safety of the astronauts in orbit has long been a critical concern. In 1941, science fiction author Harry Walton wrote about a rescue vehicle—calling it a "lifeship"—in his novel Moon of Exile. In 1946, science fiction scion Arthur C. Clarke published a version of a space rescue mission in his first short story, titled "Rescue Party," in which aliens on a survey of the solar system try to evacuate humanity from Earth in the face of the Sun exploding. Such dramatic space rescue stories sparked serious concern among advocates as the Space Age dawned. In the 1950s Wernher Von Braun advocated the building of a space station in Earth orbit, and with it individual protective return capsules for its crew. In his scenario a parachute with steel-wire mesh reinforcements and solid rocket booster brings the crewmember to Earth, and a radar beacon would signal the landing location. But when NASA began its human spaceflight programs in earnest in 1958, none of them had the capacity for a rescue of a stranded astronaut in Earth orbit. Concern that this was the case led to the following exchange of correspondence on the subject. In the end, NASA decided to build as much reliability as possible into the system and accept the risk, which its officials believed was minimal. The first true space rescue capability developed by NASA for its *astronauts was for the Skylab program, 1973 to 1974. If a crew had to return to Earth from the orbital workshop, an Apollo capsule was available to return the crew.*

Document I-59

EXECUTIVE OFFICE OF THE PRESIDENT
NATIONAL AERONAUTICS AND SPACE COUNCIL
WASHINGTON

EXECUTIVE SECRETARY
MAY 21, 1965

MEMORANDUM FOR THE PRESIDENT

Subject: Space Rescue.

The space rescue issue involves the development of a capability to send up a spacecraft to save the life or lives of astronauts whose equipment has failed while in space.

I have discussed the question of developing such a capability with Jim Webb and he feels that it is too early to attempt to develop a practicable competence for such a purpose. In any event, it is something which should be studied, and the President should know that it is being studied and should be prepared to respond as to why we do not have such a capability should a tragedy in space occur.

An unsolicited space rescue proposal has been prepared by the Martin Company. Mr. Earl Cocke, former National Commander of the American Legion and now a consultant to the Martin Company, is representing that Company in attempting to sell their space rescue proposal. He has indicated that he plans to outline his proposal to the President and has left a brief summary and a detailed presentation with the President's office. Such documents have, in turn, been transmitted to me.

In brief, the Martin Company proposes a National Orbital Rescue Service to begin promptly and in a multi-phased manner. This would call for the building of a space rescue capability over the next ten years at an estimated cost of about $50 million per year. That figure would include a provisional system which could be gotten ready in a relatively short period and also a permanent system.

I hold no particular brief for the Martin proposal but, in view of Mr. Cocke's assertions, I thought it advisable that the President know about it. If a study is desired, it would be appreciated to be so advised.

[Signed]
E.C.Welsh

Document I-60

THE WHITE HOUSE
WASHINGTON

May 25, 1965

TO: Honorable Robert McNamara
Secretary of Defense

Honorable James Webb
Administrator, NASA

FROM: Bill Moyers [Signed]

The President asked if he could have your recommendations on the attached memorandum.

Attachment

[SECRET] [DECLASSIFIED]

OFFICE OF SECRETARY OF DEFENSE
WASHINGTON DC 20301

May 29, 1965

MEMORANDUM FOR Mr. Valenti/Mr. Busby
Special Assistants to the President

Bill Moyers asked me to get the Secretary's comments to the President by the end of this week so that they would be available to the President before the Gemini shot. I am, therefore, sending this out to you by pouch.

[Signed]
Joseph A. Califano, Jr.
The Special Assistant to the
Secretary and Deputy
Secretary of Defense

Attach.

[SECRET]

THE SECRETARY OF DEFENSE
WASHINGTON

May 29, 1965

MEMORANDUM FOR MR. BILL MOYERS, SPECIAL ASSISTANT TO THE PRESIDENT, THE WHITE HOUSE

SUBJECT: Comments on Need for Space Rescue

With regard to Dr. Welsh's memorandum of 21 May 1965, we are familiar with several proposals by industry for developing separate space rescue systems. Our view of this subject is the following:

1. If we go ahead with MOL, we will provide crew safety features beyond those possible in the earlier manned spaceflight programs. For example, the primary mission being performed in the laboratory vehicle will always be backed up by the return capsule as a lifeboat. In the unlikely event that the laboratory has a major failure, the crew can move to the return capsule, separate from the laboratory, and then wait up to six hours in orbit before selecting a preferred deorbit and landing sequence. In addition, we will employ the same practices that have been employed in Gemini and Apollo concerning design redundancies, extensive qualification testing of parts, and full attention to astronaut abort modes for every phase of the flight.

2. It would appear that any genuine rescue service separate from the basic flight hardware would be useful only if it could be sustained on hold for quick launch throughout the manned program; could be capable of rendezvous and docking under uncertain conditions; and could be assured of higher reliability than the orbiting vehicle requiring help. These essential techniques are among the most important objectives of the Gemini, Apollo, and MOL programs. Until they are demonstrated, a separate program for space rescue could not proceed with reasonable and genuine objectives.

3. It is possible we may strand an astronaut in orbit some day. It is very likely that astronauts will be killed, though stranding them is one of the less likely ways. The nation must expect such a loss of life in the space program. There have been several deaths already in our rocket development. We would be untruthful if we were to present any different image to our citizens.

4. As the manned space program evolves to a capability and rate of operation which might warrant a separate rescue arrangement, I expect the Department of Defense to play a large role in the regular operation, and correspondingly to participate in any operations to rescue from stranded spacecraft, should a decision be made that they are justified. For the time being, we consider space rescue similar to commercial aircraft or commercial ocean traffic rescue. In these cases every realistic precaution is taken to reduce probabilities of catastrophic failure, and to insure that effective rescue forces are

> available to retrieve passengers should a major failure occur. The extensive ship and aircraft rescue forces which we deploy globally for each manned flight now typifies this practice.

I would point out that [text redacted in document] rescue can take place only to about 400 feet. As a result, a disabling accident in the rather small part of the ocean where the bottom is between 400 [text redacted in document] feet deep would result in a similar "stranding."

I see no advantage for a specific study of the space rescue question at this time. However, I wish to assure you that the matter of crew safety will remain paramount in our manned military space program. In view of the higher public attention to manned spaceflight, I would note that we will continue to provide this program significantly more crew safety precautions that we have in our similarly dangerous aircraft testing programs.

[Signed Cyrus Vance]

Document I-61

June 2, 1965

MEMORANDUM TO THE PRESIDENT

Subject: Space Rescue

With reference to Dr. Welsh's memorandum of May 21, 1965 on the subject of space rescue, our concern for the safety of United States astronauts means that we take steps to reduce risks by every conceivable means. We maintain intense efforts in the fields of reliability, crew training, equipment check-out, design redundancy, safety margins, and the use of short systems. We have also given careful consideration to the practicability of space rescue within the current or immediately predictable state-of-the-art.

It is obvious that we could not have provided a space rescue system in the Mercury Project, which was devoted to demonstrating the feasibility of manned space flight itself.

In the case of Gemini, the equipments and operational techniques essential to space rescue are being developed as part of the Gemini Program. A considerable number of the Gemini experiments are devoted to rendezvous, docking, manned extravehicular activities, tether dynamics, and the use of tools and repair of equipment in space – techniques which must be mastered before a practical space rescue system can be developed. However, in Gemini, we are building on all of the measures for safety that have come from our extensive experience in test flying and such advanced systems as the X-15 – the measures which have also been instrumental in achieving our perfect record of astronaut safety thus far. The redundancy designed into the retro-system for return from orbit is optimized for crew safety. The orbital parameters of the next Gemini mission are planned so that the orbit will decay to reentry within 24 hours after the planned termination of the flight, should all other provisions for initiating the de-orbiting landing sequence fail.

We are actively continuing our studies of all aspects of space rescue. The Mission Analysts Division of our Office of Advanced Research and Technology has evaluated the Martin Company's proposal for the development of a space rescue capability over a ten-year [2] period. It is our judgment that the knowledge needed to begin the design of such a space rescue system is not yet available, but will come from our present developmental and flight program.

You may be assured, Mr. President, that we shall continue to give first priority to considerations of astronaut safety.

[Signed]
James E. Webb
Administrator

Cc: AD/Dr. Dryden
AA/Dr. Seamans, M/Dr. Mueller, W/Adm. Boone

Document I-62

Document Title: Julian Scheer, Assistant Administrator for Public Affairs, NASA, Memorandum to Mr. Marvin Watson, The White House, 24 May 1965.

Source: Folder 18674, NASA Historical Reference Collection, NASA History Division, NASA Headquarters, Washington DC.

Document I-63

Document Title: Marvin Watson, The White House, Memorandum for the President, 24 May 1965.

Source: Folder 18674, NASA Historical Reference Collection, NASA History Division, NASA Headquarters, Washington DC.

As the Gemini program evolved in 1965, questions about the propriety of lauding the program as a "space spectacular" emerged. NASA, the White House, the media, and the public had treated the various Mercury flights as singular events worthy of intense reporting. Each Mercury launch was exhaustively covered on all three television networks and the *astronauts, NASA operational activities, and recovery received considerable exposure. Each astronaut also enjoyed media hype at the time of their mission. But was such involved reporting appropriate for the Gemini program? Julian Scheer, NASA's Director of Public Affairs, did not think so. He advocated a more routine approach to operations, aimed at making spaceflight appear more normal than unusual. While NASA continued to enjoy significant media attention during Gemini, attention to later missions was somewhat less pronounced than for their Mercury counterparts.*

Document I-62

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON DC 20546

OFFICE OF THE ADMINISTRATOR

May 24, 1965

MEMORANDUM to Mr. Marvin Watson
The White House

This is in response to your questions about astronaut activities.

During the Mercury program and on into the first manned Gemini flight, space flight was new to this nation and we found a new group of heroes created by the American people. Each flight was a "first" of some kind, we were behind the Russians and our flight program was smaller and more understandable. Both US and Russian space flyers' names became well known.

As a result, New York City always wanted a ticker tape parade and the White House showed, on behalf of the American people, its appreciation of the work the astronauts had done.

We are now entering a new phase of our program. We expect to have gained 2,000 or more hours of space flight between now and the end of the decade when we expect to reach our goal of placing two men on the moon. Each flight, of course, will have new and different elements, but, generally speaking, these are long duration flights of two men (Gemini) and earth orbital Apollo flights.

The image that is, perhaps, best for this nation is that of a nation with this capability, a nation that goes about its work in an orderly and well-planned manner. We will fly these flights as best we can and put these flyers right back into the flight schedule for a future mission.

[2]

We feel that any build-up of personalities resulting from these flights should be spontaneous, based not on the fact that the astronauts flew, but what they accomplished in flight or difficulties they overcame or obvious skills they demonstrated.

Each flight is not going to be spectacular, each astronaut is not going to deserve a medal or award or special recognition. We are at the point, we feel, where we have to very carefully look at each flight and consider it as part of an ongoing program which will be oft-repeated in the months to come.

Therefore, we prefer to have a mechanism built into our Public Affairs program which will enable us to react quickly to given situations and to allow us the flexibility to choose the course that appears best at the time of the completion of a successful mission.

We would expect that you would be interested in this kind of flexibility, too, and would want to consider these things against a day-by-day backdrop.

We would not, of course, move forward on any plans without the most careful consultation with the White House, especially those which may have political implications.

On the upcoming flight, Gemini 4, we must consider that Astronauts Grissom and Young were received at the White House less than ten weeks from this launch date (June 3) and participated in New York and Chicago parades. Similar events 90 days later, unless the flight departs radically from the flight plan, may be too much saturation and repetition.

Therefore, in summary, it is our recommendation that we plan no events in advance of the Gemini 4 flight but be prepared to move rapidly in case there is interest there. We will, however, discourage other activity, such as ticker-tape parades, and will have under consideration a visit by the astronauts to the University of Michigan campus in late June or early July. Both graduated from the University.

[Signed]
Julian Scheer
Assistant Administrator
For Public Affairs

Document I-63

EXECUTIVE MEMORANDUM

THE WHITE HOUSE
WASHINGTON

MAY 25, 1965
Tuesday, 2:15 PM

Mr. President:

Information in the attached memorandum was agreed to by Director James Webb.

NASA suggests that since there will now be frequent space flights, you should reconsider the policy of White House receptions and ceremonies for the astronauts.

The next flight is scheduled for June 3 and will last four days. There will be some six days debriefing in Houston, Texas, which will mean approximately ten days from blast-off until they would be at the White House.

Since both of these astronauts are graduates of the University of Michigan and that the University has asked that both come to the University, Director Webb suggested that you consider not having the White House or Capitol ceremonies and allow it to be handled in this manner.

Do you want a White House ceremony?

Yes__________ No__________

Director Webb also states that the Vice President has become most interested in this program and he would like some guidance from you as to what part the Vice President should play. Do you want the Vice President to receive a lot of credit?

Yes__________ No__________

If you said ‘No’ on the White House ceremony, Director Webb suggests that since the astronauts will be in Houston for debriefing, and if you are in Texas, you might want to have them come to the Ranch.

Yes__________ No__________

Marvin

Document I-64

Document Title: Robert C. Seamans, Jr., Associate Administrator, NASA, to The Administrator, “Extra Vehicular Activity for Gemini IV,” 24 May 1965.

Source: Folder 18674, NASA Historical Reference Collection, NASA History Division, NASA Headquarters, Washington DC.

Document I-65

Document Title: L. W. Vogel, Executive Officer, Memorandum for the Record, “Top Management Meeting on Gemini 4 Extra-Vehicular Activity,” 8 June 1965.

Source: Folder 18674, NASA Historical Reference Collection, NASA History Division, NASA Headquarters, Washington DC.

In November 1964 an initial ground simulation for extra-vehicular activity (EVA) was performed by the Gemini III crew in an altitude chamber. But Gemini III was too short for EVA operations and ground controllers and engineers looked to the Gemini IV mission. Manned Space Center Director Robert Gilruth approved altitude chamber tests for the Gemini IV crew on 12 March 1965. But Alexey Leonov made the first spacewalk a week later, spurring a faster schedule for Gemini EVA tests. However, response at Headquarters was still lukewarm, largely due to concerns about the safety of such a new activity. On 14 May 1965, Gilruth arranged for an EVA demonstration for Associate Administrator Robert Seamans. Seamans agreed that it was safe to move the first EVA from the Gemini VI mission to Gemini IV and discussed the matter with Administrator Webb and Hugh Dryden. Webb generally agreed to the proposal, but Dryden was strongly against it. In response to a request from Webb, Seamans drew up a brief making the case for the Gemini IV EVA and delivered it to Webb on 24 May. Webb gave it to Dryden who returned it to Seamans the next day with the words "is recommended" underlined and the handwritten notation "Approved after discussing w. Dryden, J. E. Webb, 5-25-65."

Document I-64

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
Washington, D.C. 20546

May 24, 1965

MEMORANDUM

To: The Administrator

From: Associate Administrator

Subject: Extra Vehicular Activity for Gemini IV

The Project Approval Document for Gemini, date December 16, 1964, states the following objectives: Development of earth orbital rendezvous techniques, long duration flights of up to two weeks, extra vehicular activity, controlled re-entry, and astronaut operational space flight experience as a prerequisite for the Apollo program. Consequently, extra vehicular activity has been recognized as a primary objective of the Gemini program.

Against Extra Vehicular Activity during Gemini IV

The primary objective of Gemini IV is to extend astronaut and spacecraft time in orbit to four days. Extra vehicular activity reduces by a small but finite amount the chance of success and consequently should not be included.

For Extra Vehicular Activity during Gemini IV

Risk is involved in all manned space missions and consequently we must achieve maximum significant return from each flight, assuming that additional flight operations do not unduly reduce the chance of achieving our primary goals.

Conclusion

The hardware for extra vehicular activity is flight qualified and the astronauts are trained for this operation. Since extra vehicular activity is a primary goal for the Gemini program, it is recommended that this activity should be included in Gemini IV. The flight plan is being carefully planned toward this end and if a decision is reached to proceed a thorough review will be made of the public information releases in order to provide a full understanding

[2] of the care exercised in preparation for this mission and the safeguards available to the astronauts.

[signed]
Robert C. Seamans, Jr.

Document I-65

MEMORANDUM FOR THE RECORD

SUBJECT: Top Management Meeting on Gemini 4 Extra-Vehicular Activity

On May 24, Mr. Webb, Dr. Dryden and Dr. Seamans met with Dr. Mueller and Dr. Gilruth in connection with extra-vehicular activities on the Gemini 4 flight scheduled to take place on June 3.

Concern was expressed about changing the pattern of the flight. Making changes at the last minute always injected the possibility of something being overlooked and not properly considered. Also, if the Gemini 4 flight had to be cut short for any reason, opening the hatch would be blamed. Extra-vehicular activity in Gemini 4 was too obvious a reaction to the Soviet spectacular in this regard.

On the other hand, it was pointed out that suit development to permit extra-vehicular activity was part of the Gemini 4 program all along. Extra-vehicular activity had been originally planned for Gemini 4. One of the basic objectives of extra-vehicular activity was to be able to evaluate the possible utilization of man in space to carry out experiments, repair and adjust scientific satellites, and anything else that would require man to be outside of the spacecraft. The large antenna program was noted as one experiment which would require extra-vehicular activities by man.

It was then stated that there was no questioning of the propriety of having extra-vehicular activity in the Gemini program, but what was being questioned was it being performed on the second manned flight in the program. Since it was not essential to the basic mission of the Gemini 4 flight, which was to check out the reliability of the spacecraft and its systems for a 4-day period, our space posture might suffer if the 4-day period did not materialize.

The counter argument continued with comment about the great concern for the welfare of the astronauts and the fact that in the Gemini 3 flight we had a complete check on all systems. We have confidence in the spacecraft and the astronauts have trained for extra-vehicular activity and-, if nothing than for morale purposes, they shouldn't do anything less than what they can do and have been trained to do. Extensive tests had been conducted under zero-gravity conditions in a K-135. The astronauts practiced getting in and out of the spacecraft under zero-gravity conditions a sufficient number of times so as to build up about an hour of experience. Also, it was pointed out that if we don't accomplish extra vehicular activity (EVA) in Gemini 4 then we must do it on Gemini 5. It is a logical extension of the Gemini program to do EVA on Gemini 4. If

[2]

EVA is successful on GT-4, we will not do it on Gemini 5. If a decision were made today not to have EVA on GT-4, then we could do it on GT-5. However, it would be more of a compromise of the program to do EVA on GT-5 than on GT-4 because of the many other things programmed for GT-5.

The question was raised as to what risk we would be taking on a possible short Gemini 4 flight because of EVA and not finding out as much as we should find out about weightlessness as a problem. Weightlessness can be a problem, even in G-4, and we presumably will be concentrating on this problem in G-5. To this question it was noted that Dr. Berry said that there were no reservations about weightlessness being a problem over a 4-day period. There is no indication that 4 days of weightlessness will hurt man; therefore, this is not a great problem to be considered in the Gemini 4 flight. However, in connection with the Gemini 5 flight of 7 days there possibly are some reservations, primarily because no one has been in space for that period of time. Some medical experts feel that there will be a risk, others do not. Probably a problem just as pressing as the weightlessness problem, is the problem of confinement for 7 days or longer periods.

The question was raised again as to the element of risk to complete the 4-day Gemini flight because of EVA. The reply was that the added risk was simply having to depressurize the spacecraft, open the hatch, seal the hatch, and repressurize the spacecraft. These procedures, involving various systems and sub-systems, of course add a degree of risk because of a possible failure. But these procedures have been done hundreds of times with no failure. Nevertheless, there is always a risk that something will not work, but this is a small risk.

It was noted that one cannot justify EVA in Gemini 4 just because the Russians did it, and one cannot justify EVA in Gemini 4 just because you want to get film out of the Agena rendezvous vehicle on a later Gemini flight. In rebuttal, it was commented that the main reason for EVA in the Gemini program is to further develop the role of man in space. The sophistication of equipment that we put into space is getting ahead of the sophistication of experiments we can do. Experiment sophistication can be increased through the use of man in space, but the use of man in space must be checked out by EVA. The determination as to whether man in space by extra-vehicular activity can repair things, can calibrate satellites, etc. should be looked upon as a significant step forward and not as a stunt.

A strong comment was made that it is no more hazardous to do EVA in Gemini 4 than in later flights. The training for EVA on Gemini 4 was adequate and the only question that was holding up EVA on Gemini 4 was qualification of space suit equipment. This equipment is now fully qualified.

[3] On the other hand, the thought was raised that most of our thinking to date is that man's primary role in space is within the confines of a spacecraft.. We are trying more to qualify the spacecraft in Gemini 4 than we are EVA. However, it was noted that EVA is also important to the Apollo program.

It was acknowledged that everything that had been said was correct, but it still remained a fact that the consequences of failure on Gemini 4 would be more adverse than the consequences of failure on Gemini 5 or 6. There would be no reservation about EVA on Gemini 4 if it was absolutely necessary to accomplish the basic missions of the flight. It is essential to learn more about spacecraft systems over a 4-day period, and therefore we have an obligation to the Government to be sure that we qualify the spacecraft.

It was explained that EVA was planned for the second orbit of Gemini 4 which does create some risk for completing a 4-day flight as opposed to having EVA on one of the latter orbits. However, there is some concern about the ability of an astronaut to undertake EVA after 4 days of flight. The trade-off in risks involved in not knowing the condition of the astronauts after some time in orbit as to what could go wrong with the mechanical systems involved in EVA argued for EVA on an early orbit.

It was again noted that it was more important to check out the spacecraft for 4 days so that it would be possible to extrapolate the guarantee of spacecraft operation for 7 days.

To a comment that in the eyes of the public Gemini 4 would be a success with EVA, a statement was made that Gemini 4 with EVA might not necessarily be considered a success in the eyes of the decision makers. As a guide to risk taking, it was suggested that if there was a 90% chance to have a Gemini 4 flight for 4 days and that with EVA this chance would be only 89%, then we should risk 1% less chance for a 4-day flight for what can be gained from EVA. However, if a chance for a 4-day flight would be only 80% with EVA, then this additional 10% possibility for not having a 4-day flight would not be an adequate trade-off to be gained by EVA and we should not undertake it on Gemini 4.

It was noted that there was no comparison between the risk between the first Mercury flight and the Gemini 4 flight. It was recalled how the Air Force had admonished against the first Mercury flight, but NASA top management decided to go ahead because this flight was absolutely essential to the program. If we take into consideration the risks still inherent in using the rocket as a means of propulsion, then every time we use this means of propulsion we should find out everything that can be found out on the flight.

[4] It was noted that we should not be too concerned about the public reaction in determining what is the best course of action. The decision as to whether or not there would be EVA on Gemini 4 should be made in the light of what is best for the program and should not be influenced by possible public reaction.

After the foregoing discussion, the concern was still raised that the importance of Gemini 4 was to check out the reliability of the spacecraft for 4 days and project this reliability for 7 days. EVA therefore might jeopardize getting everything we should get from Gemini 4. If Gemini 4 does not go for 4 days, then we are in a very difficult position for 7 days on Gemini 5 and presumably we could not go for 7 days on Gemini 5. The real question is whether or not EVA is important enough in view of the risk, no matter how slight, of jeopardizing a 4-day Gemini 4 flight and jeopardizing a 7-day Gemini 5 flight.

Then it was pointed out that if you look at the entire program, EVA is more logical for Gemini 4. If Gemini 4 lasts 3 days then we should not be concerned about spacecraft reliability for 7 days. The basic problems are really to check-out confinement and weightlessness. Therefore, Gemini 5 is more important than Gemini 4 and if there is any chance of reducing total flight time due to EVA, EVA then logically should be accomplished on Gemini 4 rather than on Gemini 5. Every guarantee was given to top management that if EVA were approved for Gemini 4, very firm and adequate instructions would be given covering the procedure.

Mr. Webb, Dr. Dryden and Dr. Seamans then gave careful consideration to the discussions they had with Dr. Mueller and Dr. Gilruth. In their opinion it was important, whatever the decision, that there be an adequate explanation to the public to avoid any unnecessary misunderstanding and to minimize any adverse reactions. There was a strong feeling to ratify EVA for Gemini 4 in order to get the maximum out of the flight. There was unanimity in that EVA eventually would be carried out, but there was some reservation as to whether or not it was the best judgment to have EVA on Gemini 4 as a risk beyond that which has to be taken. It was concluded that Dr. Seamans would discuss the matter further with Dr. Mueller and Dr. Gilruth, in view of the discussions which took place, and that if he did not care to press for EVA on Gemini 4, such EVA would not be undertaken. However, if the final discussion led Dr. Seamans to press for EVA in Gemini 4, then it would be unanimously approved for the flight.

NOTE: Following the meeting, a memorandum from Dr. Seamans to Mr. Webb, dated May 24, 1965, recommending EVA for the Gemini 4 flight was approved by Mr. Webb and Dr. Dryden.

[signed]
L.W. Vogel
Executive Officer

Document I-66

Document Title: James E. Webb, Administrator, NASA, Cabinet Report for the President, "Significance of GT-3, GT-4 Accomplishments," 17 June 1965.

Source: Folder 18674, NASA Historical Reference Collection, NASA History Division, NASA Headquarters, Washington DC.

The first two piloted missions of the Gemini program occurred on 23 March 1965 (GT-3) and 3 to 7 June 1965 (GT-4). Both were quite successful. The first mission was a checkout of the Gemini launch system and orbital spacecraft that demonstrated its flight-worthiness. In this mission the crew proved their mischievousness by smuggling a corned beef sandwich aboard. Both Gus Grissom and John Young enjoyed a few bites, but they were reprimanded for their hijinks by project managers because of the fear that crumbs from the bread might float into the spacecraft's systems and damage electronics. It was a lighthearted episode that pointed out the serious nature of the enterprise. There is, not surprisingly, no mention of this incident in this report of the mission by NASA Administrator James E. Webb. What is truly significant about GT-4, however, received considerable treatment here. Edward White's 36-minute extra-vehicular activity (EVA) of spacewalk on the first day of the mission proved successful and a source of pride for the U.S.

June 17, 1965

CABINET REPORT FOR THE PRESIDENT

FROM : Administrator, National Aeronautics and Space Administration

SUBJECT: Significance of GT-3, GT-4 Accomplishments

On March 22, the first manned Gemini mission, GT-3, served to flight qualify the crew-spacecraft combination as well as checkout the operational procedures. During the course of the four-orbit mission, the two-man crew maneuvered their craft in orbit preparing the way for the rendezvous missions to follow. GT-3 also initiated the use of the Gemini spacecraft as an orbiting laboratory. Astronauts Grissom and Young also executed the first manned, controlled, lifting reentry.

With the success of GT-3, NASA moved forward the time-table for the Gemini program and decided to conduct extra vehicular activity (EVA) on the next mission. GT-4 was launched on June 3, more than 3 weeks earlier than our target date. GT-4 successfully achieved one of the major objectives of Gemini—to demonstrate that two men can carry out extended space flight while performing an extensive series of scientific and operational experiments during the mission.

During the third revolution, Astronaut White executed the first of a series of EVA that will be continued on later Gemini and Apollo flights. This successful experiment of EVA shows that man can maneuver in space for inspection, repair, crew transfer and rescue. All these can have both peaceful as well as military space applications. Tests of GT-4 rendezvous equipment have given important data which is being applied to the remaining eight Gemini missions.

The use of MCC-Houston for control of the GT-4 mission was a major milestone. This new facility worked perfectly and its use is essential in future Gemini and Apollo rendezvous flights. All 11 experiments and all operational checks were accomplished despite significant changes to the scheduling and time phasing. This ability for the ground crews to work with a well-disciplined space crew indicates a growing capacity to make changes in plans while operations are being conducted and, therefore, realize the most from each flight.

[2]

The excellent condition of the crew throughout the entire mission, including their recovery at sea, indicates the effectiveness of the working environment and life support system of the spacecraft. The crew was quite active and this apparently helped keep them in good condition. Medical monitoring during the flight and post-flight examination revealed no requirement for a period of rehabilitation or "decompression."

This second flight of the Gemini spacecraft indicates its excellent handling characteristics and provides strong assurance that more extended missions can be now undertaken. The computer which failed was not critical to the mission and the minor mechanical difficulties encountered were not serious.

It is significant that the first operational flight of Gemini, GT-4, has provided significant experience in each of the major mission areas of Gemini: long duration flight, rendezvous and docking, extra vehicular activity, and the conduct of experiments. The success of the GT-3 and GT-4 missions has proven the design and confirmed the results of the ground tests, has increased our confidence in the reliability of the overall Gemini systems, and has enabled NASA to advance the Gemini Program such that rendezvous and docking are now scheduled during the Calendar Year 1965.

James E. Webb

Document I-67

Document Title: NASA Program Gemini Working Paper No. 5038, "GT-4 Flight Crew Debriefing Transcript," No date, but soon after the June 1965 Gemini IV mission.

Source: NASA Collection, University of Houston, Clear Lake Library, Clear Lake, Texas.

The first multi-day mission of the Gemini program took place during the flight of Gemini IV, 3 to 7 June 1965. Since this was the first of the Gemini program's longer missions, it created a new set of challenges both for the astronauts and those in Mission Control. For example, Mission Control divided into a three-shift operation with flight directors for each shift. Chris Kraft acted as both Mission Director for the entire flight and Flight Director for the first shift, while Gene Kranz took charge of the second shift and John Hodge the third. Gemini IV proved a successful mission for many reason, not the least of which was its 36-minute spacewalk by Ed White on the first day of the flight. This transcript provides a vivid first-hand account of the initial U.S. extra-vehicular activity.

[CONFIDENTIAL] [DECLASSIFIED]

NASA Program Gemini Working Paper No. 5038

GT-4 FLIGHT CREW DEBRIEFING TRANSCRIPT

[No date included; declassified Mar 15, 1973 under Group 4 (declassified after 12 years)]

[only pp. 4-19 through 4-66 provided]

[4-19]
4.2 Extravehicular Activity

White
And this was the time I went after the gun.

McDivitt

Okay. At that time we reverted from station-keeping, which we were both attempting to do, to EVA preparation, which we both had to do. That's when Ed went after the gun, and we started our preparation. We weren't really far behind at this time. All we had to do was get the gun out and get the maneuvering unit. The cameras were already out. You had the Zeiss too, didn't you?

White
Yes. The Zeiss came out with the Hasselblad, from the same package as the movie camera. And the storage certainly was a lot easier. What do you think?

McDivitt
That's right.

White
Particularly getting it out of that center thing. You can just zip them out of there with no problem at all.

McDivitt
So, at about 1:30 we started to assemble the gm. If you look at the checklist, you see that we probably got the gun [4-20] assembled in nothing flat.

White
It's no problem to assemble the gun.

McDivitt
We started our egress preparations essentially on time. As a matter of fact, I think we even got started a little earlier.

White
Then, we weren't worrying about anything else.

McDivitt
Then, we weren't worrying about staying with the booster. We probably started it about 1:35 or 1:40. Over the States we started our egress preparation. We went to our other checklist.

White
You were over Ascension, calling off the checklist.

McDivitt
I started reading the checklist off to Ed and we went through it. He unstowed everything. Why don't you tell them what you did there, Ed? I just read the checklist off to you, and you went ahead and did it.

White
Okay. I had to get back into the right-hand box, and I unstowed the items there. The first time I went back in there, I took the first items out, and I did not unstow the full box, I remember I told you, "It's all coming out, Jim. I'm going to bring them all out on the lanyard." Remember?

McDivitt
Right.

White
We'd take them off piece by piece if we need it. At that time I pulled the whole lanyard out and the cockpit was full of little bags. I was quite happy that they had prevailed upon me to put a lanyard, on all this equipment. I had thought at one time that it would be more desirable not to put a lanyard on. We'd been working a lot in our simulations without the lanyard and it seemed pretty easy. But looking at it now, I highly recommend that everybody keep that stuff on a lanyard.

McDivitt
We would have really had a mess if we'd had all those things floating around. It was bad enough as it was.

White
Yes, eight or ten of those little bags, and I was glad they were all tied on to one string. I could control them in that manner. They were quite simple to unsnap. I thought the snap attachment made it pretty easy to unstow and selectively pick out the items that I wanted. I unstowed the pouches that I needed, and then we got ready to take the long umbilical out. I had a little difficulty. It took me about three tries to get it out. It's fairly big package to come through a small hole. It was a good thing that we had taken the Velcro off of the batch, because there no tendency for anything to hang up as we removed it. On the third try I got it out.

[4-21]

McDivitt
I thought you did an extremely good job getting the bag out. You got it out a lot quicker than I'd ever seen you do it in the Crew Procedures Trainer in Houston or in the simulator at the Cape.

White
You didn't know it. It took me three tries.

McDivitt
Well, maybe it did, but it sure looked like it came out a lot easier. I thought you got it out in a big hurry. I didn't notice that it took you three tries. I saw you start, and then just a short time later, it was out.

White
Well, it did come out pretty easy, and I think the storage was satisfactory, but I'd certainly recommend that nothing be on the outside to keep it from coming out. It's a real tough –

McDivitt
Yes, we need the velcro off of there. We're pretty well sure of that.

White
The rest of the equipment - the "Y" connectors, the bag that contained the "Y" connectors, and the attachments for the chest pack I handed to you. I think you were keeping track of most of those things until the time I needed them.

McDivitt
Yes, I was.

White
The storage of the ventilation module from the floor came off pretty easily. That's when I started going ahead and putting it all on. You read the checklist off to me. I had gone ahead and done a few things anyhow. As you read them off, I checked them off to be sure that I had done them all. I think we had everything out without much problem at all. I think it took us longer actually to put it all together.

McDivitt
That's right. It did. We started going through the checklist here and putting the things on, and we started getting more and more rushed. We were supposed to start the Egress Preparation Checklist at about 1:44. We probably started it at about 1:35 or so. We started it about 10 minutes early, roughly, maybe 5 to 10 minutes early. We were supposed to be ready to start the depressurization at 2:30 over Carnarvon.

[4-22]

White
I think I could have gone through and hooked everything all up, but I felt that we should go through fairly close to the procedure we had set up on the checklist.

McDivitt
That’s right.

White
I think this slowed us down.

McDivitt
Well, we set the procedure up so that when we finished with it, it would be right. I think this helter-skelter thing that we were being forced into was for the birds. So as we got farther along, it became apparent to me that the thing to do would be to stop.

White
Right.

McDivitt
Go ahead with the assembly of the stuff. Why don’t you comment on that?

White
I’ve commented in my Self-Debriefing about the equipment and the assembly of it. I thought there was no difficulty at all in connecting the “Y” connectors, the hoses, and the chest pack. I thought the connection of the chest pack to my harness was a good one. With the velcro I could move it in and out whenever I wanted to so that I could make my connections on the inlet side of the ECS hoses. It went along pretty smoothly, as a matter of fact. I think as we progressed along in it though, we felt that we had everything done. I didn’t really feel that we had everything done in a thorough manner. And I think you had that same feeling.

McDivitt
That’s right. When we got to Kano or Tananarive - I think it was Tananarive - I called whoever I was talking to and said that we were running late and I thought that we would probably not do the EVA on this particular rev. I knew that we had another rev on which we could do it. It looked to me like we had all the stuff hooked up, but we hadn’t really had a chance to check it. I also noticed, Ed, that you were getting awfully hot. You were starting to perspire a lot. I didn’t like the way you looked to start this whole thing off. So I told them over Tananarive – I believe it was Tananarive – that we would go ahead and continue on, and I would let them know whether or not we were going to depressurize at the next station. We went on ahead and it looked to me like you were all hooked up and about ready to go except for one thing.

White
We forgot the thermal gloves. I did not have my thermal gloves on.

[4-23]

McDivitt
You did not have the thermal gloves on, which is sort of insignificant, but we hadn’t really had a chance to check over the equipment to make sure that it was in the right spot.

White
Well, we talked and you said, “What do you think?” We talked it over and I had the same feeling. I thought it sure would be smart if we had about 20 minutes to just sit here real still before we went out.

McDivitt
I think we were in a situation where it would probably have gone all right. We had completed about 80 percent of what we really should have had done as far as the checking went, and I just didn’t feel that we were in the right shape. Ed didn’t think we were, and besides, I could see Ed. He couldn’t see himself. Ed looked awfully hot, and he looked like he was getting a little pooped out from playing around with that big suit. I thought that the best thing for his sake, and I knew he wouldn’t admit it, was to let him rest up for another orbit.

White
I agree that was the best judgment.

McDivitt
So, when we got to Carnarvon - I guess it was Carnarvon I called them and said we were not going to come out on that orbit.

White
It was Carnarvon. It was just before we depressurized.

McDivitt
So, we postponed it until the next orbit. As a matter of fact, after that we just sat there. We didn’t do a thing for about 10 minutes. I let Ed cool off a little bit. We were on two-fan operation at the time. We just sat there and we were cooled off. We went around for about 20 minutes then.

White
Okay. Then as we went back around, I asked you to go through the checklist again, and we went through item by item this time.

McDivitt
That’s right. I might add that we went right back to the beginning checklist, the Egress Preparation Checklist. We started at the top one, and we did every step on it again. We verified every step to make sure we hadn’t left anything out.

White
We actually went in and checked this time. Another thing we hadn’t really positively checked was the position of all the locks on all of the hose inlets and outlets. This time we [4-24] actually checked all those locked. All of them were locked in, but it was a good thing to do, I believe.

McDivitt
You want to make sure. We did do our Suit Integrity Check before we started all this stuff.

White
That's right. We started before we actually went to the unstowing of the stuff from the right-hand aft food box. We went to the Suit Integrity Check.

McDivitt
Well, I don't know where it is, but we did it when we were supposed to do it.

McDivitt
We did the Suit Integrity check before we started the Egress Preparation Checklist. That's when we did it, over the States.

White
I think we did that just about the time you decided to give up on the booster. We did the Suit Integrity Check. Both suits checked out all right, It went up to 8.5 and it leaked down to about 8.3 or something like that.

McDivitt
Same thing with mine. It went up to 8.5 and leaked down just a little bit. Not enough to be concerned about.

White
No. Oh, one thing that we did do on that extra orbit that we went around – I disconnected the repress system and we went back on the -

McDivitt
Oh, yes. We never even got on the repress system, did we?

White
Yes, I believe we were, but then we turned it off. We were all ready to depressurize, and then we went back on the spacecraft ECS system, full, and went through and reverified the whole checklist again. The only things that I would say we hadn't done to my satisfaction the first time was to check the inlet and outlet positions of the locks, and I didn't have my thermal gloves on. It turned out I didn't need them.

McDivitt
Also, during this period of time I alined [*sic*] the platform, which was completely misalined. It was probably alined [*sic*] within a couple degrees, but as we went around in Orbit Rate it got farther and farther out of tolerance. So, I managed to aline [*sic*] the platform. Here again, I might comment on the fact that our initial flight plan was so optimistic that it was almost unbelievable. The both of us worked full time on doing nothing except preparing for EVA, and we didn't quite get the job done. I can't believe that we could have possibly flown formation with the booster and taken pictures of it and all the [4-25] other things that we had scheduled, and still prepared for this thing and even come close to completing it.

White
Well, the way we would have had to do it, would have been without a checklist. I would have had to just go ahead and hook everything up. I think we could have done it satisfactorily in this manner, but it wouldn't have been the way we would have wanted it.

McDivitt
Yes, that's right. I don't think that's the way it should be done. It was just too bad that we had a time limit on it, but when we did get rid of the booster, or the booster no longer became a part of the flight plan, then the time limit vanished. We found out that we really needed that extra orbit, or probably could have used another 20 minutes.

White
Yes. We went back. And I remember as we came over Carnarvon, we had about a 15 minute chat back and forth - kind of a rest period. We were all hooked up at that time, and that's the time we went on the repress flow, ready for the depressurization. I think they gave us a GO then for our EVA.

McDivitt
That's right. We depressurized the cabin and got down to 2 psi to check our blood pressure. We tried to put our blood pressure plugs in the blood pressure plug port and found out that we didn't have any blood pressure plugs on either suit. This was quite a surprise - an unpleasant one, I might add. Well, we decided that from our past experience and our knowledge of the suit that, even if we did spring a leak in the blood pressure cuff, the size hole that we had in the suit would not be catastrophic, and we decided to go ahead with the EVA.

White
It was within the capability of the system we were using.

McDivitt
At Carnarvon we not only got the go-ahead to start the depressurization, we also got the go-ahead to open up the hatch, the go-ahead that we weren't supposed to get until Hawaii. So, we went ahead and did that.

White
Yes. I'm kind of curious of the whole time. We were out nearly an orbit, I think. We didn't get it closed back again till we got back around to Carnarvon.

McDivitt
We were in a whole orbit depressurized.

White
Yes, I don't think people quite realize that.

[4-26]

McDivitt
We'll remind them. As we got to the hatch opening thing, we had our first difficulties with the hatch. The gain gear, I guess you want to call it – actually I call it the ratchet–didn't want to engage into the UNLOCK position. We fooled with it a few times and it finally engaged in the UNLOCK position, and Ed was able to go ahead and start.

White
The first indication of trouble was when I unstowed the handle to open the hatch. The handle freely moved up and down with no tension on it at all. I knew right away where the trouble was. It was up in that little spring on the gain pawl. So, I went up and manipulated it back and forth in hopes that I could break the lubrication loose in the spring to get it to work. We must have spent several minutes with the hatch. I thought perhaps it might have been stuck in the manner that the hatch got stuck in the Wet Mock, where it just was stuck. You could ratchet it open, but the hatch itself wouldn't open. It was pretty apparent the trouble was in the gain pawl. I jimmied it back and forth, and then I decided to go ahead and try the technique of actuating it in sequence with the hatch handle. If you actually replaced the operation of the spring with mechanically moving the gain pawl up and down, you can do the same work that the spring does.

McDivitt
Your fingers sort of take the place of the spring and rive this little pawl home.

White
This is the first time we actually tried this in a suit. It requires you to press up with your left arm to get at the gain pawl, and at the same time to hold yourself down. And I think later on this was a source of some of our problems which I brought out now so that we can find out later on. I felt it start to engage and start to ratchet the lugs out. Jim also verified that they were coming open. I backed them off, and I remember Jim saying "Ooop! Not so fast!" and at that time it popped. The hatch actually popped open, jumped open about 3 or 4 inches.

McDivitt
I was expecting the hatch to come open with a bang. Although we had the cabin to vent and it had bled on down to where there was nothing indicated on the Cabin Pressure Gage, we still really had the repress valve on. He was bleeding right into the spacecraft. We never got down to a vacuum and, even though we had a cabin pressure of only a tenth of a psi, we spread it over the entire area of that hatch, and that puts a pretty good size force on it. I had a real tight hold on [4-27] the hatch closing device, and when it popped open I was able to snub it.

White
It didn't really open with much force, did it?

McDivitt
Well, it did. It opened with a fair amount. It popped and I couldn't stop it the first inch or so. Then, of course, as soon as it opened, that much pressure bled off. I just sort of snubbed the thing to keep it from flying all the way open. Now if I hadn't been holding onto it, I don't think it would have gone open more than 2 or 3 feet.

White
This is another point too. There's more force on the hatch actuator than I thought. I didn't just flip the door open with my hand. I had to actually forcibly push it open, similar to the force with which I opened the hatch lying on my back under 1-g. That's about the force that I had to on the hatch to open it.

McDivitt
This extra force that we are talking about is due to the 0-rings they put in the pyros that are used for jettisoning the hatch. This is something that they put in just before the flight – something that we'd gone out to the spacecraft to feel. We knew just about what the force was, but it was pretty high.

White
Okay. At this time I had certain things that I had to accomplish. I had to mount the camera on the back of the adapter and mount the umbilical guard on the edge of the door. I elected, as I had planned, to go ahead and mount the camera first and then the umbilical guard. I mounted the camera and it went on without too much difficulty. The three little lugs on the bottom are a good mounting scheme. I think I would make a little easier engaging device for working out in a hard suit. I had familiarity with it, and it did lock up there all right. The umbilical guard for the umbilical on the side of the door took me a little longer to mount. Back to opening the hatch – I had the thermal gloves on when we were opening the hatch, and because of the fine work I had to do with the little gain and the drive lugs up there. I had to remove the thermal gloves so that I could actually actuate those small levers. I couldn't do them with any precision with my gloved hand. So, I took the thermal gloves off at this time, and I handed them to Jim. When I got back out, I didn't notice any temperature extremes. I felt quite confident that there wouldn't be any heat, since we just came out of the dark side, so I decided to do the actual work in putting this equipment on with my plain pressure suit gloves. [4-28] I had much more feel with them. Let me get back now to the umbilical guard on the door. It went on pretty well. It took me a little longer and it took me four or five tries to get the little pin into the hole that actually snubbed the guard down on the door. I did something then that I hadn't planned to do. The bag floated up and out of the spacecraft and now it was above the point where the hose was going through the umbilical guard. I had planned to keep it down inside. I left it there for two reasons: (1) I figured it was there already and I would have had to take the umbilical cord off again and scooted it back down, and (2) I also felt that Jim might have had a better view if it wasn't sitting right in front of him on the hose coming up from the repress valve. I elected to go ahead and leave the bag there. I then reported to Jim that I had everything all mounted and was ready to go. I had planned to take a short series of pictures. Since we had gotten out early, I had a little extra time at this time, so I went ahead and turned the outside EVA camera on. I took a short sequence of pictures that actually gives the egress up out of the seat, I kind of went back down and came out again so they would get an actual picture of it, and then I turned the camera off again. I mounted the camera and I turned it on while it was on the mount. I took a short sequence when I asked Jim to hand me my left thermal glove, which he did. I put the thermal glove on while the camera was running. I turned back around. I wanted to be sure the camera was off, so I took it off the mount, and I turned the camera off and actually visually took a look to see if the switch was off.

McDivitt
Did you knock it off one time? I thought you said the camera fell off.

White
By golly, I did. So I must have mounted it four times. That's right. I knocked it off one time during this time when I was out there. I got the picture of the egress, and then I asked you to hand me the gun. At this time the camera wasn't running. I had the glove on my left hand, and I went ahead and took the gun and made sure that it was ready to go. I had the camera on at that time and the valve was on. I checked the valve to be sure it was on and I was essentially ready to go. I don't know how long this took, but it took me longer than I thought. We had had early egress and it wasn't too much before I got the GO that I was ready to leave the spacecraft.

[4-29]

McDivitt
I'm not sure whether we got that GO from Hawaii or Guaymas. I sort of suspect that we got that GO from Hawaii, not Guaymas as we had originally planned.

White
Well, it sure seemed short from the time I was mounting all that stuff out there to the time you told me to go.

McDivitt
That's right. I'm sure we were talking to Hawaii, and they said you're clear to proceed with EVA.

White
And that's when I went. I bet we went out at Hawaii.

McDivitt
I think we went out at Hawaii.

White
I delayed from the time you gave just a minute, long enough to actuate the camera on the outside. This was kind of interesting. When I actuated that camera, I had my gun tied to my arm with the tether. It floated freely to my right. I turned back around and turned the switch ON on the camera, and listened and made sure the thing was running. I knew it was running, and put it down. I think you'll see this on the film. I wanted to be sure it was running when I mounted it back there. I actually took it off and turned it on, and I remember it jiggling up and down when I was trying to stick it on there. It ought to be a funny looking film. And it might even show the gun floating beside me as I was mounting it. That's when you said, "Slow down. You're getting awfully hot." I was working pretty hard to get that on. I mounted the camera again, and this is where I tried to actually maneuver right out of the spacecraft. I knew right away as soon as I got up – I felt even before – that the technique of holding on to the bar in the spacecraft and sticking a finger in the RCS thruster wasn't going to work. I mentioned that to Jim before – that I didn't think I would be able to do it.

McDivitt
I think you and I both knew how you were going to do, and everybody else was planning for us how we were going to do it, but without any real experience in it. People who didn't know a lot about it were planning this sequence, and it wasn't the way it should have been.

White
I couldn't have done that. I didn't have three hands. I couldn't hold the gun and put a finger in the RCS nozzle, and hold the handle at the same time. I thought it would be more desirable anyhow to actually depart the spacecraft with no velocity, other than that imparted by the gun. This is exactly what I did. I thought that I was free of the spacecraft, and I fired the gun. I realized that my legs were still [4-30] dragging a little bit on the side of the seat, so I pulled myself out until I could see that my feet were actually out of the spacecraft. I think you called me and said I was out of the spacecraft.

McDivitt
I called and told you that you were clear. That's right.

White
And that's when I started firing the gun and actually propelled myself under the influence of the gun. I don't believe I gave any input into the spacecraft when I left that time, did I?

McDivitt
No, you left as clean as a whistle.

White
Later on, I gave you some pretty big ones.

McDivitt
You were really bouncing around then.

White
Now at the time, I left entirely under the influence of the gun, and it carried me right straight out, a little higher than I wanted to go. I wanted to maneuver over to your side, but I maneuvered out of the spacecraft and forward and perhaps a little higher than I wanted to be. When I got out to what I estimate as probably one-half or two-thirds the way out on the tether, I was out past the nose of the spacecraft. I started a yaw to the left with the gun and that's when I reported that the gun really worked quite well. I believe that I stopped that yaw, and I started translating back toward the spacecraft. It was either on this translation or the one following this that I got into a bit of a combination of pitch, roll, and yaw together. I felt that I could have corrected it, but I knew that it would have taken more fuel than I had wanted to expend with the gun, so I gave a little tug on the tether and came back in. This is the first experience I had with tether dynamics and it brought me right back to where I did not want to be. It brought me right back on the top of the spacecraft, by the adapter section. Jim was calling me and said that I was out of his sight. I told him that I was all right, that I was up above the spacecraft, I looked down and I could see attitude thrusters firing, little white puffs out of

each one. I wasn't very close. They looked just like what Chamberlain's report told us. It looked just like about a foot and a half or maybe 2 feet of plume from the spacecraft and certainly didn't look ominous to me at all. In fact it looked kind of like the spacecraft was really alive and working down there. I knew Jim was doing his job holding attitude for me.

[4-31]

McDivitt
Let me comment on the attitude-holding right now. Initially we started out in blunt-end-forward, banked to the left about 30° or so. This happened to be the attitude we were in. We wanted to be blunt-end-forward for the sun, and they told me it didn't make any difference what attitude that we were in when we opened up the hatch. We had originally planned on opening the hatch toward the ground. I was called by some station that said it didn't make any difference what attitude I was in when I opened the hatch. We opened the hatch. We opened it in that particular attitude, and I held the attitude for the first portion of the time that Ed was out. When you had the gun you managed to stay reasonably well out in front. I held the spacecraft essentially stationary with respect to the local horizontal. After you ran out of fuel in the gun you were on top of the spacecraft all of the time, I felt that unless you really had to have the thing stabilized, to maintain your sense of balance or whatever you want to call it, I wouldn't fire the thrusters.

White
You asked that already when I was out.

McDivitt
Yes. I asked you if you needed it and you said no. So, then I felt it would be better not to fire the thrusters, because you were drifting back up over the cockpit. I could see that you were going up over us. I couldn't see back behind me, but I could see by the motions that you had when you went by me that you were going to continue on. I felt that it would be a lot safer if we just let the spacecraft drift unless it got into very high rates. I fired the jets a couple of times just to knock off the rates. I let it start drifting when you got on the tether so that you wouldn't get back there on top of one of those thrusters when I fired them. From about the time you ran out of fuel until you got back in I didn't do much attitude controlling. I did some. Everytime [*sic*] the rates got up pretty high, I'd knock them off. You were able to maneuver around the spacecraft when the spacecraft itself had rates of say +/-2 degrees/second in a couple of the axes at the same time. Here again before the flight we discussed the axis system. Ed selected the spacecraft as his axis system. It didn't appear that he was having a bit of trouble with it. He was maneuvering with respect to it, regardless of what the earth, sun, moon, and stars were doing. It was pretty obvious to me that was exactly what he was doing.

White
Well, when I came back the first time to the spacecraft with the gun –I had used the tether to bring me back – I did go back up on the adapter area. This is the first time it had happened. I said, "All right. I'm coming back out again."

[4-32]

This is one of the most impressive uses of the gun that I had. I started back out with that gun, and I decided that I would fire a pretty good burst too. I started back out with that gun, and I literally flew with the gun right down along the edge of the spacecraft, right out to the front of the nose, and out past the end of the nose. I then actually stopped myself with the gun. That was easier than I thought. I must have been fairly fortunate, because I must have fired it right through my CG. I stopped out there and, if my memory serves me right, this is where I tried a couple of yaw maneuvers. I tried a couple of yaw and a couple of pitch maneuvers, and then I started firing the gun to come back in. I think this was the time that the gun ran out. And I was actually able to stop myself with it out there that second time too. The longest firing time that I put on the gun was the one that I used to start over the doors up by the adapter section. I started back out then. I probably fired it for 1 second burst or something like that. I used small burst all the time. You could put a little burst in and the response was tremendous. You could start a slow yaw or a slow pitch. It seemed to be a rather efficient way to operate. I would have liked to have had a 3-foot bottle out there – the bigger the better. It was quite easy to control. I feel that with the gun there would be no difficulty in maneuvering back to the aft end of the spacecraft, and this was exactly what I did later on. Just on the tether. I got all the way back. So, I ran out of air with the gun, and I reported this to Jim. I didn't attempt to take any pictures while I was actually maneuvering with the gun. The technique that I used with the gun was the technique that we developed on the air-bearing platform. I kept my left hand out to the side, and the gun as close to my center of gravity as I could. I think that the training I had on the air-bearing tables was very representative, especially in yaw and pitch. I felt quite confident with the gun in yaw and pitch, but I felt a little less confident in roll. I felt that I would have to use too much of my fuel. I felt that it would be a little more difficult to control and I didn't want to use my fuel to take out my roll combination with the yaw. We divided our plan so that I would have a part of it on the maneuver and a part of it on the tether. I don't know how far along we were when the gun ran out.

McDivitt
Right on schedule when the gun ran out. We planned 4 minutes for the gun portion of it. We were just about on schedule.

White
I bet we used a little more than 4, because I think we came out earlier than we thought.

[4-33]

McDivitt
No, I started the event timer to time it.

White
Well, this is where my control difficulty began. As soon as my gun ran out I wasn't able to control myself the way I could with the gun. With that gun, I could decide to go to a part of a spacecraft and very confidently go. I think right now that I wish that I had given Jim the gun and taken the camera off. Now I was working on taking some pictures and working on the tether dynamics. I immediately realized

what was wrong. I realized that our tether was mounted on a plane oblique to the angle in which I wanted to translate, I remember from our air-bearing work that everytime you got at an angle from the perpendicular where your tether was mounted, it gave you a nice arching trajectory back in the opposite direction. You're actually like a weight on the end of a string. If you push out in one direction and you're at an angle from the perpendicular, when you reach the end of a tether, it neatly sends you in a long arc back in the opposite direction. Each time this arc carried me right back to the top of the adapter, to the top of the spacecraft, in fact, toward the adapter section. One time I was so close to the thrusters back there that I called Jim. I said, "Don't fire any more", because I was right on the thrusters. I was even closer than that foot and a half which I noted to be the length of the thruster plumes, and I didn't want to sit on a firing thruster.

White
We were discussing the EVA and I was saying that I spent approximately 70 percent of my time, it seemed, trying to get out of the area back above the spacecraft in the adapter area.

McDivitt
Yes, you intended to go toward the position that was directly over the cockpit. You always arced past it because you were coming from the front.

White
This was exactly right because that's exactly where my tether was connected. Chris had been very emphatic that he wanted me to stay out of this area, and I had agreed to stay out of there, I tell you, I was doing my level best to keep out, but the tether dynamics just put me back there all the time.

McDivitt
Let me interject something here. When we were talking about the control modes and how we were going to control the spacecraft, we decided on the Pulse Mode rather than the Horizon Scan Mode, or anything like that. The Horizon Scan Mode would leave me free to use both hands to take pictures of you, and that way I wouldn't have had to control the spacecraft. But since it was an automatic mode and it fired whenever it felt [4-34] like firing, it didn't give us any flexibility, and this is why I felt that the best mode to be in was Pulse, in case you did get back there.

White
That's exactly what happened.

McDivitt
I didn't have to worry about the thruster going off in your face. I didn't want the thrusters to fire, and they didn't fire because I didn't touch them. It was a wise choice.

White
I think this was good. When you look at it from a picture-taking viewpoint, it gave a wider spectrum of pictures. You got different views of the earth and the horizon. I'm glad we weren't held to a specific mode.

McDivitt
I think that the picture we did take or the attitude that we started out, which is shown in the newspaper, is just about right.

McDivitt
I guess we banked over to the right, I don't know.

White
That must have been just as I came out.

McDivitt
I don't remember, but it had enough of the ground in the background so that it was certainly worthwhile.

White
On one of my passes back to the adapter area I got so far back that I was about 3 or 4 feet from the adapter separation plane, perpendicular to it. It was rather jagged. There did appear to be some sharp edges, but it really didn't look very imposing to me. I took a picture of it. That's one picture I believe was good and should come out.

McDivitt
The trouble is it was probably set on infinity and you were up about 5 feet.

White
No, I set the camera to about 15 feet or so. It might be a little fuzzy because it was too close.

White
No, I didn't see the far side of the adapter. It didn't go all the way around. I think I could have pushed off and gotten back that far.

McDivitt
No. Better to stay away from it.

White
Well, I felt that if I got going I could have swung all the way around and had my umbilical right on the edge, without anything to hold on to or any gun to control myself. This [4-35] didn't seem like it was at all safe, and I had told Chris that I wouldn't go behind the craft. So I didn't go back there.

McDivitt
That must have been just about the time I told you to come back in.

White
No, I would estimate this was about two-thirds of the way, and about this time I was after pictures. I knew that was a part of the flight plan that I had, in my mind, fulfilled satisfactorily. So I tried to get some pictures, and this is where I really imparted some velocities, trying to get away from the spacecraft into a position so I could take a picture. I went out to the end of my tether cord quite a few times

doing this. I seemed like every time I would be completely 180 degrees to the spacecraft. I'd have beautiful views of the ground but I couldn't see the spacecraft. It was a definite mistake to mount the camera on the gun. That made it very difficult to use the camera. I had to point not only the camera but the gun with the long thrusters mounted out on the little arms. I'd want to take a picture of an object like the spacecraft, and there were too many loose items to get tangled up in and block the camera. I know my tie-down strap was floating loose. I had left that out intentionally so that I could get it later on any time I had to pull my helmet down. Occasionally when I got in close to the spacecraft, the bag and strings associated with the bag were tangling up around the vicinity of the gun and the camera. And it seemed like the umbilical was right in front of the camera all the time. So, I think the pictures will verify that I was flicking my right arm quite a bit in the later part of the flight, trying to clear things out from in front of it to get a picture. Whenever I was in a position to get a picture it seemed like I was facing away from the spacecraft. I took a couple of shots in desperation, and I think I might have gotten a piece of the spacecraft. But I never got the picture that I was after, I wanted to get a picture of Jim sitting in that spacecraft, through the open hatch, with the whole spacecraft. I know that I didn't get that. In fact, as time went on I realized that I wasn't going to get much of a picture. I was trying everything I knew to get out there and get stabilized so that I could turn around and get a good picture. I just couldn't do this. This was at the time when I was looking a little into the tether dynamics, and I actually kicked off from the spacecraft pretty hard. I remember Jim saying, "Hey, you're imparting 2 degrees/second rotational velocity to the spacecraft when you depart." I was pushing the spacecraft [4-36] quite vigorously. I wanted to push off at an angle of about 30 or 40 degrees to the surface of the spacecraft. And any time I pushed off from the surface of the spacecraft, my main velocity was perpendicular to the surface. It shot me straight out perpendicular to where the tether was attached. Again, this wasn't in the position that Jim could take a picture of me, and it wasn't too good a position for myself. I usually ended up facing away from the spacecraft.

McDivitt
Let me interject something here. In desperation I took the Hasselblad camera and stuck it over out through Ed's open hatch, and asked him if he could see the camera and if he could tell me which way to point it. He couldn't see the camera so he never really did tell me which way to point it.

White
No. This was the time that you said, "Hey, get in front of my window." It just so happened that I was right up close to the spacecraft and that's when I came over. Do you remember me coming over and actually looking about a foot from your window, Jim?

McDivitt
Yes.

White
Looking right at you.

McDivitt
Yes, I think that was the time the movie camera wasn't going and I was fooling around with it, trying to make sure that it was running.

White
Oh, that would have been a very interesting picture.

McDivitt
I'm not sure it was going, Ed, because, as you know, we had so much trouble making the left-hand one run. We had that trouble throughout the remainder of the flight. You pushed a switch over and it seemed to run sometimes, but sometimes it wouldn't. I kept worrying about whether or not it was running so I would grab a hold of it to see if I could feel it clicking over. I switched the ON-OFF switch on a couple of times to make sure I could tell the change in the feel of it. I'm afraid this time is one of the times that I didn't have the camera going, because I was trying to make sure that it was going. I'm not positive. I hope I got the picture, but I'm not sure about it.

White
That was the time that I came right in, and I couldn't have been more than a foot from your window, looking in, I could actually see you sitting there.

[4-37]

McDivitt
That's probably when you put a mark on my window.

White
I think the way I did that – I could actually see you in there and I pushed away with my hands a little bit. I think this was the time that either my arm or my shoulder contracted the upper part of your window, and you called me a "dirty dog" because I had messed your window up. You know, as you look back in retrospect, I wish you'd handed me a kleenex and I wish I'd cleaned up the outside of those two windows. I think we could have done it.

McDivitt
Yes. We'd have never gotten to the Kleenex at that time, but I think we might have done something about it.

White
I think I might have, but we might have smeared them so irreparably that it might have –

McDivitt
That's right. When you looked at that window of mine from the inside while the sun was shining, it looked like it was a black paint smear, such as if you'd take a piece of white linoleum and a black rubber soled shoe and made a mark on the linoleum. It had that kind of consistency. It was absolutely opaque. Just as black as it could be.

White
Yes, I could tell. When I hit it I could see from the outside that it turned white.

McDivitt
It turned black from the inside.

White
From the outside it was white.

McDivitt
From the inside it was black. When I got the thing turned around a different way with the sun on it, it was perfectly clear as if you had taken the coating off, and what I was seeing was through a perfectly clear surface. So, I don't know really whether the thing was black, that you placed something on the window that would make it black, or whether you'd taken something off that was very white, very thin.

White
I smeared the film that was on your window. I'm quite confident that is what happened.

McDivitt
I looked at our spacecraft windows after they got it onboard and I could still see that little hunk of window. It looks to me like what you did was remove a layer off the window, rather than put something on it. You took something off the window, rather than put something on it. You took something off it. Except I can't possibly imagine why it was so black and opaque with the sun shining on it at certain angles.

[4-38]

White
I'd like to comment on the ease of operation outside on a tether. If you've ever tried to hang on the outside of a water tower, or about an 8-foot diameter tree, you can visualize the problem I had out there. The decision to leave the hatch open was probably one of the very best that we made. I had nothing outside the spacecraft to stabilize myself on. There just isn't anything to hold onto. I think Jim will remember one time when I tried to hook my fingers in the RCS thrusters. I think Jim could see because –

McDivitt
I could see.

White
I was right out in front of Jim's window. This gave me really nothing particularly to hold onto. It didn't stabilize me at all. I had nothing really to hold onto, and so if you have ever tried to grasp an 8-foot diameter tree and shinny up at, you know the kind of feeling that I had outside there. There just wasn't any-thing for me to hold onto. One thing though that I'll say very emphatically – there wasn't any tendency to recontact the spacecraft in anything but very gentle contacts. I made some quite interesting contacts. I made one that I recall on the bottomside of the right door in which I had kind of rolled around. I actually contacted the bottom

of the spacecraft with my back and the back of my head. I was faced away from the spacecraft, and I just drifted right up against it and just very lightly contacted it. I rebounded off. As long as the pushoffs are slow, there just isn't any tendency to get in an uncontrollable attitude.

McDivitt
It seemed Ed did hit it pretty hard at one time. I thinly that was after he pushed off violently; he went out and it seemed, he came back and bashed it pretty hard. I remember a pretty solid thump. It seemed it was over the right-hand hatch or just right behind – .

White
I know a couple of times I kicked off with my feet, and I think I know the time you are talking about. I came in with my foot. It wasn't so much the contact with myself –.

McDivitt
What did you do? Contact and push off?

White
I contacted and pushed with my foot.

McDivitt
I heard a big thump and I think I called you at this time to take it easy.

White
I believe that was on the front end of the R and R Section on my side where you couldn't see me.

[4-39]

McDivitt
It was a position that I couldn't see.

White
One of the pictures that I saw last night in the movies, I think, was made at that time. I was coming in fairly rapidly and I wanted to get back out, so I kicked off again with my foot fairly hard. It was a very good kick. I felt that I certainly could have controlled myself without the gun out there if I had just some type of very insignificant hand-holds or something that I could have held onto. I believe that I could have gone on back to the adapters with a minimum of several hand-holds to go back there, going from one to the other. I was actually looking for some type of hand-holds out there. I remember that the only one that I saw was the stub antenna on the nose of the spacecraft. I could see the ceramic covering over it, I believe it was ceramic, or some kind of covering over it.

McDivitt
Yes, it's white.

White
I felt that this wasn't quite the thing to grab onto; this was at the time when I wanted to get out at about 10 or 12 feet directly in front of the spacecraft. I certainly had the urge to hang onto the antenna and push myself out. But I didn't and there really wasn't anything to hold onto. You really need something to stabilize yourself. I worked around the open hatch.

McDivitt
Let me ask you a question. How about putting the hand-hold inside the nose cone? A fairing is up there for launch, just the fairing. We could mount a hand-hold right inside.

White
I think we could have really made some money if we had had an attachment for the tether out there right on the nose of the spacecraft.

McDivitt
Strung the tether out there and then attached there?

White
Right. Have a second attach point and put it right out there. It would give you something to hold onto out there.

McDivitt
Yes.

White
There wasn't anything to hold onto on the R and R Section.

McDivitt
I know it.

White
It had smooth corner and the only thing I could have grabbed was the antenna, and I didn't want to grasp that. We thought [4-40] one time of holding on out there and thrusting, but –.

McDivitt
There isn't anything to hold onto. I think you probably could have gotten a hold on the antenna and held onto it without hurting it. I examined it pretty closely before the launch, and it looked pretty sturdy.

White
I thought this was something we needed and I didn't want to fool with it.

McDivitt
As it turned out we finally needed that antenna because that was the antenna that we used the whole flight – that stub antenna in the nose.

White
Yes.

McDivitt
When we opened up the spacecraft the hatch came open with a bang. The air that we had inside was obviously of greater pressure than that outside, and we had a great outflow of things including a piece of foam that we had used to pack our maneuvering gun in its box. It was the first thing that we put in orbit. But then throughout the time that Ed was out, he wanted the door wide open. It was pretty obvious that the flow was from the spacecraft to the outside because partway through his maneuvers his glove floated out and floated away from the spacecraft with a reasonably good relative velocity. The entire time he was out, even after we had the hatch open for 20 to 25 minutes, we were still getting particles floating out through the hatch. It was the flow. The streamlines were very obvious. It was from inside the spacecraft to the outside. I guess the spacecraft was out-gassing at a sufficient rate to cause a reasonably large pressure differential from inside to outside, and it was certainly relieving itself. I noticed this even as we were trying to get the hatch closed. There was still a flow from inside to outside.

White
Okay. I think that pretty well covers most of the things that we actually did while I was out there.

McDivitt
Now, as for getting back in – .

White
Yes, let's go all the way back through and come back in. The time really did go fast! I had watches with me, but I didn't look at them.

McDivitt
I was watching the time. I noticed my watch around 4 minutes, 6 minutes, and 8 minutes. And then you got involved in [4-41] floating around as we were trying to get that last picture.

White
The time really flew!

McDivitt
You kept getting behind me all the time and I became distracted from the time we were on VOX, completely blocking out the ground. Our VOX must have been triggered constantly, because whenever we were on it they couldn't transmit to us.

White
That's where the time got away from me.

McDivitt
That's right, and it was 15 minutes and 40 seconds when I looked at my clock. So, I thought that I had better go to the ground. I said to the ground, "Do you have

any message for us?" because I knew it was time to get back in. And they just said, "Yes. Get back in!"

White
Right. I remember hearing Gus say, "Yes, get him back in."

McDivitt
This is what all the fuss was about. They might have been transmitting to us to get back in but we were on VOX and couldn't hear a thing.

White
I did a few things after this time that I wasn't doing to deliberately stay out. But I was deliberately trying to do one last thing. I was trying to get that last picture. And this was one of a couple of times that I kicked off the space craft really hard, to get out to the end of the tether. And I wasn't successful in getting the position so that I could get a picture. I felt this was the one part of the mission that I hadn't completed. Everything else was successful and I wanted very badly to get that picture from outside. I spent a moment or so doing this. This was also the period of time in which I called down to Jim and said, "I'm actually walking on top of the spacecraft." I took the tether held onto it, and used it as a device to pull me down to the space craft. I walked from about where the angle starts to break between the nose section and the cabin section. I walked from there probably about two-thirds of the way up the cabin, and it was really quite strenuous. Could you see me walking along, Jim?

McDivitt
No, I couldn't see but I could feel the thumping on the outside.

White
That's when I got to laughing so hard. This was when Jim was saying to come in.

[4-42]

McDivitt
Yes, I think this is when I got a little stern and said, "Get in here!"

White
When I was walking on the top and was laughing, Jim probably didn't think I thought he was serious. But it was a very funny sensation. Now as far as delaying, there were certain things that I had to do before I came in. And there wasn't anything in the world that was going to hurry me up in doing them. We had just agreed that we'd do things in a slow manner and this is the way we'd do it.

McDivitt
Let me talk about the time here. It is implied in the papers that Ed didn't really want to come back in, and didn't. I think one of the things is that we didn't hear. We didn't have any transmissions from the ground after he stepped outside until I went off VOX at 15:40. They said, "Come back in!", and I told him to come back in. I think that he probably delayed about a minute or 2 minutes.

White
I think so, trying to get the pictures.

McDivitt
And at that time I got a little irritated and hollered at Ed, too. Then he started back in.

White
But when I came back I had things to do.

McDivitt
Yes. I know it. That's what I'm trying to say to get this thing in its proper perspective.

White
Yes.

McDivitt
We were 3 minutes 40 seconds late getting started back in because we just lost track of the time. I couldn't see Ed any longer. I was trying to keep track of what he was doing without being able to see, and I lost track of time. Then I think he delayed probably a minute or a minute and a half before he started back in.

White
That's right.

McDivitt
So, those are the two delays. We'd agreed on that he'd start back in after 12 minutes, From then on all the time was spent just trying to get back in.

White
I had certain things to do. I had to disassemble the camera that was on the spacecraft. I did this very slowly. I had to disconnect the electrical connection to it and hand the camera back in to Jim. Then I had to go out and disconnect [4-43] the umbilical, and this really went pretty well. The little tether that I had them put on the ring, a pull ring, to disconnect the pin worked pretty well. I disconnected the umbilical and discarded the umbilical cord.

McDivitt
That was the last thing Ed put into orbit.

White
Right. I put that in orbit. Earlier, it was really quite a sensation to see the glove floating off. I asked Jim a few minutes before about the glove, or Jim had asked me, "Hey, do you want this other glove?" About a minute later, I saw it go floating out of the hatch.

McDivitt
All I can say, Ed, was about a half hour later I was sure thankful that we had gotten rid of something. We had so much other junk that we didn't want.

White
I saw the glove come floating out of the right-hand hatch, and it was a perfectly clear picture of the glove as it floated out. It floated out over my right shoulder and out – it looked like it was on a definite trajectory going somewhere. I don't know where it was going. It floated very smartly out of the spacecraft and out into space.

McDivitt
I think this had a lot to do with that out-gassing. There was a definite stream –.

White
Yes. It was following the streamline right out of the spacecraft.

McDivitt
It went out perpendicular to the spacecraft, whichever direction that is.

White
Back to getting back in the spacecraft - I had the one thermal glove on the one hand, my left hand. I always wanted my right hand to be free to operate that gun and the camera. The way the camera was mounted on there, I had to use both hands - one hand to actually stabilize it with the gun and the other hand to reach over. Again, I think dynamics played a little bit of a role there. Everytime I brought my hand in from a position out on my left, it tended to turn me a little bit, which is exactly what we found happened on the air-bearing tables. I think that the camera should have been velcroed to my body somewhere and used independently of the gun.

McDivitt
Yes. I got the same impression. I got the impression that what you really should have done was –.

White
Dropped the gun.

McDivitt
Unhooked the camera out there floating around and just thrown the gun away. I don't think you ever should have tried to bring it back.

White
Well, what I should have done was fold the gun and handed it to you.

McDivitt
That would have taken longer. It would have taken precious seconds out of the very few that we had anyway. I think you should have just unhooked it and thrown the gun away.

White
This was probably the thing that I was most irritated with not completing. I didn't feel the pictures were satisfactory with the camera outside. But I think the reason was that my camera was not in a position so I could use it adequately. But coming

back in was the last thing. As a matter of fact, before I dismounted the movie camera and dismounted the umbilical, I folded the gun.

White
I took the lanyard off with the camera on it, and handed Jim the gun and the camera.

McDivitt
And I stuck it down between my legs.

White
That was the first thing I handed in. Then I handed in the 16-mm camera, and then I threw away the umbilical. This was where the fun started. I found it was a lot more difficult coming back in that I had remembered in the zero-g training. It seemed like I was contacting both sides of the hatch at the same time, much firmer than I had in the zero-g airplane.

McDivitt
You mean you were hitting the hatch on one side and the hatch opening on the other side.

White
Coming back in, I was contacting the side of the spacecraft on both sides.

McDivitt
Yes, that's right.

McDivitt
You weren't really hitting the hatch on both sides; you were hitting the hatch opening on both sides.

White
Yes. I was coming down through there. I felt a much firmer attachment wedging in there than I'd remembered from the zero-g training. I think this might be associated with the extra 7/10 or 8/10 pound of pressurization on the suit. I just might have been a little fatter. I did notice that the suit was a little harder. I felt this type of suit during my pre-work, so this wasn't a [4-45] surprise to me at all. But I did feel like I was a little fatter getting in and wedged a little tighter.

McDivitt
I really don't think Ed was any fatter. I think that link the suit holds the suit to whatever volume it's going to go to. And I don't think a couple psi are going –.

White
Well, I felt like I was hitting a little more as I came in.

McDivitt
Yes. I think what happened was he was stiffer, and he wasn't bending his legs and his arms any.

White
You mean with the harder suit I was stiffer?

McDivitt
Harder. And your arms were stiffer and you weren't bending them around as much. It looked a lot more rigid.

White
This might have been.

McDivitt
Not semi-rigid – Ed was rigid.

White
All right. This might have been.

McDivitt
And that looked to me like it might have been the problem.

White
This might have been part of the recontact on the side of the spacecraft that I noticed. But as I came back in, I noticed that I had to work a little harder, and I hoped the tape was running because I think we had a very good commentary. We were both talking very clearly back and forth to each other during this time, and I was telling Jim that I was going to come in slow because it was a little tougher than I had thought. We were talking back and forth about being slow and taking it easy.

McDivitt
I actually helped push Ed down in there. I don't know whether he felt it or not in that suit.

White
No, I couldn't.

McDivitt
I reached over and I steered his legs down in, and I sort of got him settled in the seat a little better than what he was getting himself.

[4-46]

White
Yes. Right. I was kind of free wheeling my feet up there.

McDivitt
Yes. It looked to me like Ed was holding on to the top of the open part of the hatch and just swiveling around that part. It looked like he didn't have enough mobility and strength in his arms to actually twist his body down against the force of the suit into the seat.

White
After awhile, I reached my left arm underneath, the same technique we had used in the zero-g training, and actually I had my hands all over the circuit breakers.

McDivitt
Yes. Ed was a real hazard to the switches.

White
Yes, and I pulled myself down in and that's when I really started coming in – when I got hold of the underneath side of the circuit breaker panel and pulled myself in. That's when my first real progress was made toward actually getting down in.

McDivitt
Because, while I could steer Ed from where I was, really didn't have the strength to pull him in.

McDivitt
It was 90 degrees to the way that he really wanted to be pulling. I could steer. I did do a little bit of pushing, but not a heck of a lot. I wasn't really contributing much to the effort there except –.

White
You were guiding me down into the footwells.

McDivitt
Yes. That was about it.

White
But once I got my hands up underneath the instrument panel, I was back pretty well in familiar grounds – the work that we'd done five dozen times in the zero-g airplane, and I knew the technique pretty well.

McDivitt
Ten thousand times! White does check pretty well.

White
I really did it a lot. Maybe the suit was stiffer, or maybe I was fatter, but I wasn't going in quite as easy as I had before – getting into the initial position to pull myself down into the seat. So it took me a little longer. If you recall, I had to go back out again one time. I got back down and started to wedge myself down, and I got two fat cramps at the bottom of my thighs in both legs, where the muscles started to ball up a little.

[4-47]

McDivitt
Oh? Did you get in your thighs or calves?

White
Both of the muscles in the back of my thighs balled up in a ball, and I thought, “Well, I have to go back out and let them straighten up.” So I straightened my legs out.

McDivitt
We had that problem before in the zero-g airplane.

White
This is the time Jim said, “Hey while you’re up, why don’t you throw the visor out?” I hesitated a minute because I thought, “Well, you son-of-a-buck, you might have problems here. You might have to be spending an orbit or so trying to get in.”

McDivitt
No, as a matter of fact, I don’t think that is when you did throw it out. I think you threw it out when you came back down and you started to close the hatch. You were having trouble. It wouldn’t close, and you said, “I’m going to have to take this visor off so that I can see these things.” And I said, “Listen, if we get this thing closed we’re not going to open it again. Throw the visor away.”

White
That’s right. That was when I got the cramps, went back up again, and then I came back down again, and said, “Hey, I can’t see them. I’m going to have to take the visor off.”

McDivitt
No, it was a little bit later than that. You had already started to try to close it, and you were having difficulty closing it.

White
Okay. Let’s get the sequence out. We came down in. I got up to straighten my legs a little but, went back up, then I came back down –.

McDivitt
–with all your equipment on –.

White
I hadn’t held the handle yet, had I?

McDivitt
No. You hadn’t done a thing with it.

White
So I got back down into position –.

McDivitt
–with all your equipment on and pulled the hatch down.

White
The hatch was down far enough to close at this time.

McDivitt
I thought it was.

[4-48]

White
I did too. I felt it was down far enough. I can tell by looking right straight down at the edge–.

McDivitt
Yes. I can tell by looking up underneath the right-hand side to see where the dogs are.

White
Okay. So I thought the hatch was down far enough to close at that time. I reached up and got the handle, but I don't know what I said to you.

McDivitt
You didn't say anything. I don't know whether you said anything to me or not, but you didn't have to say anything to me. I saw you move that handle, and I saw how easy it was going, and I saw that the dogs weren't moving.

White
I think I said something. I don't remember what I said. But I said something, and you knew right away what had happened.

McDivitt
You didn't say a word. I was watching the dogs and that lever, and I knew what the trouble was.

White
Right. So I guess that's when I said, "I'm going to have to take the visor off because I can't see." And then we went back up and Jim said, "Well, we're not going to open the hatch again. Why don't you throw the visor out." I hesitated for a minute to throw it out because I thought that we might have a problem.

McDivitt
Actually, we had a little more difficulty than we had expected. We fooled around for a minute or 2 or maybe even 3 or 4 with the handle. It was pretty apparent to us that we weren't going to get the hatch closed with normal, straight-forward techniques, and that we were going to have to start going to other things. While we say that we came down and moved the handle once or twice, it was over about a 3 or 4-minute period, at least.

White
The normal method of closing the hatch is for me to come down and wedge myself down, hold onto the little canvas handle up there, and actually apply a downward force on the hatch to help close it. Then with my right hand I use the hatch handle to ratchet the hatch down. This is normally our technique to ratchet the hatch down. This is normally our technique we would always use, and never in

the past has Jim had to help me with the hatch-closing device. This wasn't the case this time. As soon as I had gotten up there to operate the gain lever, I couldn't operate the canvas handle anymore. I couldn't apply any torque or pull there because –.

[4-49]

McDivitt
Not only that, but you were actually pushing yourself up off the seat. And I'm not sure that even the first time that we had the hatch closed far enough. It looked like it was closed far enough. As a matter of fact, later on when we got it down to that position it looked like it was closed fine. It really wasn't closed far enough because you never did get those dogs out until we - .

White
No, the dogs came out, Jim, the first time I got torque on it. Those dogs started out, then it closed.

McDivitt
Did they? Okay.

White
Yes. I think we had it down far enough.

McDivitt
It looked to me like we did, and I couldn't understand why they weren't coming out. I knew that the ratchet wasn't engaged, but I got the impression that it was from watching your hand when you came down one time. You had the ratchet engaged and the little tit pin that sticks in the door that doesn't allow things to come closed wasn't there.

White
No, the ratchet wasn't engaged. There was nothing on the handle at all, It was free, completely free. The situation hadn't changed at all. Another thing I'd like to point out now, too, was the chest pack was in the way of bringing the handle down to a full-crank position. And I wanted definitely to do this because you can interrupt the sequence of the dogs if you don't fully stroke the handle each time.

White
We went back up so that I could actually see and observe the levers. This was the time Jim said to throw the visor out because we probably wouldn't open the hatch again, once we get it closed. And this seemed like very good sound advice to me. The only thing I was a little questionable about was that at this time I had the inkling in my mind that we might spend quite a bit of time getting this hatch closed, and I might want the visor when I was back out again. But I thought the judgment to throw the visor out was best, and I threw it out – opened the door about a foot and a half and threw the visor out. The next time we came back down, I was still having the little bit of problem with the cramps, but not nearly the problem I was having with the gain lever.

McDivitt
One superseded the other.

White
That’s right. One problem became of much higher magnitude than the other. So this was the time that we started working.

[4-50]

I knew what I had to do. I knew I had to work the gain lever in sequence with the handle again, just like we had when we opened it. We both had an inkling that this was going to happen when we opened it the first time. But this posed the problem of when I reached up with my left arm to work the gain lever. It takes a great deal of force. This isn’t the direction that the suit is designed to reach in. And it takes a great deal of force to lift your arms up in the vicinity of your helmet to operate something there. In so doing it pulled me back up out of the seat. And I think this is the time that Jim noticed that I was up higher than I had ever been before, and he actually felt that my helmet was up against the hatch. I tend to agree that I was up in that position.

McDivitt
Yes. I actually pulled Ed down in the seat by pulling on the –.

White
I think so.

McDivitt
I did it in steps. I’d pull down and Ed would come down. Then I’d pull some more, he’d come down some more.

White
I was actually pushing up with my left hand, and my helmet was wedged right up against the hatch. I had a little bit of area in which they actually see the dogs that I was working with up there.

McDivitt
You could see them though?

White
Yes, I could see them. At least I could see what positions they were in. I could see the little lever operating under the spring – where I was actually operating the spring on the gain lever. This is where I think we got some very good teamwork, because it was necessary that Jim pull down in conjunction with the time that I pulled down on the closing handle and operated the gain lever. I just hope that the tape worked because I can remember I was in there. Jim was talking to me, and then when it came to the point when we really had to make the big pull I felt a little torque on the handle. I knew that we had it at that time if we could only get the hatch down close enough so that the dogs would engage. And I can remember giving the old – I think I was yelling HEAVE! HEAVE! Is that what I was yelling?

McDivitt
I think so.

[4-51]

White

And it was perfect timing, because I could see Jim or I could see the hatch come down each time that I was yelling HEAVE! I think it was probably the most–.

McDivitt
The most interesting moment of the flight.

White
Yes. It was the most interesting moment of the flight, but I think it was probably the most, if you want to say, dramatic. I don't know the right word. But it was probably the most dramatic moment of my life – about those 30 seconds we spent right there. The dogs started latching. I could feel them going in, and then I could feel them come over dead-center. Jim called out that the dogs were in.

McDivitt
I knew that once we got them moving we'd be all right.

White
Yes, once they started coming in. As long as we got those dogs to engage, with the little lever that permitted them to come out and lock, I knew that we had it hacked.

McDivitt
Yes. So did I. Even if we would have had to reenter with the hatch in that position, we'd have been all right. I don't think that the heat leaks were that tremendous.

White
I knew we could continue and dog it on in all the way. It seems like whenever you know you're right on something, you want to be darn sure that they fix it. This was going through my mind then. And I remember that I felt I was right in that the bar and the attachment on that bar and lanyard were not strong enough. I remembered that, and I knew how hard you were pulling on that thing. I think, if nothing else, they ought to be sure. Howe many times did we break that attachment at the bar?

McDivitt
We broke the attachment about three or four times on the zero-g airplane. Every time they kept telling us it wasn't made out of the right kind of stuff, and the stuff we were going to have in the spacecraft would be the right material. Well, it didn't break in the spacecraft, just coincidently, or maybe because we both had doubts about the strength of that particular piece. The same thing crossed through my mind. I was thinking that the success or failure of this hatch closure depends on whether this hatch closing device stays hooked onto that spacecraft and doesn't break off.

White
We would have been flat out of luck!

[4-52]

McDivitt
We would have been in deep trouble! I'm not sure we wouldn't have been able to get the hatch closed, because we had put that canvas strap on there and I might have been able to pull you down that way. But I had about all the pull I had in me on that last –

White
I know you did.

McDivitt
–on that last thing and I had a lot of mechanical advantage over it. When we went to that canvas strap we would have had to go with no mechanical advantage – as a matter of fact, a mechanical disadvantage.

White
This is one thing that didn't fail, but I recommend that it be made stronger.

McDivitt
Stronger anyway!

White
I think so.

McDivitt
For nothing else than a psychological purpose.

White
Right. I'd like to take the spacecraft now and see if I could break it, because I had the feeling that I never had been confident that the attachment nor the bar nor the lanyard were strong enough.

McDivitt
When I say I was really pulling as strong as I could, I really had some pull left in me, but I guess what I should have said is that I was pulling about as hard as I dared pull at the time. I guess I could have pulled another few pounds, but I hated to apply more than was needed on there because of the lack of confidence in the strength of it.

White
Everything I had was in it over there. I was pulling down with my legs as hard as I could and operating. I was pulling on the handle. I remember one time you said, "Hey don't pull on that handle so hard! You're going to break it!"

McDivitt
I was cautioning you to take it easy, which you don't usually have to do.

White
This was when we were yelling HEAVE! I was heaving on the handle as I was pulling it down each time. It felt like to me that the handle was giving. But I didn't give a darn! If it broke, it was going to break. So one of the points we learned out of this was we'd like to see the bar and lanyard strengthened.

[4-53]

White
Let me say one thing about the decision to go ahead and open the latch. If we hadn't done so much work together with this hatch and run through just about every problem that we could possibly have had, I would have decided to leave the hatch closed and skip with EVA when we first started having trouble with it. We had encountered just every conceivable problem that we could possibly have with the hatch. If it failed we'd know exactly what it was.

McDivitt
That's right. I personally had disassembled this cylinder and piston and spring combination up at McDonnell prior to the altitude chamber, so I knew exactly what it was made of. I am sure the problem was that the dry lubrication coagulated, or whatever a dry lube does, and was causing the piston to stick. I knew how we could do this thing. Carl Stone and I had dismantled it and put it back together, cleaned it out, put it back together, relubricated it, put it back together, and it operated fine. I figured out how to make the thing work with it not working properly by using you finger as the spring.

White
That's the exact technique we had used.

McDivitt
If we hadn't had the training together that we had, and had not encountered all these problems before, I know darn well I would have decided not to open the hatch.

White
Maybe we sound overdramatic about the effort we made getting me back in, and I'll honestly say it's one of the biggest efforts I ever made in my life, but I don't think we were all done then.

McDivitt
There were a lot of things we could do.

White
We could have gone around several orbits working on closing the hatch. That wasn't the last time we were going to get a chance to close it. So there were things left if we understood, and other procedures we could have used to go ahead and close it. When we got it closed back in, I was completely soaked wasn't I?

McDivitt
Yes. You were really bushed.

White
Sweat was just pouring down. In fact, I could hardly see. It was in my eyes.

McDivitt
So I told you, "Just sit there and I'll get a repress. Don't even move for 30 minutes." I just left the repress valve where it was. I closed the vent valve, and we had a lot of instructions from the ground to close the water seal and a whole bunch of other things that didn't make any sense to me. I knew that the spacecraft was repressurizing. I watched. There wasn't anything else that we had to do right then, and we were both bushed, especially Ed. He was perspiring so that I could hardly see him inside the face plate. So, I just said, "You sit there and I'll sit here and we'll just coast around. When we get the thing repressurized, we'll start doing something." That was exactly what we did. I did finally extend the HF antenna and try to call somebody on HF and let them know that we were back in safely and that thing was repressurizing. I didn't get any response until we got to Carnarvon, which was about 3 minutes later. I called and told them that we were repressurizing and had the hatch closed.

White
You know, that was some pretty good gage reading that we saw when we got the first ½ psi.

McDivitt
The first ½ psi. Ha! Ha!

White
That was a really big one. Since we've described the whole operation, we'd like to go back now and specifically point out the pieces of equipment that we used and our opinions of them, a few features that came out loud and clear to use in operation, general conclusions on EVA as an operation, and what we have to do to make it an operational procedure. So the first thing I'll do is go down through the equipment. As an overall comment on the equipment, I would say I felt very confident the equipment would do the job. And without question the equipment performed as it was advertised. It performed just exactly as it had been designed. There wasn't one thing on them as far as the VCM, the umbilical, the gloves, the gun, and the visor that didn't perform just exactly as it had been designed. There wasn't one thing on them as far as the VCM, the umbilical, the gloves, the gun, and the visor that didn't perform just exactly as it had been designed. I'll take them all one piece at a time, and discuss them a little. I'll start right with the visor. The visor was a rather controversial piece of equipment from the beginning. And I, for one, doubted a little bit the necessity for quite the protection that we were providing, although I had helped right from the beginning in the design with some of our ideas on the visor. It turned out, though and I commented on this during the time that I was out, that I was very happy to have the visor. I was able to look directly into the sunlight. I did so in installing the camera on the back of the adapter. I felt that the vision out of the visor was about as it would be on a normal sunny day [4-55]. This is because it is so bright up there in space. I felt as if my vision was what I would consider normal. I was looking at the different parts of the spacecraft and down at the ground, and the view that I received at this time was what I would expect on a normal sunny day. I was certainly glad to have the visor

and I left it down throughout EVA. I think on a later flight we might recommend going ahead and lifting the visor and observing any changes we might see in visual acuity when looking down at the ground. The ground vision through the visor really didn't seem to me to be degraded at all. Evidently just the intensity, and not what I was seeing, was cut down.

McDivitt
Let me comment a little bit on that visor. I didn't have a visor, and the bright sunlight that was in the cockpit didn't seem to bother me. I imagine that the visor turned out just like a pair of sunglasses. You go outside on a normal day and wear a pair of sunglasses. If you don't have them, you're squinting. But if you start out without them you tend to get accustomed to it. I think I was accustomed to what light there was coming through the spacecraft, admittedly much less than that outside. Ed was accustomed to the sun visor and it turned out just like two people with and without sunglasses. They both could have adapted. I didn't look into the bright sun straight ahead.

White
Well, the first time I looked into the bright sun, the first thought I had was, "Boy! Am I glad I've got this visor on!"

McDivitt
I know you mentioned it on the radio.

McDonnell
– because I was looking straight into the sun. I had to look into it to attach the camera onto the adapter section. I don't normally wear sunglasses. As you know, Jim, I have never worn sunglasses very much, and I didn't notice it from then on, throughout the time I was out. I had no impulse whatever to lift my visor. My vision was as clear as I could have expected it to be without the visor. There are a few design points in the visor that we could make better and I'll briefly go into them right now. When you are seated in the spacecraft one visor slips up underneath the other and back along the back of your helmet, so that instead of resting on your helmet on the headrest you're resting the visor on the headrest. You certainly don't want to do that. The visor should be restrained in some manner from slipping up along the back of the helmet. Also, my visor was quite difficult for me to raise and lower. Once it was down it fit quite snugly, for which I was happy. But it was difficult for me [4-56] to raise and lower. It was actually a two-handed operation, which is one of the reasons why I didn't raise it outside, although I had no impulse to raise it when I was outside. I think that we might be able to design them to be raised up and down more easily.

McDivitt
Let me make a comment on that visor. I never did see any need for the little lexion visor.

White
That's exactly the point I was going to get to next. I think that one single visor made as close to the helmet liner as possible, providing the maximum amount of headroom and a minimum amount of interference, is what we actually need. I

don't believe we need the lexion outer visor. As they pointed out to us, it doesn't really protect, because it bows in and it doesn't really give you the protection that it should be affording. I would recommend one visor, one sun visor only. It'll be simpler to operate.

McDivitt
I think so too.

White
Okay. The Ventilation Control Module, I can say without qualification, worked exactly as it was planned to work. There was not one complaint that I had with it. It provided me with the proper flow. The flow was less than with the normal ECS suit system, but it was adequate to keep me cool and ventilated, except for two times during the flight. Those times were when I attached the camera right before departing the spacecraft and reentering the spacecraft. But I think it performed with out fault.

White
The umbilical was another item that I thought performed its part of the flight quite well. I had no complaints about it. I did tend to get it tangled up with the bag and the strings that were attached to the bag during EVA.

White
I am very thankful that we decided to design the gloves in the manner in which we did, the two-piece glove that was easily donned or doffed under pressurized conditions. As it turned out, I took them on and off twice while pressurized. I was quite happy that we had them designed in this manner. As it turned out, the heat on the side of the spacecraft, or the cold on the side of the spacecraft when we came out of the dark side, were not noticeable to the touch at all. I didn't use a right-hand thermal glove at any time during the flight. I took it off when I was opening the hatch and, as I pointed out earlier, it floated off during the EVA operation. I didn't have opportunity to use it again if I had [4-57] wanted to. Coming back in we had difficulty closing the hatch, and I, at this time, removed my left-hand glove and used the plain pressure suit gloves for this operation. The pressure suit gloves were comfortable. In fact, there were no sensations of either hot or cold through my gloves.

White
The gun, I think, was an outstanding point in the flight, a highlight of the flight. It worked just as we had felt it would work and it was, I felt, simple to operate. The training that I had on the air-bearing platform provided me adequate orientation in the use of the space gun. I think that now that we have a little more time to prepare ourselves for the next time we use this gun, training with it on zero-g flights would be appropriate. I don't believe we will have any trouble using it in the zero-g aircraft.

White
One mistake that we made on our EVA equipment was the mounting of the Contarex camera. This camera should have been attached by velcro to me, so that I could use it independently of the gun. It would have been easier for me to use, and I would

have had a much higher probability of getting satisfactory pictures with it. It was a case of lumping too much together - putting the gun and camera together.

White
The attachment of the VCM to the harness was a good type of attachment. It was easy to disconnect the two velcro attachments and move the chest pack in and out. I had to do this both when I opened the spacecraft hatch, so it would clear the hatch handle, and I had to move it out of the way when I closed the spacecraft and pumped the hatch handle.

White
Now we can get into some conclusions. While I was out, I decided to put a piece of velcro strip on the side of the adapter to see if later on we might use this as a method for attaching items on the outside of the spacecraft, if the velcro was still there and if it was in good shape. I think the velcro could be made into a very useful item for a type of tether. I think you might even be able to do something along the line of just having some female velcro on the gloves and pieces of the male velcro at points along the adapter. This might provide us at least some attachments so that we could maneuver ourselves back to the adapter section. This would be about the simplest kind of handle that we could use. I do believe that we need some type of handles on the outside of the spacecraft. Jim suggested one on the nose and in the cover on the R and R section up there. I think this is an area that we certainly have a possibility of using. I certainly would have found it useful. I would still be a little hesitant, though, of breaking the antenna. You would want to be sure that this wouldn't be broken during EVA. I think the feeling I had out there, again, was like holding onto an 8-foot tree. There wasn't anything to hold onto. You definitely need some kind of hand-holds. The decision to leave the hatch open was one of the best decisions that we made. It provided me with a center of operations for my work. I was able to stabilize myself by holding onto the hatch. It was also surprising to me how much force it took to open the hatch the first time against the preload and the actuators, due to the seals. One other very good decision was to have me wear the heavy suit and Jim the light suit. I think this was one of the things that made our operation easier. It certainly made my getting back in the spacecraft and Jim's assistance in closing the hatch much easier for him. Also, I was handing him things in and out. He was performing quite a bit of coordination in the operation with pieces of equipment that were going in and out of the spacecraft, and I believe that by being in that light suit he was able to do this much easier than if he had been in a heavy suit.

McDivitt
I might make a comment on that suit, too. When we opened up the hatch we were in a vacuum. I noticed that the temperature of the suit dropped slightly so that the suit was a little bit cooler inside. I was wondering if I was going to get too cold through the suit, but the rest of the time we were out the temperature never changed. I don't remember looking at the suit inlet temperature, but the suit itself stayed reasonably warm. I had sun in the cockpit, and I had the cockpit open without the sun in it for a relatively long period of time, 4 or 5 minutes at a time. This didn't seem to affect my temperature inside the suit.

White
I think you felt the temperature more than I did.

McDivitt
I felt the temperature go down, rather than up.

White
I felt that also while outside. I would say it was a very comfortable figure. I figure that I was probably at 68 degrees temperature out there inside the suit, which was cooler than I had been anytime during the flight. It wasn't a cold feeling, just a very natural comfortable temperature.

McDivitt
Suit inlet temperature was running about 55° during most of the flight. It got down around 52°, so it probably might have even been cooler than your 68°.

[4-59]

White
Well, it was cooler inside the suit when I was outside the spacecraft than at any other time during the flight. It wasn't uncomfortably cool there at all.

White
I think that we can go on with some conclusions. Some conclusions that I had were:

> 1. I didn't notice any extremely hot temperatures on the outside of the spacecraft. I also didn't contact surfaces for any period of time to transfer much in the way of a heat load to any part of my suit including the gloves.
>
> 2. There's a definite requirement for some type of handholds outside the spacecraft.
>
> 3. We should think a little more on where we want to operate during EVA and where to attach the tether. The tether was not attached at a point that would provide me the capability to operate in the area that I wanted to.

McDivitt
You couldn't get to the nose. It provided great operation for directly above.

White
Straight above.

McDivitt
I just don't know how you would get the thing out there. You would have to run it along the spacecraft, then attach it somewhere at the front.

White
It would preclude operations in other areas. You would either have to accept where we are going to operate or –.

McDivitt
You could have multiple attachment points around the spacecraft.

White
Of course, now, if you have a gun with a good air source, Iwouldn't particularly care where it was attached. I think you could go ahead and, maneuver to any point you want if you have a gun. Again, where you're pushing off of surfaces, you tend to go perpendicular to the surface from which you push off. I found when I pushed as hard as I wanted to I'd still tend to go straight up above that hatch instead of out toward the front. I think this is a fairly obvious conclusion, but it proved out. Every time I pushed off I went straight up instead of at an angle to the surface where I wanted to go.

[4-60]

McDivitt
Something that you should bear in mind is that you were pushing off from the front, which tended to make the front go down as you went out.

White
Yes. Everything was working against getting where I wanted to go. Everything I did tended to put me up.

McDivitt
When you started you went in a straight line forward and tended to push the spacecraft down. I think, initially, where I was holding the attitude, you didn't have that much trouble. Of course, you weren't pushing as hard either, because you had the gun.

White
No, I wasn't.

McDivitt
Later on, when we started free drifting, you were back behind me where I couldn't see.

White
Did you feel me stomping around back on the adapter and hitting the adapter?

McDivitt
Well, I felt you hitting things back behind me, and once you went behind the line that was directly overhead the spacecraft. I couldn't see you through your open hatch.

White
I never really had a good contact with the adapter back there.

McDivitt
Just as well. We wouldn't want to disturb those radiator tubes too much,

White
No. Well, now that we're back, we'll have some conclusions on the adapter area. I made it a point right from the beginning to take a look at the thermal lines, the thermal paint on the adapter. It looked like it was in good shape. It was all there. There was discoloration around the attitude thrusters, particularly from the thrusting. The color of the thrusting is just like the RCS thrusting – nice and clear plume. It looked like from outside, though, that I could see a lot more of the plume than I could when I was sitting inside the spacecraft looking out at the RCS thrusters firing. Again, the camera was not attached in an opportune manner to operate.

McDivitt
Which camera? The camera on the spacecraft?

White
I'm really after that camera on the gun. That one wasn't attached good. The camera on the spacecraft was okay. It was a little difficult to attach because of the attachment [4-61] on the bottom of it. You can't have it at any angle to make it engage. It has to be perfectly flat with the mounting plate on the bottom. A big conclusion that I came to – and I'll see how you feel about this one, Jim – I feel that storage in the back of the adapter section was certainly a very high priority for later missions. I feel that we can adequately store equipment in the adapter area, particularly larger pieces of equipment that we don't have room for in the crew station or pieces we don't have particular use for in the early part of the flight. If we can lick the problems in opening and closing of the hatch, we can store equipment in the back of the adapter section as a routine operation.

McDivitt
That's right. I think the extravehicular activities have proved to other people what we already knew a long time ago that EVA is quite simple. I think the thing we've got to iron out is the hatch opening and closing. This is really our problem. I don't think you or I will ever have any doubt about the extravehicular activity. That was, I thought, going to be pretty straightforward. It looked like to me it was pretty straightforward.

White
I felt that I could operate equipment out there. I could assemble equipment. I could put pins in, pull pins out, and screw things in. I did all these things during the flight. I turned the gun on, and I put in the pin to operate the umbilical guide. I attached the camera. I don't think you could do these operations very effectively with big heavy gloves on. Although my gloves operated satisfactorily, I think that for assembly of items you want to have – you ought to look into the glove area a little more thoroughly and try to get a piece of a glove with some type of a surface that will give us some heat protection and gives us a high sensitivity of feel through it. The big conclusions, the final conclusions, that I'd like to draw are that EVA can be made a normal routine operation if the following modifications are made to the spacecraft:

> 1.The highest priority is that the spring back there on the gain lug has convicted itself, and I don't believe that that's a good design. There should be some way that either the lubrication is made foolproof or the spring made stronger.

McDivitt
I think that we really want to say here is that the locking mechanism is inadequate as it is, completely inadequate. Until it is fixed, I think we should take it easy.

[4-62]

White
That's right. I think we almost had a bad experience with that gain thing. We knew about it ahead of time. We thought we had it fixed, but it's not fixed. I think it convicted itself, and it's guilty, and it has to be fixed.

> 2. I recommend that at least the egress kit on the right of the crew compartment be removed to provide more room in the spacecraft. I see no reason for it being in there. I think it would be worth the effort and the additional money to provide the extra room in the spacecraft, So, my second recommendation on EVA is to remove the egress kit, at least from the right-hand side, to provide more head room.

McDivit
Yes, that's good. I might add that it's a good thing that we had that egress kit modified to the minimum height, because without that we would have been in deep trouble.

White
That's right.

White
Yes. You and I had been telling each other that that was the biggest thing we did on our whole 9 months prior to the flight - to get that thing cut down. I think it sure paid for itself on our flight.

> 3. My third item is to make the bar and lanyard completely foolproof in strength. That was a device that provided us with the added force we needed to close the hatch, just as we sat there and said we might need during the SAR of the spacecraft in St. Louis. I think the attachments of the bar and the cable to the spacecraft should probably be at least doubled in strength, so there just isn't any question in the pilots' minds or the engineers' minds. I guess the engineers were convinced that you didn't have Jim and me convinced that those two attachment points –.

McDivitt
We've seen it break too many times, I think.

White
We've broken the bar, and we've broken that attachment point. I had actually physically twisted the attachment right off the spacecraft up in the zero-g airplane.

I certainly wouldn't have put my full strength into it if I knew my life depended on that attachment. It should be made absolutely foolproof.

McDivitt
Well, that was the point I was trying to make earlier when I said I was pulling as hard as I could. Then I said that I really wasn't pulling as hard as I was capable of.

White
You didn't have confidence in that attachment.

[4-63]

McDivitt
I didn't really think that I should pull on it any harder,

White
No. I think that should be the third recommendation and it should be corrected.

McDivitt
I think we could spare a couple of extra pounds of weight there, just for the pilots' peace of mind.

White
That's right. Take the time it takes to put a new attachment on there. They told us they didn't want to do it because they'd have to rerig it. I think they'd better rerig it and take the time to put a good attachment on there.

> 4. The final thing really doesn't fit in with the first three recommendations, but I would sure like to have the opportunity to use that gun again with about a 10-times supply of oxygen in a great big canister. I think that maybe this is one of the items we could carry in the back of the adapter. We could use a small supply to provide the means to go back there to get a great big canister. Then we'd have a unit that we could actually do some maneuvering with.

McDivitt
That's right. I think that, in essence, we proved the usefulness of a self-stabilized or a man-stabilized maneuvering unit –.

White
Yes.

McDivitt
– rather than one that is gyro-stabilized with automatic stability features. I think that although you didn't burn up a lot of fuel, you certainly proved the feasibility of this type of maneuvering unit.

White
We had an awfully small amount. We just had the 6 feet/second.

White
We proved, in my mind, that I had the capability to go from Point A to Point B with that maneuvering unit.

McDivitt
Let me ask you this question, and be honest about it. Would you detach your tether and go without it? Don't be too optimistic, because other people's lives may depend on it,

White
I think that we probably have not done enough investigation to do that at this time, but I feel we are progressing toward the point. We made the first, say 50 percent, of the step toward being able to detach the tether and go. I don't believe that I would detach the tether and go with that 6-feet/second –.

[4-64]

McDivitt
Oh, no. I didn't mean that. I mean with that type of unit.

White
If I had some more change of V in a unit like that I think that I would be willing to detach myself on the next flight, right now, from the spacecraft and go. That's combined with two things, you see. You have two things working for you. You have the capability to maneuver yourself, and, if you should get out of control, the spacecraft still has the capability to come over and get close enough so that you could get yourself back in control and get in the spacecraft.

White
I think that 40 or 50 feet/second would be a minimum, I had 6 and I'd like to see, probably, a capability of about 10 times that. That may be a little –.

McDivitt
It's difficult. I would think it would be difficult to fix a number on it until you fixed the job.

White
Yes.

McDivitt
If you wanted to go to something that was 10 feet away and come back, you'd probably get by with 20 feet/second.

White
If I wanted to get out of the spacecraft and go along to the back of the adapter and get in the adapter without being attached to the spacecraft, I'd only need two or three times the amount. I'd be happy to go with that.

McDivitt
There are some problems in the capability to aline one's self onto an object. I think chasing the booster around points this out. You say you'd be willing to go away because the spacecraft can come and get you. Admittedly it can, but keep in mind the difficulty we had with the booster. I don't really anticipate us ever getting into the situation like that because you'd never get so far away that you're in different orbits, like we were with the booster –.

White
What I visualize is a 25 to 50 foot operation where you're going out to investigate either another spacecraft or another satellite up there, or making a transfer similar to the type of transfer that we visualize as a backup mode for Apollo. I think with the gun I had, if the LEM and the Command Module were there, I'd be satisfied to depart the Command Module and maneuver over to the LEM situated 10 to 20 feet away from the Command Module. I feel I could do that at the present time. I don't think it would be a very smart thing at the present time to go maneuvering off 200 to 300 feet away from the spacecraft with this type of device. I think this device is designed and has its greatest usefulness in close operation around the spacecraft.

[4-65]

McDivitt
That's right. There is no need to maneuver off about 400 or 500 feet away, because if you want to go that far, use the spacecraft. This gun is for a close-working job.

White
I think it's a valuable tool in this manner.

McDivitt
Okay. That's the same conclusion I came to. We'd be willing to do it at close range.

White
I'd be willing to do it right now. I might not go tell somebody else to go do it, but I'd be willing, with the training that I had with it, to transfer 15 or 20 feet without a tether. But I think we should spend some more time with the gun.

McDivitt
I think so too.

White
I also think it would be of value to go in the zero-g airplane with it.

McDivitt
Yes, I think so too.

White
I think the work that we might do in the zero-g airplane doesn't necessarily have to be done in full regalia, with all the pressure suits in a pressurized condition. I think we can go up there and learn a lot about the gun without pressure suits on, in a plain flying suit type operation - perhaps polish the training off with a little

work in pressurized suits. If you work in the zero-g airplane with a pressurized suit, it's pretty awkward.

White
In pitch and yaw I felt I could maintain effectively zero rates. I don't know how it looked to you, Jim, but it looked like I could establish a rate and take the rate out without too much trouble. The yaw is the lowest moment of them all. Pitch was very easy, just to pitch the thing up and down. I'm still a little suspicious of roll. That's the area that I would like to look into a little more. I think that you could get yourself into a kind of balled up situation with pitch, roll, and yaw all coupled up. It might take a little bit of fuel to get yourself straightened back out again. But just in translating from Point A to Point B, you could care less if you rolled, as long as you kept pitch and yaw straight. And that's why I say I think you can translate and correct pitch and yaw very successfully and effectively forget about roll, just as we do in our reentries or our retros.

[4-66]

White
The question is: Was there any problem with the gun of maintaining a fairly well stabilized attitude and still get my translation input? I did this actually three different times, and this was what I had done when I was coming back to the spacecraft the last time. I had to put in both pitch and yaw and had taken them out and I was coming back. I was going to fire my last thrust toward the spacecraft. I got a little burst. I could feel a little burst and then it petered out. But you can put a translation in. I was also surprised that I was able to stop at the time I tried to stop it out there, about one-half or two-thirds of the way out on the end of the lanyard. It seemed to stop pretty well. It was either the gun or the lanyard dampening me. It didn't dampen me in roll, so I then it was the gun that actually did it.

McDivitt
I think that this previous bunch of words just spoken covers a lot of detail of the first three or four orbits of our flight, and it covers that first phase of mission sequences that I first mentioned. I think the next thing we should do is go through the interim orbits, about 50 or 55, or however many there were, where we set about to save up enough fuel to do something constructive, to check on our orbit to see what it was, to see how we were decaying, what our lifetime expectancy would be, and perform the experiments that we'd initially set out to do on our flight plan. Although it's not going to be of much use to go through it in a chronological order, I suppose that is probably the best way. As I just finished saying, we're not going to get an awful lot out of going through the flight plan sequentially, but we'll do it quickly, and then we'll come back and discuss each experiment or operation, check an entity in itself, and we'll discuss the systems as an entity, too. We'll do this, generally, in elapsed time.

McDivitt
Going back to the EVA for just one moment. I'd like to say that the use of the manual heaters on ECS Oxygen bottle was about two 5-minute periods separated by about 10 minutes. We really didn't need an awful lot of manual heater when we were doing the extravehicular activity.

Document I-68

Document Title: "Summary of Telephone Conversations RE Gemini 7/6," 25–27 October 1965.

Source: Folder 18674, NASA Historical Reference Collection, NASA History Division, NASA Headquarters, Washington DC.

Document I-69

Document Title: "Gemini Program Mission Report, Gemini VI-A," January 1966.

Source: Folder 18674, NASA Historical Reference Collection, NASA History Division, NASA Headquarters, Washington DC.

Document I-70

Document Title: "Gemini VIII Technical Debriefing," 21 March 1966.

Source: NASA Collection, University of Houston, Clear Lake Library, Clear Lake, Texas.

The Gemini program consisted of a methodical series of steps intended to develop procedures and experience necessary for the Apollo program. These documents discuss three important Gemini missions. Gemini VI was the first test of rendezvous in Earth orbit. The mission plan called for the spacecraft to maneuver to intercept an Agena target vehicle. When the Agena spacecraft failed, NASA quickly reconfigured the Gemini VI mission plan to rendezvous with another Gemini mission, Gemini VII. The flight proved to be extremely successful and the results were an important validation of the rendezvous concept for Apollo. The Gemini VIII mission successfully docked with an Agena target vehicle but because of problems with the spacecraft control system, the crew was forced to undock after approximately 30 minutes and spent most of the rest of the shortened mission overcoming a failure of the attitude control system or the flight's early return to Earth.

Document I-68

SUMMARY OF TELEPHONE CONVERSATIONS RE GEMINI 7/6

October 25, 1965

3:10 p.m.

Dr. Mueller called Mr. Webb (from the Cape) to report on the accident, giving details of the Agena explosion. He said it would be ten days before the investigation would be completed. He said it did not affect our actual schedule; will probably move some of the flights forward. Press conference held; no need for further information to the press.

October 26, 1965

3:00 p.m.

Mr. Webb called Dr. Mueller about a Herald Tribune article on the accident. He wanted to know if there were any feeling on the part of Lockheed that "this thing" was not ready to fly. Dr. Mueller assured him there was no reservation on the part of either NASA, AF, or Lockheed.

October 27, 1965

5:25 p.m.

Mr. Webb called Dr. Mueller to inquire as to the possibility of scheduling a rendezvous in December, with a view to announcing that we are looking into the possibility of doing it. Mr. Webb said that a possible announcement might state that we re taking down the booster for the Gemini 6 and erecting the one for Gemini 7 because of the experience we have gained in mating the Gemini 6 spacecraft to the booster, we may be able to re-erect Gemini 6 in time for a rendezvous with Gemini 7 during its 14-day mission. It would further state that in reporting this to the President, he has asked us to endeavor to do this rendezvous in December.

> Mr. Webb said that Dr. Seamans was a little more conservative than he was, but Mr. Webb felt it would give the image that we have the resources to retrieve.
>
> Dr. Mueller said they would have a much better view of the situation by Monday and could tell whether it was a 20-80 chance or a 80-20 chance of succeeding.
>
> [2]
>
> Dr. Seamans asked if it would place an undue burden on Chris Kraft, and Mueller said it would not as long as we tell them they don't <u>have</u> to do it.

6:__ p.m.

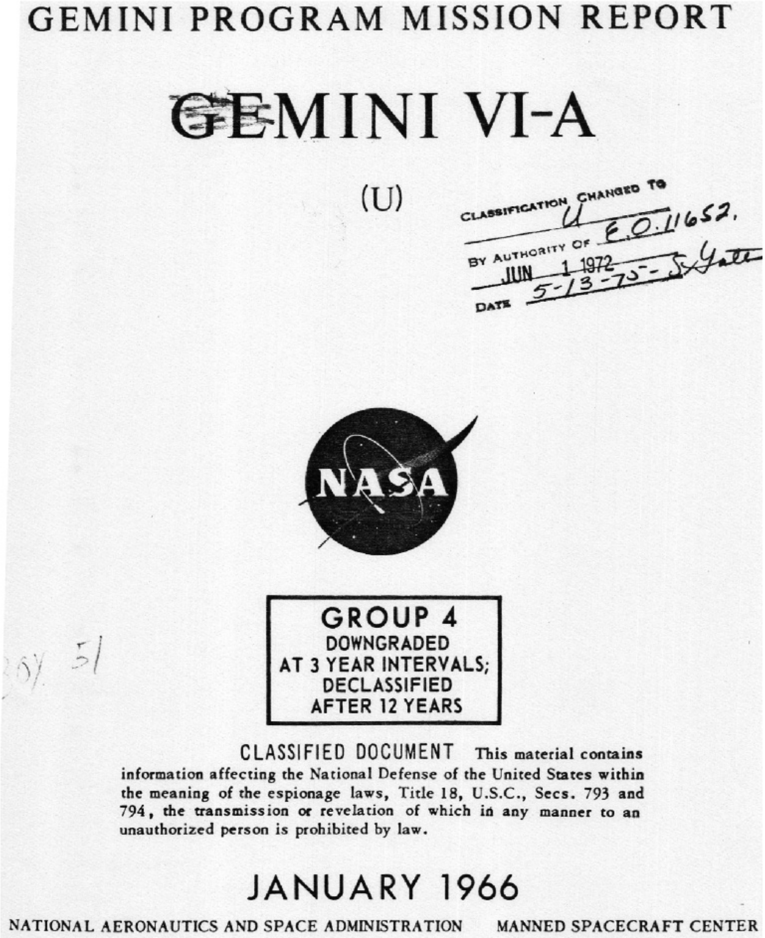
> Mr. Webb called Mr. Joseph Laitin at the White House. He explained to Mr. Laitin that we were taking down the booster set up to fly Gemini 6 in order to erect the one for Gemini 7. He said we were going to look very carefully over the next several days at whether or not it might be possible to launch Gemini 7 the latter part of November or early December, and if it gets off with no damage to

the launching pad, to launch Gemini 6 before the 14-day trip is over. He said we, would not know for sure until next week whether or not this was possible.

Mr. Webb said he would like some judgment from Mr. Laitin and Mr. Moyers as to whether or not it would not be a good idea for the White House to put out a press release saying that NASA has informed the President that the Gemini 6 booster is not adequate enough to carry Gemini 7 into a 14-day orbit; that, therefore, the Gemini 6 booster is being taken off the pad and Gemini 7 is put on the pad for a launching as early as possible in December. Second, that we have told him that we have already done the work of mating Gemini 6 and the booster and both to the launching apparatus itself, and that there is a possibility that if Gemini 7 got of without damaging the launching pad, Gemini 6 could be launched and have a rendezvous between Gemini 6 and 7.

Mr. Webb said we couldn't promise that we could do it, and the President mustn't tell us to do it but to endeavor to do it.

Document I-69



GEMINI PROGRAM MISSION REPORT

GEMINI VI-A

(U)

CLASSIFICATION CHANGED TO U
BY AUTHORITY OF E.O. 11652,
~~JUN 1 1972~~ 5-13-75 - S. Yate
DATE

GROUP 4
DOWNGRADED
AT 3 YEAR INTERVALS;
DECLASSIFIED
AFTER 12 YEARS

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JANUARY 1966

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION MANNED SPACECRAFT CENTER

[1-1]

1.0 MISSION SUMMARY

The fifth manned mission and first rendezvous mission of the Gemini Program, designated Gemini VI-A, was launched from Complex 19, Cape Kennedy, Florida, at 8:37 a.m. e.s.t., on December 15,1965. The flight was successfully concluded with the recovery of the spacecraft and the flight crew at 23°22.5' N. latitude 67°52.5' W. longitude by the prime recovery ship (U.S.S. Wasp), approximately 1 hour and 6 minutes after landing. This rendezvous mission was launched from Complex 19 within 11 days after the launch of the Gemini VII space vehicle. The spacecraft was manned by Astronaut Walter M. Schirra, command pilot, and Astronaut Thomas P. Stafford, pilot. The crew completed the flight in excellent physical condition and demonstrated excellent control or the rendezvous and competent management of all aspects of the mission.

The primary objective of the Gemini VI-A mission was to rendezvous with spacecraft 7. The secondary objectives of the Gemini VI-A mission were to perform a closed loop rendezvous at M=4 (fourth darkness of the mission), conduct station keeping with spacecraft 7, evaluate the re-entry guidance capability of the spacecraft, conduct visibility tests of spacecraft 7 as a rendezvous target vehicle, conduct 3 experiments, and conduct systems tests. The primary objective and all secondary objectives of the mission were successfully accomplished except for one of the three experiments for which valid data were not received.

The Gemini launch vehicle performed satisfactorily in all respects. The countdown was nominal, resulting in a launch within one-half second of the scheduled time. First-stage flight was normal with all planned events occurring within allowable limits. The first stage offset yaw steering technique was used for the first time on this flight in an attempt to place spacecraft 6 in the same orbital plane as spacecraft 7. The technique results in a "dog-leg" trajectory, and it was used successfully.

Staging was nominal; however, the crew reported that the flame front caused by staging enveloped the spacecraft in such a manner that it deposited a thin burned residue on the windows which affected the visibility through them. The pilot was able to verify this phenomenon as he had been observing a string of cumulus clouds prior to staging and also observed them after staging. He reported that the clearness and whiteness of these clouds was diminished after staging.

The second stage flight was normal and all but 7 ft/sec of the -660 ft/sec out-of-plane velocity achieved during first stage operation was steered out during second stage flight. The spacecraft was inserted into an orbit having an 87.2 nautical mile perigee and an

[1-2]

140 nautical mile apogee. The apogee was about 7 nautical miles below the planned altitude. The slant range to spacecraft 7 from spacecraft 6 at its insertion into orbit was a nominal 1067 nautical miles.

Nine maneuvers were performed by spacecraft 6 during the following 5 hours 50 minutes to effect the rendezvous with spacecraft 7. These maneuvers were all performed using the spacecraft guidance system for attitude reference. Initial radar lock-on with spacecraft 7 occurred at a range of 248 nautical miles. Continuous lock-on started at a range of 235 nautical miles and no losses of lock occurred until the system was turned off at a range of 50 feet from spacecraft 7. The rendezvous phase of the mission was completed at 5:56:00 ground elapsed time when spacecraft 6 was 120 feet from spacecraft 7 and all relative motion between the two vehicles had been stopped.

Station keeping was performed at distances between 1 foot and 300 feet for about 3 1/2 orbits after which a 9 ft/sec separation maneuver was performed.

The relative motion of spacecraft 6 from the separation maneuver was stopped at a range of about 30 miles.

The spacecraft and its systems performed very satisfactorily throughout the mission, except for the delayed-time telemetry tape recorder which failed at 20 hours 55 minutes ground elapsed time because of a bearing seizure. This recorder malfunction resulted in the loss of all delayed-time telemetry data for the remainder of the mission.

The flight progressed nominally to its full duration. All checklists and stowage were completed in preparation for retrofire and reentry and the reentry control system was activated. Retrofire occurred exactly on time at 25:15:58 ground elapsed time for a landing in the West Atlantic landing area (primary). The reentry and landing were nominal, and the landing point achieved was less than 7 nautical miles from the planned landing point. The crew remained in the spacecraft until the spacecraft had been secured on the deck of the recovery ship.

[pp. 2-1 through 7-17 not included]

[7-18]

7.1.2.3 <u>Rendezvous Phase</u>.-

7.1.2.3.1 Radar acquisition of spacecraft 7: At approximately 3 hours g.e.t., the ground update for acquisition of spacecraft 7 was received as an attitude of or yaw and 5.50 pitch up. The ground controllers also indicated that the initial computer readout of range (248 nautical miles) would occur at 3 hours 15 minutes g.e.t. The [7-19] radar was turned on in the standby position at approximately 3 hours 5 minutes g.e.t. The analog meter indication cycled exactly as predicted, and the range and range rate indications oscillated until the set warmed up. The radar was then placed on "ON".

The first radar-range readout on the MDRU was 248.66 nautical miles, which is the maximum range readable. At this time, the radar lock-on light was flickering. The radar lock-on became steady at 246.22 nautical miles, At that time, a radar test was performed with the rendezvous mode of the computer to verify the interface and sequencing of the computer and the radar. This radar-computer test was not conclusive in that the specified 130° angle of orbit travel to rendezvous (wt) was not inserted and the last wt that was loaded was 180°, which had been used for a prelaunch test. Subsequent to the N_{SR} maneuver and the final switching to the rendezvous mode, the correct value of wt (130°) was loaded. The computer cycled properly, holding the range in the register for 100 seconds, and the IVI's corresponded to the computer readout of total-velocity-change for rendezvous. The initial-velocity-change for target intercept was also noted, and the values were found to be decreasing as range decreased. The event timer was synchronized with the initiation of the N_{SR} maneuver. Four minutes after initiation of the N_{SR} maneuver, the computer was switched to the rendezvous mode and continuously monitored by the pilot. A time synchronization revealed that the event timer was approximately 7 seconds ahead of the computer time sequence (for 100-second intervals). The event timer was resynchronized with the computer-time and counted correctly throughout the remainder of the run. After the NSR maneuver, the range was approximately 169 nautical miles. The pilot did not record anything on the data sheet until the values began to match the nominal values at approximately 136 nautical miles range. After that, the values were recorded and data points were frequently called to the ground. The computer solution for the total-velocity-change for rendezvous was very close to nominal. The target-centered coordinate plot (see fig. 7.1.2-1) [not included] showed that the NSR maneuver had placed spacecraft 6 into the nominal trajectory and that the maximum deviation was approximately 0.25 mile high with no ellipticity. During this time, the elevation and azimuth pointers were oscillating approximately ±1.5° from the electrical null. The period of the oscillation was approximately 4 seconds. As the range decreased to 97 miles, there was a noticeable reduction in the amplitude of the oscillation; however, the period remained constant. It should be noted that both the azimuth and elevation readings crossed the null point simultaneously during these oscillations. At a range of 79 miles, all pointer oscillations ceased and remained steady throughout the remainder of the rendezvous operation [7-20] and down to a range of 20 feet. The radar data were continually being plotted and computations made as spacecraft 6 approached the point of terminal phase initiation.

7.1.2.3.2 Visual acquisition: Visual acquisition of spacecraft 7 occurred at 5 hours 4 minutes g.e.t., 54 miles slant-range from spacecraft 6 to spacecraft 7. The target vehicle appeared as a bright star, 0.50 to the right of the boresight line on the optical sight. The target appeared brighter than the star Sirius, and during postflight comparisons, the flight crew believed it was probably brighter than the planet Venus. The target stayed in sight because of reflected sunlight until 05:15:56 g.e.t., or for approximately 12 minutes. Spacecraft 7 was lost in darkness about 3 minutes prior to the transfer thrust, at a range of approximately 30 miles. The crew, however, could have determined a backup solution during the programmed tracking period prior to transfer, and would have been able to perform the maneuver without visual contact.

7.1.2.3.3 Terminal phase: During the terminal phase, the crew used the data provided by the IGS (closed-loop) to perform all maneuvers. However, the pilot did make all backup computations for each maneuver in order to compare them with the results of the closed-loop solution. The target-centered coordinate plot revealed very quickly that the relative trajectory was near nominal and that the transfer thrust would be very close to the planned value of 32 ft/sec along the line of sight. For the backup procedure, the component normal to the line of sight was determined from the time change of the total pitch angle. The ground solution, transmitted from Guaymas, indicated that the value was 31.5 ft/sec. The initial time transmitted to the flight crew for the initiation of the terminal phase was 05:16:54 g.e.t. A short time later this was refined to 05:18:54 g.e.t. The onboard computer solution gave a thrust time of 05:18:58 g.e.t., 4 seconds later than that computed on the ground.

As the point of terminal phase initiate approached, it became evident that the exact- time to initiate the maneuver would be near the halfway point between two of the computer solutions that are 100 seconds apart. At this point the crew discussed the situation and decided to take the second of these solutions, if it still met the basic criteria. This decision was made to insure that transfer would occur from a position that would place spacecraft 6 forward and below spacecraft 7 at final rendezvous, and that braking would occur slightly later than nominal rather than earlier. This was the crew's approach to being conservative with respect to the lighting conditions during the braking maneuver in that, being slightly later, it would insure that the target would be in daylight during the final approach. A pitch angle to spacecraft 7 of 20.8 deg was selected for terminal phase initiate at a range of 41.06 nautical miles. At this time the START COMP button was pressed, [7-21] and the initial computer solution produced a value of 31 ft/sec forward, 7 ft/sec up (this value later decreased to 4 ft/sec up at the time of thrust), and 1 ft/sec right. The backup solution was computed to be 23 ft/sec forward and 2 ft/sec up, and a notation was made of this anomaly. The crew discussed the problem and decided that if a backup maneuver had been necessary they would have applied the nominal thrust of 32 ft/sec. This decision was reached because of the nominal trajectories that were indicated, up to that point, on the onboard target centered coordinate plot. In case the radar or computer had failed, the thrusts that would have been applied were those necessary to achieve changes in velocity of 2 ft/sec up and 32 ft/sec forward.

After completion of the transfer thrust, the fuel remaining was 62 percent. At this point, the time system was reset to zero based on the beginning of the first computer time cycle that occurred 270 seconds after depressing the START COMP button (nominally, this time coincides with the end of the transfer maneuver). The crew used this phase elapsed time (p.e.t.) as a time reference through final rendezvous. The target was not in sight during the tight-tracking period from 3 to 5 minutes after the transfer maneuver. During the 3-to-5 minute tight-tracking period, the analog range rate was 160 ft/sec at 3 minutes 30 seconds p.e.t. Computations from the onboard computer showed

156 ft/sec. At 4 minutes 30 seconds p.e.t., range rate from the analog meter was 155 ft/sec, and the computer value was 152 ft/sec. These comparisons show the close agreement between the analog meter readout and the computer solution and provided the crew with high confidence in the radar-computer interface.

At 5 hours 23 minutes g.e.t., during the 3-to-5 minute tight-tracking period, spacecraft 7 lights were barely visible and not sufficient for tracking. This time corresponds to a range of approximately 24 miles.

Subsequent to 5 minutes p.e.t., the spacecraft was pitched down to horizontal, using the direct attitude-control mode, to align the platform. It was decided that alignment would be conducted during the planned optional alignment period, from 5 minutes to 10 minutes p.e.t. This decision was based on the fact that 1.5 hours had elapsed since the last alignment. During this alignment period (with the platform in SEF, the control mode in pulse, and the flight director indicator displaying platform and attitude), very little motion was detected in the pointers, indicating that the platform had been in good alignment. In addition, the optical sight and the visible horizon also indicated good alignment before starting the align period. This excellent performance of the platform provided the crew with further confidence in the spacecraft 1GS system. At 10 minutes 20 seconds p.e.t., direct control was selected and the spacecraft was pitched back up in order to track spacecraft 7. The radar lock-on light had not extinguished;

therefore, lock-on was continuous during the alignment period. The radar was nulled on [7-22] the target, and the target lights appeared very dim in the sight at this time. The target lighting was evaluated as sufficient for subsequent tracking and angular measurements.

At this time, an estimation was made, using the data entered on the target-centered coordinate plot, that the first midcourse correction would require slight forward and up velocities. The IVI's indicated 7 ft/sec forward, 7 ft/sec up, and 5 ft/sec left at a p.e.t. of 11 minutes 40 seconds. This p.e.t. corresponds to 5:31:31 g.e.t. After the midcourse correction thrust was applied, the IVI read zero in all axes. A second tight tracking of the target was required again between 15 minutes and 17 minutes p.e.t. It was not difficult to observe the docking light on the target spacecraft at this time. The acquisition lights did not show clearly, but they could have been tracked for backup solutions from approximately 12 minutes after the transfer maneuver through final rendezvous.

During the second period of tight tracking, the range rate was noted from the analog meter at 15 minutes 30 seconds p.e.t. and indicated 90 ft/sec. The computer data gave a range rate at this time of 91 ft/sec. At 16 minutes 30 seconds p.e.t., the analog meter indicated a range rate of 85 ft/sec and the onboard computed range rate was also 85 ft/sec. At 17 minutes p.e.t. the range to the target was 7.7 nautical miles. After this data point was obtained, the desired velocity changes in guidance axes were zeroed in the computer, and tight tracking was maintained for a period of 3 minutes to determine the backup solution for a normal-to-the-line-of-sight correction. The command pilot remarked that the spacecraft 7 docking light was as bright as the Agena. At 16 minutes p.e.t. (5:35:51 g.e.t.) the pilot remarked that he could see the docking light even though he had a brightly lighted area in the cockpit.

The docking light on spacecraft 7 was displaced 0.50 to the right of the zero position in the optical sight, while using the radar null as the pointing command. Farther to the left, approximately 100, two bright stars, Castor and Pollux, were in sight. These stars provided excellent pitch, roll, and yaw reference. In addition, there were sufficient stars near and around the target to permit good tracking. It was also noted that the docking light obscured the acquisition lights because of its relatively greater brilliance. However, the spacecraft 6 crew requested that the spacecraft 7 docking light be left on.

The target-centered coordinate plot indicated that small up and forward corrections would be required for the second mid-course correction. The backup solution indicated 6 ft/sec up. No backup velocity correction along the line of sight could be obtained because the computer math flow locked out ranges at this time. At 23 minutes 40 seconds p.e.t., the computer solution gave a correction of 4 ft/sec forward, 3 ft/sec up, [7-23] and 6 ft/sec right. When this maneuver was completed, the IVI was zeroed and the computer switched to the catchup mode. The pilot then cleared MDRU addresses 25,26, and 27 (X, Y, and Z, desired velocity changes in guidance axes) and the IVI displayed all zeros.

From this point, the pilot continually called out the pitch angle to spacecraft 7 as it increased and the range decreased. The command pilot, at this point, acquired a very good star pattern to maintain a celestial line of sight. Very little motion was discerned during this period. The target-centered coordinate plot indicated a flight path that was forward of and nearly parallel to the nominal trajectory. At one point, the pilot stated that it appeared as if the target were going *up;* however, the command pilot decided not to make any changes at that time. At a range of 2 miles it again appeared from the pilot's plot that the target was going *up* a small amount, but there was no apparent motion in relation to the star background. At 5 hours 46 minutes g.e.t., no relative motion was observable. The range rate was approximately 42 ft/sec, and at 05:48:11 g.e.t., the target appeared to start moving down a small amount but this relative motion was stopped. At this point, the START COMP button was pressed. This caused all subsequent changes in velocity to be displayed in cumulative totals. At 05:49:06 g.e.t., both the command pilot and the pilot noted that the reentry control system (RCS) heater light came on at the telelight panel. This was at a range of 1 mile. This indicates that the panel was observable to the crew during this critical period. The total pitch angle, from 1.30 nautical miles into station keeping at 120 feet, was approximately 125°.

7.1.2.3.4 Braking maneuver: During the terminal phase a combination of radar display and optical tracking was utilized by the command pilot with the platform continually in orbital rate. The target held steady on the indicator throughout the terminal phase maneuver. At 05:49:41 g.e.t., the command pilot remarked that the docking light was quite bright, and the pilot noted the same thing.

At 0.74 mile range (05:49:58 g.e.t.), the pilot noted that the target appeared to be moving down. This comment was prompted as a result of seeing sunlight reflected off frost particles leaving spacecraft 6 and confusing them with stars. Spacecraft 6 was approaching the BEF attitude (spacecraft 6 was 30° beyond the local vertical). The ballistic number of these particles was such that they trailed the spacecraft, tending to move upward toward the nose of the spacecraft. As the crew observed the frost particles, they appeared to go up in relation to this apparent star field. There were stars still visible beyond these bright particles and these stars confirmed that the target was not moving in relation to the stars. This illusion for the pilot developed from the lighting conditions in the right crew station. This side of the cockpit was lighted sufficiently to permit the pilot to record data and work with the computer throughout this period. As a result, when [7-24] he made an out-the-window observation, he could not see the stars, and the particles appeared as stars to him. (This could have resulted in additional fuel expenditures if both the command pilot and the pilot had reacted identically.) At 0.48 mile range, the crew started decelerating spacecraft 6 from a closing range rate of approximately 42 ft/sec. During this period, there appeared to be no out-of-plane motion. As the braking continued, the velocity was reduced in a continuous thrust. The command pilot peered behind the black shield on the vernier scale until the pointer for range rate just appeared, having determined in the training simulator that this represented approximately 7 ft/sec. At this point, thrust was terminated and the range was approximately 1200 feet. The target had dropped slightly and a downward thrust was also added. At 800 feet range, 32 minutes after the translation maneuver, the closing velocity was approximately 6 ft/sec and the IVI's were cleared. The cumulative velocity changes at this point read 27 ft/sec aft, 14 ft/sec left, and 7 ft/sec down.

The total distance encompassed during the braking maneuver was 0.24 nautical miles (from 0.48 to 0.24 n. mi. from the target). When the range was 0.20 nautical miles, the pilot called the range to spacecraft 7 in feet to the ground and to the command pilot.

At a range of approximately 700 feet, the sunlight illuminated spacecraft 7 and the target was so bright that no stars were visible. The total impact of the brightness was as if a carbon arc lamp had been turned on immediately in front of spacecraft 6. The range decreased nominally, during which time both the pilot and command pilot continually commented on the brightness of the target. Because of the brightness, the radar display and the flight director attitude indicator (FDAI) were then used for tracking. As spacecraft 6 approached a range of 300 feet from spacecraft 7, the pitch angle decreased to 90° and held that value. Spacecraft 6 then continued to approach from directly below spacecraft 7.

At 240 feet, all rates in translation, except the closing velocity, had been reduced to zero. The closing velocity was being reduced by a series of small thrusts to approximately 2 ft /sec. Finally, at a range of 120 feet, all relative motion between the two spacecraft was stopped at approximately 36 minutes after the translation maneuver.

The final braking maneuver was difficult because of (1) the brightness of the reflected sunlight from the target at a range of approximately 700 feet, and (2) the fact that the crew could no longer use stars as a reference. Also, the target spacecraft was changing pitch attitude in order to track spacecraft 6 and, as a visible object, could [7-25] not be used for attitude reference with relation to motion in a pitch maneuver of spacecraft 6.

A very low, relative translation rate remained near the end of the braking maneuver. Spacecraft 6 had moved from a pitch angle of 90° to a pitch angle of 60° by the time the forward relative velocity was reduced to zero. The crew elected to continue this motion at a 120-foot radius, pitching down to the SEF attitude, and holding this position. At this point, spacecraft 6 was in the SEF position, with spacecraft 7 facing it in BEF, and all relative motion was stopped. The attitude control system was placed in SEF platform control mode, and all maneuvers were then performed with the maneuver controller.

The performance of the guidance and control system and radar system during all phases of rendezvous was excellent and the use of radar for rendezvous was shown to be extremely valuable. Throughout the rendezvous phase, the radar maintained positive lock-on and an accurate indication of range was available through the minimum readable value of 60 feet. The attitude indications were steady throughout the entire maneuver.

7.1.2.4 Station keeping.- From the crew's analysis of the timing, spacecraft 6 arrived in formation with spacecraft 7 about 23 seconds earlier than predicted prior to lift-off. In the SEF attitude, the distance between the spacecraft was closed to approximately 6 to 10 feet in order to observe spacecraft 7 in detail. Still photographs and motion pictures were taken and all exposure values were determined with the spot meter. The results of this photography indicate that a spot meter is a valuable aid in photographing objects in space. Initially, station keeping was accomplished in platform mode with minute thrust motions made with the maneuver controller. Shortly after the start of station keeping, the sun striking the command pilot's window completely obscured his view of spacecraft 7. The pilot gave voice positions of the target, and finally, control was passed to the pilot for approximately 1 minute until the spacecraft moved out of this sun angle. (This effect will continue to be a problem for station keeping.) The crew did not elect to do the in-plane fly-around at this point because they wanted to determine the composition of the strap observed hanging from the adapter of spacecraft 7. Shortly thereafter, the Gemini VII crew informed the Gemini VI-A crew that they also had a strap hanging from their adapter. This subsequently was determined to be part of the shaped charge holders. (See section 5.1.9.) [not included]

During the final portion of the first daylight period, station keeping was conducted in platform mode and finally in pulse mode when it was determined to be an easy task. Spacecraft 6 closed to about 1 foot, nose to nose with spacecraft 7, and it was concluded that [7-26] docking would not present any problems. It was also noted during this period that one spacecraft could influence the horizon scanners of the other spacecraft.

During the first night period, station keeping was maintained at ranges varying from 20 to 60 feet and the spacecraft were nose to nose. During the transition from daylight to night, the blurred horizon caused the scanner to lose track; therefore, orbit rate was selected prior to entering this period to avoid any transients that might occur during the period of scanner loss. Station was maintained by first using the docking light and platform mode, then with the docking light and pulse mode, then without the docking light and using the illuminated windows of spacecraft 7 as a reference. During a subsequent night pass, an out-of-plane position was encountered where the crew could not see the window of spacecraft 7. The hand-held penlights were then utilized to illuminate spacecraft 7 at a range of approximately 30 or 40 feet. The crew determined that they had sufficient lighting for station keeping. The most efficient way to conduct station keeping was to maintain station in horizon scan mode, letting the spacecraft drift in yaw. The recommended position for maintaining station is in the out-of-plane position, rather than trying to maintain station above or below the spacecraft. This provides a visual aid in that the horizon relative to the target permits holding pitch and roll relatively steady in the horizon scan mode.

During the second daylight period, spacecraft 7 was scheduled to perform an experiment and conduct a small amount of station keeping. To provide a fixed target for the D-4/D-7 experiment, spacecraft 6 was moved to a nose-to-nose position, 20 feet from spacecraft 7. The amount of fuel remaining in spacecraft 7 did not permit more than about 2 to 3 minutes of station keeping, and both the command pilot and pilot maneuvered o the nose of spacecraft 6 or this period. Subsequent to the station keeping performed by spacecraft 7, spacecraft 6 again picked up the nose position and the command pilot initiated an in-plane fly-around.

The in-plane fly-around was conducted for 20 minutes starting at 7 hours 42 minutes g.e.t. The pilot conducted an out-of-plane fly-around for 11 minutes starting at 8 hours 10 minutes g.e.t.

The command pilot, during the in-plane fly-around, allowed the range between the two spacecraft to increase to an estimated 300 feet. The relative position of spacecraft 6 at that time was above spacecraft 7, and slightly to the rear. This distance appeared to be excessive for proper station keeping and the range was quickly reduced to less than 100 feet. The radar system was not used during the station-keeping period. These ranges were determined both by visual observation in relation to the 10-foot diameter of the spacecraft as viewed through the [7-27] optical sight during the flight and by measurements after the flight of photographs taken with known optical systems.

It is recommended that station keeping not be conducted in-plane above or below the target. The ideal condition for station keeping is SEF or BEF in platform mode; however, station keeping can easily be conducted out-of-plane at ranges up to 60 or 80 feet without losing the perceptive cues that pilots have learned to recognize in formation flying with aircraft.

The smallest distance between spacecraft 6 and spacecraft 7 during station keeping was approximately 1 foot, and both the command pilot and pilot flew at this distance with great ease. This, of course, greatly enhanced the crew's confidence in the control system for subsequent station-keeping operations. The control-system response can be described as perfect. The torque-to-inertia ratios of the attitude control system using the pulse mode, and thrust-to-inertia ratios of the translation system using minute inputs, were excellent for the station keeping performed during this mission. Docking with a target vehicle could have' been easily executed by applying a small burst of forward thrust from the l-foot range.

Document I-70

[CONFIDENTIAL] [DECLASSIFIED]

GEMINI VIII

TECHNICAL DEBRIEFING

March 21, 1966

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

MANNED SPACECRAFT CENTER

HOUSTON, TEXAS

PREFACE

This preliminary transcript was made from voice tape recordings of the Gemini VIII flight crew debriefing conducted by Captain Schirra immediately after crew recovery, March 18, 1966.

A subsequent debriefing was conducted at the Crew Quarters, Cape Kennedy, Florida, by Mr. J. Van Bockel on March 19-20, 1966.

Although all material contained in this transcript has been rough edited, the urgent need for the preliminary transcript by missions analysis personnel precluded a thorough editorial review prior to its publication.

Note: The section covering the problem area encountered after docking and referred to as the Gemini VIII Self-debriefing is contained within Section 4.0, Orbital Operation.

[pp. 2-54 not included]

[55]

GEMINI VIII SELF DEBRIEFING

Armstrong:

Okay. Approximately 7 hours 00 minutes in the flight plan, we were in configuration to perform a Platform Parellelism Check and had just completed the yawing of the Agena-Spacecraft combination to spacecraft BEF position, 0-180-0. We were on the night side. We had docked at approximately 6:34, and that was just a couple of minutes into the night side, or thereabouts. In the Flight Plan – at the position where we were sending command 041 with the computer already set up with Addresses 25, 26, and 27 inserted. At the time, the Flight Plan was on the left-hand side and I was reading the commands to Dave, and, at the same time, was working on restoring the cabin into a better configuration after just recently completing the Post-docking Checklist. Then Dave reported that there was some kind of divergence. How did you remember that, Dave?

Scott:

Well, we had just finished putting the commands in, and the next thing on the Flight Plan was to start the Agena recorder. I had just sent 041 command to the Agena and written down the time at which the recorder started. I looked up and saw the Spacecraft-Agena [56] combination starting a roll. With no horizon, it wasn't apparent until I happened to glance at the ball and I didn't really feel it at first. I called Neil and he suggested turning the ACS off. I turned it off as fast as I could and also in a short period of time turned off the Horizon Sensor and the Geo Rate to give spacecraft control to the combination.

Armstrong:

I would agree that I could not feel the angular acceleration either. We had the lights up in the cockpit and could not really see outside, since it was night and we had no horizon reference. My initial notice of the acceleration was an increase in rates and attitudes on the attitude ball.

Scott:

Yes. That was my same indication. With no horizon at all, and it was hard to tell unless you looked at the ball.

Armstrong:

Since we expected the SPC-loaded yaw maneuver to come sometime within the next 10 minutes and the spacecraft was essentially inactive with the OAMS Attitude Control Power off, it seemed as though the trouble was probably originating with the Agena Control System. So, I turned on the Attitude Control Power, went to RATE COMMAND (we had previously been in PULSE) and attempted [57] to stabilize the combination. It was my impression that after some period of time, perhaps less than a minute, we essentially had the combination stabilized. But, when we'd let go of the stick, we would again start to accelerate.

Scott:

And, at some point in there when we had almost stabilized the combination, we sent a command to disable the SPC maneuver, too.

Armstrong:

That is correct. We were at the ….

I guess I read that command out of the book. 340 I think it was, or something - - S240.

Scott:

Whatever it was, and I checked it in on the card.

Armstrong:

Right. SPC Disable. Then, noting that the combination was still accelerating and desiring to stop the Agena Control System, we suggested trying to cycle the ACS on in case we could find its Rate Command operative again and help stabilize the combination. We did not see any improvement and later cycled ACS back off. In the meantime, we had sent Power Relay Reset, which I think is 271.

Scott:

Right. Okay. I think the next thing we both commented on was being able to see the ACS thruster gas, or some gas coming out of there, out of the Agena. [58]

Armstrong:

This is correct. Since we were approaching a lit horizon, as we would rotate our line of vision through the horizon we could see the cones of ACS thrust coming out of the Agena pitch thrusters. And they appeared to be on full time to me, at the times I could see them.

Scott:

Yes, I agree. And it was about a 40-degree spread, about 25 feet long.

Armstrong:

That's right. A wide cone that was illuminated by the sunlit horizon or air glow. Okay, we noted at that time that the gas pressures on the Agena were down to approximately 20 percent.

Scott:

Right.

Armstrong:

And we realized then that indeed the ACS was losing gas at a fast rate, either because of a leak or because of all thrusters firing simultaneously. We also had excessive OAMS propellant usage and I called out when we went through 30 percent OAMS propellant on the Propellant Quantity Indicator. At this time, we felt there was some possibility of a spacecraft control system problem at the same time, so we initiated procedures to check out the OAMS system and tried turning the Bias Power off. That did not stop the [59] accelerations. We turned the Motor Valves off and this did not have any apparent affect either. We turned the Attitude Control Power on and switched Bias Power drivers logic and, we think, switched the roll logic to the pitch thrusters.

None of these actions had any apparent affect, and we were simultaneously, whenever possible, trying to use the thrusters to reduce the rates. We never, however, were able to reduce the rates in any axis completely. It was obvious at this time that the only satisfactory way for diagnosing the control system was undocking the vehicle so that we could disengage possible Agena problems from possible spacecraft problems. To do so, we had to get the rates of the combination down to a value that was suitable for undocking with some assurance that we would not have a recontact problem. We, of course, had to have the OAMS on to reduce these rates and it took us quite a bit of time to get the rates down to a value that we both agreed would be satisfactory to try a release. Upon mutual agreement, Dave undocked with the use of the Undocking Switch and I used the forward-firing thrusters to back away from the Agena as quickly as possible, using about [60] a 5 second burst. We did not have excessive rates at separation. What would your analysis have been there, Dave?

Scott:

Yes, it looked like a clean separation to me with very low relative rates, and we backed straight off a good 4 or 5 feet before we started tumbling there and lost sight of the Agena. I might add that before we backed off I sent L-Band ON and UHF Enable to the Agena.

Armstrong:

Shortly after backing off, we noticed that we were essentially losing control of the spacecraft in roll and yaw and we suspected that we were over the life-time of these attitude thrusters. The spacecraft was continuing, however, to accelerate, and we were obtaining rates in roll at least that approached 200 to 300 degrees per second, or perhaps more.

Scott:

Yes, I would agree with that. It looked like even more to me, and it was by far more in roll than in yaw. The roll was the most predominate.

Armstrong:

We realized that physiological limits were being approached, and that we were going to have to do something immediately, in order to salvage the situation. So, we turned off all the OAMS thruster circuit breakers, closed the Attitude Control Power Switch, [61] closed the Motor Valves, armed the RCS, had no effect using the ACME, and went to DIRECT.

Scott:

I might add in there that the rates were high enough that both of us had trouble seeing the overhead panel due to the vertigo problems and the centrifugal force as we went around.

Armstrong:

The RCS DIRECT DIRECT was working satisfactorily and as soon as we determined that we were able to reduce the rates using this mode, we turned the A-Ring OFF and reduced the rates slowly with the B-Ring, putting in a pulse to reduce the rate, then waiting awhile, then putting in another pulse, and so on until the rates were essentially zero in all areas. At this time we carefully reactivated the OAMS, found some popped or inadvertently manually actuated circuit breakers, OAMS control and so forth. Upon reactivating the system we found that the Number 8 thruster was failed on, so we left that circuit breaker off. We had no other yaw thrusters with the exception of Number 8 but the pitch was apparently starting to come back in and we ensured that the roll logic was in pitch. We stayed in PULSE, controlling the spacecraft with pitch and roll pulses then to essentially a BEF attitude. [62]

Scott:

Do you want to add in there about the hand controller, in not getting anything?

Armstrong:

Yes. When I earlier referred to the fact that I'd lost control completely it appeared to us as though at that time we had no control out of the hand controller in any axis. I might reiterate that we reactivated the OAMS and found no roll or yaw control with the Number 8 circuit breaker off but pitch was slowly coming back then. It was somewhat ineffective at first, but it was usable after awhile. Sometime later we saw the Agena, approximately a half to a mile below us for a short period of time in daylight. It did not have excessive pitch and yaw rates at this time, nor did it appear to be tumbling end over end. However we were too far away to determine whether there were any roll rates involved in the Agena.

Scott:

Yes, I agree. It went by pretty fast. We did get to see it wasn't tumbling, but it was hard to tell exactly what attitude or rates it had.

Armstrong:

Sometime later, when preparing for retrofire, we were asked by the ground whether we had identified the proper operation of the Reentry Rate Control System. So, in checking that system out, we found that we had [63] regained some yaw control at this time, and guessed at the time that those thrusters may have been cooling down to the point where we were once again getting thrust out of them. So, we used the OAMS then in all three axes to align the platform for retrofire.

Scott:

You might add that the camera was on there during the undocking at some unknown setting.

Armstrong:

Roger, we did have the camera on during this time period – the 16 millimeter camera—but we, of course, could not take time to check the settings, and we could not identify at this time whether it was set for daylight or darkness, or for what configuration. That film may or may not come out. [64]

Scott:

One thing we might add on the stability of the combination – as far as bending we didn't notice any oscillations on the docking or post-docking between the two vehicles after TDA Rigidized. Also during the rolling and yawing maneuvers, when we had the problems with the Agena and spacecraft, I don't believe we noticed any oscillations or bending between the two vehicles. It seemed to be a pretty firm attachment.

Armstrong:

I am certain that we put fairly sizeable bending loads on the combinations as a result of the inertial loads and also the thruster loads which were long time duration and in all sorts of combinations out of both the OAMS and the Agena ACS. There certainly was no evidence of any relative motion between the Agena and the spacecraft or any noticeable deflections of any sort. After being informed by the ground that they were considering a 6-3 landing area, we realized that we had a reasonably short time to get reconfigured from the stowage point of view to an entry configuration. We immediately started to prepare for that possibility. This involved the restowage of the cameras first. (Both our right and left boxes were not yet opened so they did not pose a problem).

Document I-71

Document Title: NASA, "Gemini Contingency Information Plan," 11 May 1966.

Source: Folder 18674, NASA Historical Reference Collection, NASA History Division, NASA Headquarters, Washington DC.

Given the inherent riskiness of spaceflight, NASA officials understood that the potential of loss of spacecraft and crew during flight existed. What should be done if this were to happen? The first order, they found, was to impound all technical and other types of data relating to the mission to help reconstruct how and why a failure had occurred. A second action required obtaining statements from all individuals involved in the mission, which would probably be only preliminary to more detailed debriefings to follow. The third step, and one that was virtually as important as these others, required the management of the flow of information to the public and other parties around the world. This plan, one of several prepared prior to 1966 and similar to but less elaborate than those still in use by NASA for more recent missions, seeks to ensure the appropriate release of details and the management of information to the media and others.

GEMINI CONTINGENCY INFORMATION PLAN

MAY 11, 1966

[i]

Although extremely unlikely, situations may occur which could result in aborting a manned mission.

Attached are suggested plans of action should a contingency occur.

Coordination by the Department of State with other governments, should it be necessary, is covered in a DOS airgram of March 9, 1965, to appropriate posts.

NASA will remain the prime source of public information throughout all contingency situations, with support from both the Department of Defense and the State Department.

[ii]

INDEX

[1]

PAD OR CLOSE-IN ABORT

Should an abort occur, the crew would be located and immediately transported to the Bioastronautics Support Unit (BOSU) at Cape Kennedy.

When the Mission Director or the Flight Surgeon (in Mission Control Center-Houston) is advised of the crew's physical condition, he will immediately notify the Gemini Information Director.

Operating Plan

1. Applicable portions of Plan A will be initiated.

2. The White House, State Department, and Department of Defense Public Information Offices will be kept advised of the situation by means of a conference telephone call initiated by the NASA Headquarters Public Information Director or the Senior NASA Public Information Officer present.

3. Two Public Information Office representatives will escort a news-pool team from the Cape press site to BOSU. Upon arrival, one will establish immediate telephonic communications with the Public Information Director at the Mission Control Center-Cape or Houston, the other with the Gemini Information Director and the Director, Public Information.

4. As soon as feasible and with approval of the Assistant Administrator for Public Affairs or his designee, [2] announcement will be made of the time and site of a news conference which will include applicable personnel as recommended by the Gemini Information Director.

[3]

IN-FLIGHT CONTINGENCY

1. The Gemini Information Director and the NASA Mission Commentator will be kept current on any in-flight contingency by means of monitoring applicable circuits and/or being advised of the situation by the Mission Director and/or the Flight Surgeon.

   a. The White House, State Department, and Department of Defense will be kept advised of the situation by the NASA Headquarters Public Information Director or the Senior NASA Public Information Officer present.

   b. The NASA Mission Commentator will issue periodic releasable statements advising the press of the situation.

2. When a probability of crew fatality or serious injury is indicated the portion of Plan A covering family notification will be activated.

3. The Prime Recovery Zone Senior Public Information Officer will release information regarding crew condition to the news-pool team following coordination with the Gemini Information Director or his designee.

[4]

CONTINGENCY SITUATION IN PRE-DESIGNATED LANDING ZONES (OTHER THAN AREA OF PRIME RECOVERY VESSEL)

1. The NASA Mission Commentator will be kept current on crew and spacecraft status by monitoring applicable circuits and/or being advised of the situation by the Mission Director, the Flight Surgeon and/or the Recovery Zone Public Information Officer.

   a. The White House, State Department, and Department of Defense will be kept advised of the situation through a conference call initiated by the NASA Headquarters Public Information Director or the Senior NASA Public Information Officer present.

   b. Appropriate NASA officials will be alerted to the situation by the Gemini Information Director.

   c. The NASA Mission Commentator will issue periodic and timely statements advising the press of the situation.

2. The Prime Recovery Zone Senior Public Information Officer will release information regarding crew condition to the news-pool team following coordination with the Gemini Information Director or his designee.

[5]

CONTINGENCY SITUATION IN OTHER THAN PRE-DESIGNATED LANDING AREAS

The purpose of this section is to provide guidance and direction for Department of Defense Public Information Officers and other Department of Defense and NASA personnel in the event the astronauts make a contingency landing anywhere except in the pre-designated landing areas.

While NASA will immediately dispatch public information representatives to such an area, it is recognized that, for a limited period of time, Department of Defense or NASA personnel may be the only representatives of this government at the scene.

According to the provisions of the "Overall Plan, Department of Defense for Project Gemini Operations," dated November 7, 1963, Section IX, 4b, "when a contingency recovery operation has been initiated, acknowledgement may be made subject to the condition that NASA has made the initial announcement that reentry and landing operations have been initiated. Any other responses to news media will be based upon instructions forwarded through operational communications channels on the basis of particular circumstances involved. Contingency recovery communications channels are the appropriate operational communications channels for this purpose as long as those circuits are maintained in operational status."

It is recommended that the above quoted provisions be applicable to any landing area except the planned landing areas.

In the absence of NASA Information Officers, Department of Defense personnel on the scene will initiate and maintain communication on a priority basis with the Public Information Officer for the Department of Defense Manager for Manned Space Flight Support Operations and will keep him informed of activities at the contingency landing site, including medical examinations and/or other debriefing activities. He will serve as a point of contact for the Gemini Information Director and relay public information [6] to the Department of Defense personnel on the scene.

Following NASA's announcement that the astronauts are being taken to a specific site, the Department of Defense Public Information Officer there may respond to news inquiries with approval of the Gemini Information Director.

Under no circumstances may he comment on the physical condition of the astronauts or the conditions which resulted in the termination of the flight, with the exception of certain cleared releases which have been forwarded through communications channels from the Mission Control Center.

In the event the astronauts' arrival at any installation precedes that of NASA Public Information personnel, the Department of Defense Public Information Officer may confirm the pilots have arrived on the base. With the concurrence of the Gemini Information Director, the Department of Defense Public Information Officer may authorize news media to photograph the arrival.

Upon arrival of NASA Public Information representatives, the Department of Defense Public Information Officer will be relieved of public information responsibility in connection with the specific mission. He may, however, be requested to assist in accommodating local news media.

As regards NASA personnel:

1. The Senior Recovery Zone Public Information Officer, after coordination with the Gemini Information Director, will issue periodic and timely statements advising the prime recovery news-pool team of the situation.

2. When a probability of fatality or serious injury is indicated, that portion of Plan A covering family notification will be activated. [7]

3. The Gemini Information Director and the Director, Public Information, will be kept current on such information as crew condition, destination, and ETA of the recovery vessel.

4. Public Information personnel designated by the Assistant Administrator for Public Affairs will proceed to the recovery vessel debarkation point.

[8]

GEMINI CONTINGENCY INFORMATION PLAN

(PLAN A)

1. Notification to pilots families by telephone

    a. D.K. Slayton, Assistant Director for Flight Crew Operations (MSC), will notify command pilot's family over an unlisted phone installed by the MSC Public Affairs Office in the home. Dr. Robert R. Gilruth, Director (MSC) will speak to the command pilot's wife following notification by Mr. Slayton.

    b. Capt. A.B. Shepard, Jr., Chief, Astronaut Office (MSC), will notify the pilot's family over an unlisted phone installed by the MSC Public Affairs Office in the home. Dr. Gilruth will speak to the pilot's wife after Capt. Shepard.

2. Suggested Statements:

    a. The NASA Headquarters Public Information Director will recommend to the White House that appropriate statements (as outlined in Attachment 1 herein) be issued.

    b. The Gemini Information Director will recommend to appropriate NASA officials that applicable statements (as outlined in Attachment 1 herein) be issued.

    c. The Department of Defense Manager for Manned Space Flight Support Operations or his representative(s) will recommend to the Department of Defense (Joint Chiefs of Staff) that applicable statements (as outlined in Attachment 1 herein) be issued.

3. Astronaut and flight-controller voice tapes bearing directly on the accident may be impounded pending an investigation of the accident. [9]

4. As soon as possible, the NASA Mission Commentator will confirm the contingency situation and crew condition to news media representatives and will announce that a news conference will be held as expeditiously as circumstances permit. He will also announce the initiation of a special investigation board.

   a. The Prime Recovery Zone Senior Public Information Officer and all other NASA Public Information Office personnel located at sites other than MSC will release information following coordination with the Gemini Information Director.

   b. The NASA Mission Commentator may include the following items in the announcement of a special investigation:

      i. The Mission Director has called a meeting with the following people for the purpose of establishing a special investigation board.

      ii. When chosen, the board will conduct an investigation which will be of a technical, fact-finding nature. Its intent will be to:

         1. Determine the sequence of events related to the contingency

         2. Seek to isolate initial hardware malfunction to system component part level

         3. Seek to determine the failure mechanism and physical cause of the failure

         4. Reproduce the failure in a laboratory if feasible.

[10]

DRAFT STATEMENTS

IN THE EVENT OF CREW FATALITY

(Attachment 1)

The President would contact the command pilot's and/or pilot's wife by telephone to express personal condolence.

President:

"I have conveyed to (______) and/or (______) and members of the (______) and/or (______) family (ies) my deepest sympathy.

"This nation—indeed, the world – owes (______) and/or (______) a great debt of gratitude. He/They gave his/their life/lives in the performance of one of the highest callings of this nation. He/They has/have also contributed immeasurably to the advancement of science and technology. I have been, and will continue to be, deeply impressed by his/their dedication to the nation's space program – his/their insistence that the advancement of manned space flight was a pursuit of the highest order which must be carried out despite personal risks involved.

"The United States of America will ever revere the spirit, dedication, and conviction of (______) and/or (______)."

Vice President:

"The death(s) of (______) and/or (______) in furthering a space flight program to which he/they has/have dedicated his/their many talents is a profound and personal loss to me. My heart goes out to Mrs. (______) and/or Mrs. (______) and her/their wonderful children.

"I propose that in his/their name(s) there be established a permanent scholarship for promising space science students to enhance the space exploration effort for which he/they gave his/their life/lives."

[11]

NASA Administrator:

"I have extended my sympathy and that of all employees of the National Aeronautics and Space Administration to the (______) and/or (______) family/families.

"The nation today feels a great sense of loss. That feeling is even greater among those of us who worked with that/those competitive young man/men who was/were so completely devoted to enlarging man's capability in space flight.

"We in NASA know that his/their greatest desire(s) was/were that this nation press forward with manned space flight exploration, despite the outcome of any one flight. With renewed dedication and purpose, we intend to do just that."

Secretary of Defense:

"We in the Department of Defense feel keenly the loss of this/these outstanding young officer(s). His/Their career(s) was/were extraordinary, bridging the jet age and the space age. His/Their work and dedication will forever serve as an inspiration to men who fly."

Secretary of the Air Force: Air Force provided.

Secretary of the Navy: Navy provided.

NASA/MSC Director:

"We of the NASA Manned Spacecraft Center feel the loss of (______) and/or (______) very personally. The other astronauts, program people, and I have known and worked with (______) and/or (______) day-in and day-out.

"I have already expressed our feelings to Mrs. (______) and/or Mrs. (______) in a phone call that I prayed I would never have to make."

[12]

Assistant Director for Flight Crew Operations:

"All of us on the astronaut team have lost good friends in wartime or in flight test work. It's part of the business, and we know that better than anyone else. (______) and/or (______) was/were something very special – (an) excellent pilot(s), (a) tireless worker(s), (a) first-rate engineer(s). He/They was/were (a) remarkable man/men."

IN THE EVENT OF SERIOUS PILOT INJURY

All official statements would note the hazardous nature of the work.

NOTE: All NASA officials called upon to make public statements would assure themselves that their statements reflect the on-going spirit of this nation's manned space flight program.

Document I-72

Document Title: Robert C. Seamans, Jr., Deputy Administrator, NASA, Memorandum for Associate Administrators, Assistant Associate Administrators, and Field Center Directors, NASA, "Gemini Program; Record of Accomplishments, Attached," 17 January 1967, with attached: "Project Gemini Summary."

Source: NASA Collection, University of Houston, Clear Lake Library, Clear Lake, Texas.

Document I-73

Document Title: "Gemini Summary Conference," NASA SP-138, 1–2 February 1967.

Source: NASA Collection, University of Houston, Clear Lake Library, Clear Lake, Texas.

The lessons learned from the Gemini program proved critical to the long-term success of Apollo and the larger cause of human spaceflight. The program succeeded in accomplishing what had *been intended for it from the outset, and then some. It demonstrated the capability of Americans to undertake long duration space missions. It provided the opportunity to develop rendezvous and docking techniques that served NASA's programs well into the future. It pioneered the ability to leave the spacecraft and perform work outside in an extra-vehicular activity (EVA). This knowledge is captured in summary form in these two important documents explaining the results of the Gemini program for both NASA engineers and the general public.*

Document I-72

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

WASHINGTON DC 20546

January 17, 1967

OFFICE OF THE ADMINISTRATOR

MEMORANDUM FOR Associate and Assistant Administrators

Field Center Directors

FROM: AD/Deputy Administrator

Subject: Gemini Program; Record of Accomplishments, attached

The Gemini flight program, concluded on November 15, 1966, succeeded in accomplishing all of its pre-planned objectives some of them several times over. As can be expected in any complex developmental-flight program, some of the individual flight missions experience difficulties. The successful demonstration that these difficulties could be overcome in later missions is a tribute to the program organization, personnel directly involved, and to NASA.

A summary of achievements of the program as a whole, a mission by mission recap of flight performance in terms of the Agency's pre-stated primary and secondary objectives for each mission, and, a table recapping the major flight systems and mission performance on each mission attempt, is appended on the attachment to this memo. This document has been reviewed and concurred in by the Office of Manned Space Flight and Public Affairs as containing valid information to serve as an official reference on Gemini accomplishments.

[Signed]
Robert C. Seamans, Jr.

Attachment

PROJECT GEMINI SUMMARY

FOR INTERNAL NASA USE AND OFFICAL GUIDANCE

With the splashdown of Gemini 12 with astronauts Lovell and Aldrin aboard on November 15, 1966, the Gemini Project came to a successful conclusion. All Gemini Project objectives, including Extravehicular Activity and combined vehicle maneuvers, which were added after the project began, were fully accomplished many times over.

Rendezvous: Ten separate rendezvous were accomplished, using seven different techniques ranging from visual/manual control to ground/computer controlled rendezvous.

Docking: Nine dockings with four different Agenas were performed.

Docked Vehicle Maneuvers: Both Gemini X and Gemini XI demonstrated extensive maneuvers and a new altitude record was set on Gemini XI when the Agena Target carried astronauts Conrad and Gordon 851 miles above the earth.

Extra-vehicular Activity: EVA was conducted on five separate Gemini Missions and during ten separate periods. Total EVA time during the Gemini Project was 12 hrs, 22 min. of which a record time of 5 hours and 37 minutes of EVA was performed by Aldrin on Gemini XII.

Long Duration Flight: Gemini VII demonstrated man's ability to stay in space continuously for up to 14 days; Gemini V for 8 days, and two other missions for 4 days.

Controlled Reentry: Landing accuracies of a few miles from the aim point were demonstrated on every Gemini manned mission except Gemini V.

Conduct Scientific and Technological Experiments: Every manned Gemini mission (Gemini III through XII) conducted many experiments. In total 43 experiments were conducted successfully.

Prior to each Gemini mission, individual primary mission objectives were selected which, if accomplished, would provide full advancement of the project. Accomplishment of these primary objectives were mandatory for stating the mission to be successful. To retain the flexibility to capitalize on success, secondary objectives were also assigned*– as many as appeared feasible within the capability of the equipment and the time and experience of the astronauts.

[2]

Of the 14 Gemini mission attempts, 10 missions accomplished all of the primary mission objectives specified before the launch. The four unsuccessful missions and the reasons why they could not accomplish all of their primary objectives follows:

UNSUCCESSFUL MISSIONS	REASONS
GEMINI VI	The Agena Target Vehicle exploded. The Gemini 6 spacecraft was successfully rendezvoused with the Gemini 7 spacecraft later during the Gemini VI-A mission.
GEMINI VIII	An Orbit Maneuvering Thruster malfunction which ruled out a stated primary objective: EVA.
GEMINI IX	An Atlas booster failure drove the Agena into the Atlantic, and the Gemini 9 spacecraft was not launched until later during the Gemini IX-A mission.
GEMINI IX-A	The shroud did not come loose from the Augmented Target Docking Adapter, precluding docking – a specified primary objective for the mission.

Gemini Launch Vehicles

The modified Titan launch vehicle used as the Gemini Launch Vehicle was 100 percent successful in the Gemini Project. Out of 12 launches, 12 successful vehicle performances were achieved.

Gemini Target Vehicles

Six Gemini Agena Targets were launched and four were successfully placed in orbit, rendezvoused and docked with. The Augmented Target Docking Adapter, launched as a back-up target for the Gemini 9 spacecraft to rendezvous and dock with, functioned properly; however, the shroud failed to separate, thereby making docking impossible.

* A listing of primary and secondary objectives accomplished by mission is attached [not included].

Document I-73

GEMINI SUMMARY CONFERENCE

February 1-2, 1967
Manned Spacecraft Center
Houston, Texas

1. INTRODUCTION

By George E. Mueller, *Associate Administrator for Manned Space Flight, NASA*

The Gemini Program is over. The papers in this report summarizing the program were prepared by some of the people who contributed to the overall success. In each case, the authors were actual participants and provide a cross section of what may be called the Gemini team. As is true in any undertaking of this magnitude, involving many diverse organizations and literally thousands of people, a vital element of the Gemini success may be traced to teamwork. In the purest definition of the word, wherein individual interests and opinions are subordinate to the unity and efficiency of the group, the Gemini team has truly excelled.

Much has already been written concerning the Gemini achievements, and many of the achievements are presented again in greater depth within this report. By way of introduction, and to set the stage for the following papers, a few words are necessary to assess the achievements in the context of the goals of the national manned space-flight program. Only in this way is it possible to evaluate the significance of the Gemini accomplishments.

The Gemini Program was undertaken for the purpose of advancing the United States manned space-flight capabilities during the period between Mercury and Apollo. Simply stated, the Gemini objectives were to conduct the development and test program necessary to (1) demonstrate the feasibility of long duration space flight for at least that period required to complete a lunar landing mission; (2) perfect the techniques and procedures for achieving rendezvous and docking of two spacecraft in orbit; (3) achieve precisely controlled reentry and landing capability; (4) establish capability in the extravehicular activity; and (5) achieve the less obvious, but no less significant, flight and ground crew proficiency in manned space flight. The very successful flight program of the United States has provided vivid demonstration of the achievements in each of these objective areas.

The long-duration flight objective of Gemini was achieved with the successful completion of Gemini VII in December 1965. The progressive buildup of flight duration from 4 days with Gemini IV, to 8 days with Gemini V and 14 days with Gemini VII, has removed all doubts, and there were many, of the capability of the flight crews and spacecraft to function satisfactorily for a period equal to that needed to reach the lunar surface and return. Further, this aspect of Gemini provides high confidence in flight-crew ability to perform satisfactorily on much longer missions. The long-duration flights have also provided greater insight into, and appreciation of, the vital role played by the astronauts, the value of flexibility in mission planning and execution, and the excellent capability of the manned space-flight control system. As originally conceived, the Gemini Program called for completion of the long-duration flights with Gemini VII, which was accomplished on schedule.

One of the more dramatic achievements has been the successful development of a variety of techniques for the in-orbit rendezvous of two manned spacecraft. The preparation for this most complex facet of Gemini missions was more time consuming than any other. That it was performed with such perfection is a distinct tribute to the Gemini team that made it possible: the spacecraft and launch-vehicle developers and builders, the checkout and launch teams, the flight crews and their training support, and the mission-planning and mission-control people.

[2]

The ability to accomplish a rendezvous in space is fundamental to the success of Apollo, and rendezvous was a primary mission objective on each mission after Gemini VII. Ten rendezvous were completed and seven different rendezvous modes or techniques were employed. Nine different dockings of a spacecraft with a target vehicle were achieved. Eleven different astronauts gained rendezvous experience in this most important objective. Several of the rendezvous were designed to simulate some facet of an Apollo rendezvous requirement. The principal focus of the rendezvous activities was, however, designed to verify theoretical determinations over a wide spectrum. Gemini developed a broad base of knowledge and experience in orbital rendezvous and this base will pay generous dividends in years to come.

A related accomplishment of singular importance to future manned space-flight programs was the experience gained in performing docked maneuvers using the target vehicle propulsion system. This is a striking example of Gemini pioneering activities – the assembly and maneuvering of two orbiting space vehicles.

The first attempt at extravehicular activity during Gemini IV was believed successful, and although difficulties were encountered with extravehicular activity during Gemini IX-A, X, and XI, the objective was achieved with resounding success on Gemini XII. This in itself is indicative of the Gemini Program in that lessons learned during the flight program were vigorously applied to subsequent missions. The extravehicular activity on Gemini XII was, indeed, the result of all that had been learned on the earlier missions.

The first rendezvous and docking mission, although temporarily thwarted by the Gemini VI target-vehicle failure, was accomplished with great success during the Gemini VII/VI-A mission. This mission also demonstrated the operational proficiency achieved by the program. The term "operational proficiency" as applied to Gemini achievements means far more than just the acceleration of production rates and compressing of launch schedules. In addition and perhaps more importantly, operational proficiency means the ability to respond to the unexpected, to prepare and execute alternate and contingency plans, and to maintain flexibility while not slackening the drive toward the objective. Time and again Gemini responded to such a situation in a manner that can only be described as outstanding.

A few comments are in order on what the Gemini accomplishments mean in terms of value to other programs. There is almost no facet of Gemini that does not contribute in some way to the Apollo Program. Aside from the actual proof testing of such items as the manned space-flight control center, the manned space-flight communications net, the development and perfection of recovery techniques, the training of the astronauts, and many others which apply directly, the Gemini Program has provided a high level of confidence in the ability to accomplish the Apollo Program objectives before the end of this decade. The Apollo task is much easier now, due to the outstanding performance and accomplishments of the Gemini team.

Similarly, the Apollo Applications Program has been inspired in large part by the Gemini experiments program, which has sparked the imagination of the scientific community. In addition to the contributions to Apollo hardware development which provide the basis for the Apollo Applications Program, it has been discovered, or rather proved, that man in space can serve many extremely useful and important functions. These functions have been referred to as technological fallout, but it is perhaps more accurate to identify them as accomplishments – that is, accomplishments deliberately sought and achieved by the combined hard labor of many thousands of people. Some of these people have reviewed their work in this report.

The Manned Orbiting Laboratory Program has been undertaken by the Department of Defense for the purpose of applying manned space-flight technology to national defense and is making significant use of the Gemini [3] accomplishments. This may be considered as a partial repayment for the marvelous support that NASA has received and continues to receive from the DOD. The success of the NASA programs is in no small measure due to the direct participation of the DOD in all phases of the manned space-flight program. This support has been, and will continue to be, invaluable.

The combined Government/industry/university team that makes up the manned space-flight program totals about 240,000 people. In addition, thousands more are employed in NASA unmanned space efforts, and in programs of the Department of Defense, the Department of Commerce, the Atomic Energy Commission, and other agencies involved in total national space endeavors. These people, in acquiring new scientific knowledge, developing new techniques, and working on new problems with goals ever enlarged by the magnitude of their task, form the living, growing capability of this Nation for space exploration.

For the last quarter century, this Nation has been experiencing a technological revolution. Cooperative efforts on the part of the Government, the universities, the scientific community, and industry have been the prime movers. This cooperation has provided tremendous capability for technological research and development which is available now and which will continue to grow to meet national requirements of the future. The influence of this technological progress and prowess is, and has been, a deciding factor in keeping the peace.

Preeminence in this field is an important instrument in international relations and vitally influences this country's dealings with other nations involving peace and freedom in the world. Political realities which can neither be wished away nor ignored make the capability to explore space a matter of strategic importance as well as a challenge to the scientific and engineering ingenuity of man. This Nation can no more afford to falter in space than it can in any earthly pursuit on which the security and future of the Nation and the world depend.

The space effort is really a research and development competition, a competition for technological preeminence which demands and creates the quest for excellence.

The Mercury program, which laid the groundwork for Gemini and the rest of this Nation's manned space-flight activity, appears at this point relatively modest. However, Mercury accomplishments at the time were as significant to national objectives as the Gemini accomplishments are today as those that are planned for Apollo in the years ahead.

That these programs have been, and will be, conducted in complete openness with an international, real-time audience makes them all the more effective. In this environment, the degree of perfection achieved is even more meaningful. Each person involved can take richly deserved pride in what has been accomplished. Using past experience as a foundation, the exploration of space must continue to advance. The American public will not permit otherwise, or better yet, history will not permit otherwise.

[pp. 4-328 not included]

[329]

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22. GEMINI RESULTS AS RELATED TO THE APOLLO PROGRAM

By Willis B. Mitchell, *Manager, Office of Vehicles and Missions, Gemini Program Office, NASA Manned Spacecraft Center;* Owen E. Maynard, *Chief, Mission Operations Division, Apollo Spacecraft Program Office, NASA Manned Spacecraft Center; and* Donald D. Arabian, *Office of Vehicles and Missions, Gemini Program Office, NASA Manned Spacecraft Center*

Introduction

The Gemini Program was conceived to provide a space system that could furnish answers to many of the problems in operating manned vehicles in space. It was designed to build upon the experience gained from Project Mercury, and to extend and expand this fund of experience in support of the manned lunar landing program and other future manned space-flight programs. The purpose of this paper is to relate some of the results of the Gemini Program to the Apollo Program, and to discuss some of the contributions which have been made.

The objectives of the Gemini Program applicable to Apollo are: (1) long-duration flight, (2) rendezvous and docking, (3) post-docking maneuver capability,

(4) controlled reentry and landing, (5) flight- and ground-crew proficiency, and (6) extravehicular capability. The achievement of these objectives has provided operational experience and confirmed much of the technology which will be utilized in future manned programs. These contributions will be discussed in three major areas: launch and flight operations, flight crew operations and training, and technological development of subsystems and components. While there is obvious interrelation among the three elements, the grouping affords emphasis and order to the discussion.

Launch and Flight Operations

Gemini experience is being applied to Apollo launch and flight operations planning and concepts. Probably the most significant is the development and understanding of the rendezvous and docking process. The Apollo Program depends heavily upon rendezvous for successful completion of the basic lunar mission. The Lunar Module, on returning from the surface of the Moon, must rendezvous and dock with the Command and Service Module. In addition, the first Apollo mission involving a manned Lunar Module will require rendezvous and docking in Earth orbit by a Command and Service Module placed in orbit by a separate launch vehicle. During the Gemini Program, 10 rendezvous and 9 docking operations were completed. The rendezvous operations were completed under a variety of conditions and applicable to the Apollo missions.

The Gemini VI-A and VII missions demonstrated the feasibility of rendezvous. During the Gemini IX-A mission, maneuvers performed during the second re-rendezvous demonstrated the feasibility of a rendezvous from above; this is of great importance if the Lunar Module should be required to abort a lunar-powered descent. During the Gemini X mission, the spacecraft computer was programmed to use star-horizon sightings for predicting the spacecraft orbit. These data, combined with target-vehicle ephemeris data, provided an onboard prediction of the rendezvous maneuvers required. The rendezvous was actually accomplished with ground-computed solution, but the data from the onboard prediction will be useful in developing space-navigation and orbit-determination techniques.

[330]

The passive ground-controlled rendezvous demonstrated on Gemini X and XI is important in developing backup procedures for equipment failures. The Gemini XI first-orbit rendezvous was onboard controlled and provides an additional technique to Apollo planners. The Gemini XII mission resulted in a third-orbit rendezvous patterned after the lunar-orbit rendezvous sequence, and again illustrated that rendezvous can be reliably and repeatedly performed.

All of the Gemini rendezvous operations provided extensive experience in computing and conducting midcourse maneuvers. These maneuvers involved separate and combined corrections of orbit plane, altitude, and phasing similar to the corrections planned for the lunar rendezvous. Experience in maneuvering combined vehicles in space was also accumulated during the operations using the docked spacecraft/target-vehicle configuration when the Primary Propulsion

System of the target vehicle was used to propel the spacecraft to the high-apogee orbital altitudes. During the Gemini X mission, the Primary Propulsion System was used in combination with the Secondary Propulsion System to accomplish the dual-rendezvous operation with the passive Gemini VIII target vehicle. These uses of an auxiliary propulsion system add another important operational technique.

In summary, 10 rendezvous exercises were accomplished during the Gemini Program, including 3 re-rendezvous and 1 dual operation (fig. 22-1) [not included]. Seven different rendezvous modes were utilized. These activities demonstrated the capabilities for computing rendezvous maneuvers in the ground-based computer complex; the use of the onboard radar-computer closed-loop system; the use of manual computations made by the flight crew; and the use of optical techniques and star background during the terminal phase and also in the event of equipment failures. A variety of lighting conditions and background conditions during the terminal-phase maneuvers, and the use of auxiliary lighting devices, have been investigated. The rendezvous operations demonstrated that the [331] computation and execution of maneuvers for changing or adjusting orbits in space can be performed with considerable precision.

The nine docking operations during Gemini demonstrated that the process can be accomplished in a routine manner, and that the ground training simulation was adequate for this operation (fig. 22-2) [not included]. The Gemini flight experience has established the proper lighting conditions for successful docking operations. Based on the data and experience derived from the Gemini rendezvous and docking operations, planning for the lunar orbit rendezvous can proceed with confidence.

Extravehicular Activity

Extravehicular activity was another important objective of the Gemini Program. Although extensive use of extravehicular activity has not been planned for the Apollo Program, the Gemini extravehicular experience should provide valuable information in two areas. First, extravehicular activity will be used as a contingency method of crew transfer from Lunar Module to the Command Module in the event the normal transfer mode cannot be accomplished. Second, operations on the lunar surface will be accomplished in a vacuum environment using auxiliary life-support equipment and consequently will be similar to Gemini extravehicular operations. For these applications, the results from Gemini have been used to determine the type of equipment and the crew training required. The requirements for auxiliary equipment such as handholds, tether points, and handrails have been established.

Controlled Landing

From the beginning of the Gemini Program, one of the objectives was to develop reentry flight-path and landing control. The spacecraft was designed with an offset center of gravity so that it would develop lift during the flight through the atmosphere. The spacecraft control system was used to orient the lift vector to provide maneuvering capability. A similar system concept is utilized by the Apollo spacecraft during reentry through the Earth atmosphere.

After initial development problems on the early Gemini flights, the control system worked very well in both the manual and the automatic control modes. Spacecraft landings were achieved varying from a few hundred yards to a few miles from the target point (fig. 22-3) [not included]. The first use of a blunt lifting body for reentry control serves to verify and to validate the Apollo-design concepts. The success of the Gemini guidance system in controlling reentry will support the Apollo design, even though the systems differ in detail.

Launch Operations

The prelaunch checkout and verification concept which was originated during the Gemini Program is being used for Apollo. The testing and servicing tasks are very similar for both spacecraft, and the Gemini test-flow plan developed at the Kennedy Space Center is being applied. The entire mode of operation involving scheduling, daily operational techniques, operational procedures, procedures manuals, and documentation is similar to that used in the Gemini operation. Much of the launch-site operational support is common to both programs; this includes tracking radars and cameras, communications equipment, telemetry, critical power, and photography. The requirements for this equipment are the same in many cases, and the Gemini experience is directly applicable. The Apollo Program will use the same mission operations organization for the launch sequence that was established during Project Mercury and tested and refined during the Gemini Program.

[332]

Mission Control

The Gemini mission-control operations concepts evolved from Project Mercury. These concepts were applied during the Gemini Program and will be developed further during the Apollo missions, although the complexity of the operations will substantially increase as the time for the lunar mission nears. The worldwide network of tracking stations was established to gather data concerning the status of the Mercury spacecraft and pilots. The Mercury flights, however, involved control of a single vehicle with no maneuvering capability.

The Gemini Program involved multiple vehicles, rendezvous maneuvers, and long-duration flights, and required a more complex ground-control system capable of processing and reacting to vast amounts of real-time data. The new mission-control facility at the Manned Spacecraft Center, Houston, was designed to operate in conjunction with the Manned Space Flight Network for direction and control of Gemini and Apollo missions, as well as of future manned space-flight programs. Much of this network capability was expanded for Gemini and is now being used to support the Apollo missions. Gemini has contributed personnel training in flight control and in maintenance and operation of flight-support systems. As the Gemini flights progressed and increased in complexity, the capabilities of the flight controllers increased, and resulted in a nucleus of qualified control personnel.

[333]

The development of experience teams of mission-planning personnel has proved extremely useful in the preparation for future manned missions. Mission plans and flight-crew procedures have been developed and exercised to perform the precise in-flight maneuvers required for rendezvous of two vehicles in space, and to perform flights up to 14 days in duration. The techniques which were evolved during Gemini have resulted in flight plans that provide the maximum probability of achieving mission objectives with a minimum usage of consumables and optimum crew activity. The development of satisfactory work-rest cycles and the acceptance of simultaneous sleep periods are examples of learning which will be carried forward to the Apollo planning. The mission planning procedures developed for Gemini are applicable to future programs, and the personnel who devised and implemented the procedures are applying their experience to the Apollo flight-planning effort.

Flight-Crew Operations and Training

Crew Capability

The results of the Gemini Program in the area of flight-crew operations have been very rewarding in yielding knowledge concerning the Gemini long-duration missions. The medical experiments conducted during these flights have demonstrated that man can function in space for the planned duration of the lunar landing mission. The primary question concerning the effect of long-duration weightlessness has been favorably answered. Adaptation to the peculiarities of the zero-g environment has been readily accomplished. The results significantly increase the confidence in the operational efficiency of the flight crew for the lunar mission.

The Apollo spacecraft is designed for cooperative operation by two or more pilots. Each module may be operated by one individual for short periods; however, a successful mission requires a cooperative effort by the three-man crew. The multiple-crew concept of spacecraft operation was introduced for the first time in the United States during the Gemini Program and cooperative procedures for multi-pilot operations were developed.

The Gemini Program has established that man can function normally and without ill effect outside the spacecraft during extravehicular operations.

Crew Equipment

Most of the Gemini technology regarding personal crew equipment is applicable to Apollo. The Block I Apollo space suit is basically the same as the Gemini space suit. The Block II Apollo space suit, although different in design, will have familiar Gemini items such as suit-design concepts, locking mechanisms for connectors, and polycarbonate visors and helmets. The Gemini spacesuit support facilities at the Manned Spacecraft Center and at the Kennedy Space Center, plus the ground-support equipment, will be fully utilized during Apollo.

A considerable amount of personal and postlanding survival equipment will be used for Apollo in the same configuration as was used for Gemini. Some items have minor modifications for compatibility, others for improvements based upon knowledge resulting from flight experience. Specific examples include food packaging, water dispenser, medical kits, personal hygiene items, watches, sunglasses, penlights, cameras, and data books.

Many of the concepts of crew equipment originated in Gemini experience with long-duration missions and recovery: food and waste management; cleanliness; housekeeping and general sanitation; and environmental conditions such as temperature, radiation, vibration, and acceleration. Although the Apollo approach may differ in many areas, the Gemini experience has been the guide.

Flight-Crew Training

The aspects of crew training important to future programs include preflight preparation of the crews for the mission and the reservoir of flight experience derived from the Gemini Program. Apollo will inherit the training technology developed for the Gemini flight crews. The technology began with Project Mercury, and was developed and refined during the training of the Gemini multi-man crews. There now exists an organization of highly skilled specialists with a thorough understanding of the training task. Adequate crew preparation can be assured in all areas, from the physical conditioning of the individual crewmembers to the complicated integrated mission simulation.

One highly developed aspect of flight-crew training is the use of simulators and simulation techniques. A significant result of the Gemini rendezvous experience was the verification of the ground simulation employed in flight-crew training. The incorporation of optical displays in the Gemini simulations was an important step in improving the training value of these devices. Using high-fidelity mission simulators to represent the spacecraft and to work with the ground control network and flight controllers was instrumental in training the pilots and ground crew as a functional team that could deal with problems and achieve a large percentage of the mission objectives.

The Gemini Program resulted in an accumulated total of 1940 man-hours of flight time distributed among 16 flight-crew members. This flight experience is readily adaptable to future programs since the Gemini pilots are flight qualified for long-duration flights with rendezvous operations, and are familiar with many of the aspects of working in the close confines of the spacecraft. This experience is of great value to future training programs. The experience in preparing multi-man crews for flight, in monitoring the crew during flight, and in examining and debriefing after flight will facilitate effective and efficient procedures for Apollo.

Technological Development of Systems and Components

Gemini and Apollo share common hardware items in some subsystems; in other subsystems, the similarity exists in concept and general design. The performance of Gemini systems, operating over a range of conditions, has provided flight-test data for the verification of the design of related subsystems. These data are important since many elements of Apollo, especially systems interactions, cannot be completely simulated in ground testing. The Apollo Spacecraft Program

Office at the Manned Spacecraft Center, Houston, has reviewed and analyzed Gemini anomalous conditions to determine corrective measures applicable to Apollo. The Apollo Program Director has established additional procedures at NASA Headquarters to promote rapid dissemination and application of Gemini experience to Apollo equipment design.

The Gemini missions have provided background experience in many systems such as communications, guidance and navigation, fuel cells, and propulsion. In addition, a series of experiments was performed specifically for obtaining general support information applicable to the Apollo Program.

In the communications systems, common items include the recovery and flashing-light beacons; similar components are utilized in the high-frequency recovery antennas. Reentry and post landing batteries and the digital data uplink have the same design concepts. The major Apollo design parameters concerned with power requirements and range capability have been confirmed.

In the area of guidance and navigation, the use of an onboard computer has been demonstrated and the Gemini experience with rendezvous radar techniques has been a factor in the selection of this capability for the Lunar Module. The ability to perform in-plane and out-of-plane maneuvers and to determine new space references for successful reentry and landing has been confirmed by Gemini flights. The control of a blunt lifting body during reentry will also support the Apollo concept.

In the electrical power supply, the use of the Gemini fuel cell has confirmed the applicability [335] of the concept. The ability of the cryogenic reactant storage system to operate over a wide range of off-design conditions in flight has verified the design, which is similar for Apollo. The performance of the Gemini system has provided a better understanding of the system parameters over an operating range considerably in excess of the range previously contemplated. The design of the cryogenic servicing system for Apollo was altered after the initial difficulties experienced by early Gemini flights. Consequently, a fairly sophisticated system now exists which will eliminate the possibility of delays in servicing. The ability to estimate the power requirements for the Apollo spacecraft equipment is enhanced by the Gemini operational data.

In the propulsion area, the ullage control rockets of the Apollo-Saturn S-IVB stage are the same configuration as the thrusters used for the Gemini spacecraft Orbital Attitude and Maneuver System; the thrusters of the Apollo Command Module Reaction Control System are similar. Steps have been taken to eliminate the problems which occurred in the development of the Gemini thrusters, such as the cracking of the silicon-carbide throat inserts, the unsymmetrical erosion of the chamber liners, and the chamber burn-through. The tankage of the Reaction Control System is based upon the Gemini design, and employs the same materials for tanks and bladders. The propellant control valves were also reworked as a result of early problems in the Gemini system.

The Lunar Module ascent engine also benefited from the Gemini technology; the contractor for this engine also manufactured the engines for the

Gemini Agena Target Vehicle. Following the in-flight failure of the target-vehicle engine during the Gemini VI mission, a test program verified the inherent danger in fuel-lead starts in the space environment. Consequently, the Lunar Module ascent engine and the Gemini target-vehicle engine were changed so that the oxidizer would enter the engine before the fuel. The problem had been indicated during ascent-engine testing, but was not isolated until the required definitive data were furnished by Project Sure Fire on the target-vehicle engine.

In addition to medical experiments, several other types of experiments were conducted during Gemini and have supplied information and data for use by the Apollo Program. The experiments included electrostatic charge, proton-electron spectrometer, lunar ultra-violet spectrometer, color-patch photography, landmark contrast measurements, radiation in spacecraft, reentry communications, manual navigation sightings, simple navigation, radiation and zero-g effects on blood, and micrometeorite collection. Although the direct effects of these experiments on Apollo systems are difficult to isolate, the general store of background data and available information has been increased.

Concluding Remarks

The Gemini Program has made significant contributions to future manned space-flight programs. Some of the more important contributions include flight-operations techniques and operational concepts, flight-crew operations and training, and technological development of components and systems. In the Gemini Program, the rendezvous and docking processes so necessary to the lunar mission were investigated; workable procedures were developed, and are available for operational use. The capability of man to function in the weightless environment of space was investigated for periods up to 14 days. Flight crews have been trained, and have demonstrated that they can perform complicated mechanical and mental tasks with precision while adapting to the spacecraft environment and physical constraints during long-duration missions.

Additionally, the development of Gemini hardware and techniques has advanced spacecraft-design practices and has demonstrated advanced systems which, in many cases, will substantiate approaches and concepts for future spacecraft.

[336]

Finally, probably the most significant contributions of Gemini have been the training, personnel and organizations in the disciplines of management, operations, manufacturing, and engineering. The nucleus of experience has been disseminated throughout the many facets of Apollo and will benefit all future manned space-flight programs.

[337]

23. CONCLUDING REMARKS

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With the preceding paper, one of the most successful programs in our short history of space flight has ended. The Gemini achievements have been many, and have included long-duration flight, maneuvers in space, rendezvous, docking, use of large engines in space, extravehicular activity, and controlled reentry. The Gemini achievements have also included a host of medical, technological, and scientific experiments.

The papers have included discussions of many individual difficulties that were experienced in preparation for many of the flight missions and in some of the flights. The successful demonstration that these difficulties were overcome in later missions is a great tribute to the program, to the organization, and to the entire Gemini team.

A period of difficulty exists today in the program that follows Gemini, the Apollo Program. Yet, perhaps one of the most important legacies from Gemini to the Apollo Program and to future programs is the demonstration that great successes can be achieved in spite of serious difficulties along the way.

The Gemini Program is now officially completed.