CHAPTER 17

SPACE ARTIFACTS: ARE THEY HISTORICAL EVIDENCE?

David A. DeVorkin

Museum collections . . . show you not what there was but what was collected.

—Jim Bennett, "Scientific Instruments," in *Research Methods Guide*, Department of History and Philosophy of Science, University of Cambridge

Anyone sensitive to the immense costs involved in collecting and preserving the material legacy of modern culture must question such expenditures at one time or another. Can the needs of history, for instance, justify the effort and expense it takes to identify, acquire, transport, preserve, inventory, evaluate, and possibly even to exhibit some object of note? An 11th-century astrolabe, a Galilean telescope, or the fabulously mysterious and insightful Antikythera mechanism all, no doubt, have provided valuable insight into historic events, capabilities, unwritten norms of practice, and cultural imperatives. But what of the modern stuff, essentially the past 50 years of the Space Age? What does the *Freedom* 7 capsule tell us? Or what can Apollo 11, or Armstrong's chronograph, or the backup mirror to the Hubble Space Telescope tell us that other forms of documentation cannot reveal? Why collect and preserve material artifacts of the Space Age when there is, indeed, a mountain of documentation readily accessible that can tell us everything we might possibly want to know or can answer every question we can imagine to ask?

The act of collecting and properly preserving objects that somehow represent or inform the history of the exploration of outer space is one of the most expensive and labor-intensive ways of preserving the record of space history. As an historical activity, it is far more expensive, requiring a broad range of talents and expertise and an infrastructure at least an order of magnitude greater than that required for any library or archival facility devoted to space history, and it is many orders of magnitude greater than what is required by an individual scholar to pursue publishable space history. Why, then, do institutions and historians engage in such activity? Are the payoffs and returns proportionally worth the effort and expense? Can the payoffs be measured on scales that compare to the professional payoffs resulting from other forms of historical inquiry and outreach, or are the payoffs of a wholly different character, so removed or distinct from familiar intellectual processes and modes of communication that they demand a distinct scale for evaluation separate from, or complementary to, those in place within academe? This essay will raise these questions and explore them.

WHY ARTIFACTS ARE MARGINALIZED AS HISTORICAL EVIDENCE

In a 1962 essay in *Science*, filled with the exuberance of establishing a new discipline, Mel Kranzberg argued that there were ample reasons to support the history of science and technology disciplines as the "'newest' history."[1] Speaking more about technology than science, the newest history, he argued, offered promise of reconnecting the two cultures, as if to counter C. P. Snow's allegations. As Kranzberg wished to describe it, "It is about human work [in science and technology] . . . . Indeed, the search for truth and order and beauty in science is comparable to the same striving in literature, art, poetry." It is a very human activity to search for truth, order, and beauty, and the nature of the search reflects changing intellectual climates, human inventiveness and imagination, and human values and social systems. Technology plays an intimate part in all of this because its significance "lies in what it does." Again, following Kranzberg, "the significance of technology is in its use by human beings."[2]

In his 1962 essay, he explored the significance of the study of the history of science and technology, and its possible applications, and identified typical questions modern practitioners of the "newest history" ask and how the exploration of their answers might benefit society. Above all, Kranzberg placed humans at the center of attention as well as the institutions they build and the nations they defend. He used the telephone to describe what is important about technology: At one level, the telephone is merely a system of wires, circuits, and switches, transmitters and receivers of electrical signals. Issues historians have addressed have included who invented it and why they did it, motivations, resources available, assumptions, "but the human meaning of the telephone lies in its transmission of sound for long distances between persons." The telephone has changed the way people live their lives and communicate

1. Melvin Kranzberg, "The Newest History: Science and Technology," *Science* 136, no. 3515 (11 May 1962): 465.
2. Ibid., p. 466.

with others. Using the telephone and other examples, Kranzberg's message is "that science and technology have social consequences."[3]

Kranzberg's article, at one level, reflects modern practice. It leaves the strong impression that the "things" of technology do not constitute the knowledge base, but that they do represent history in some amorphous way. Indeed, in his campaign to increase attention by historians and scientists to the value of the history of science and technology, he emphasized its social application and minimized issues relating to what one might call a "material culture" focus. "Things" do appear prominently, and Kranzberg is clearly sensitive to the ills of Neoplatonic aristocratic dualism, the emphasis of brain over hand. But for the sake of his argument in 1962, things merely symbolize human goals and aspirations and adorn the titles, texts, and images of the literature of the history of science and technology.

Thus, in the 40-odd years since Kranzberg's essay in *Science*, an unintended consequence of his campaign, and of those of his generation, was a certain neglect of the things of science and technology, the material artifacts, as sources of information themselves. They could be sacralized and celebrated and even revered, but they did not, in and of themselves, provide a knowledge base. And as a new literature emerged in the history and technology of space exploration, a consequence of the increased interest in the field overall since Sputnik, it also reflected the same priorities of the newest history and did not include things in its formal knowledge base.

Things do matter in the geological and biological sciences, as well as in the broader ranges of natural history including anthropology, archaeology, and paleontology. Collections do constitute primary knowledge. After all, these disciplines largely grew up around collections that had to be organized and preserved somehow, and the present structure of these museums and their collections still represents the organized data the scientist needs.[4] But for the disciplines engaged in space history, where we might find historians of technology and science, or social and cultural history, military history, business history, American history, American studies, along with a smattering of sociologists, economists, policy specialists, and psychologists, to say nothing of those who came from backgrounds in aerospace itself, none of these areas of inquiry grew up around a practice of collecting artifacts, organizing and classifying them, and searching for new knowledge in the effort, through empirical analysis or some form of rational argument. As a result, although those engaged in curatorial functions most definitely think about their collections and treat them to all the standards required of their codes of ethics and institutional capabilities, few of them actually have utilized these collections as

3. Ibid., p. 466.

4. Bernard S. Finn, "The Science Museum Today," *Technology and Culture* 6, no. 1 (1965): 78–79.

primary evidence in their historical research and writings. Many have written about their collections and the objects in them, of course, ordering them by age, manufacturer, speed, function, and capability, because they are fascinated by or are somehow attracted to objects, but the data they employ are of the more traditional kind: the written and spoken word, images, pictorial representations, and the like.[5]

To make this last observation, Joseph Corn surveyed a decade's worth of articles in *Technology and Culture*, the quarterly publication of the Society for the History of Technology. He found that less than 15 percent of the authors "employed any material evidence" and, of these, most wrote on ancient or early modern technologies. "Rhetoric to the contrary, then, the history of technology as a field is not deeply committed to learning from things."[6] Corn takes this farther to identify factors that detract from the use of things as evidence and also argues that because of these social factors limiting how historians communicate processes and the influences upon them, in fact, the survival of the real thing (the true artifact and even the facsimile) is more important than one might appreciate from the published record alone.

THINGS AS "CONGEALED CULTURE"

After all, things do exist, have existed, and are constantly on the minds of at least some historians, especially those who find themselves working in museums or training those who might see museums as a career goal. Things constitute the "corpse" of much of what we call science and technology, and so they have been regarded by some as holding out potential as a source of diagnostic or even forensic knowledge offering insights unavailable otherwise. Given the emphasis on people and institutions fostered by Kranzberg and almost all subsequent workers, this potential has remained largely locked up in the things themselves, which has led at least one prominent historian of technology, Thomas Parke Hughes, to refer to them as "congealed culture."[7]

Hughes's rhetorical concept has been applied by scholars to various and sundry objects, institutions, and individuals, mainly to describe a static relic or an art object, "a kind of tomb for the creative spirit" that has somehow been transported into a context wholly unlike that of its creation: the art gallery, living room, museum, or historic site. The term has also been used to

5. Joseph J. Corn, "Object Lessons/Object Myths? What Historians of Technology Learn from Things," in *Learning from Things, Method and Theory of Material Culture Studies*, ed. W. David Kingery (Washington, DC: Smithsonian Institution Press, 1996), pp. 35–54.

6. Ibid., p. 37.

7. Thomas Hughes, commentary in Pamela Mack and David DeVorkin, "Proseminar in Space History," *Technology and Culture* 23 (1982): 202–206.

encapsulate entrenched personalities, hopelessly outdated or resistive bureaucracies, and static libraries and the books they contain.[8] Hughes, however, had no such negative thoughts in mind when he used the term at a May 1981 "Proseminar in Space History" at the National Air and Space Museum. There, he was expressing his feeling that it was the best we could hope for in material culture, but to utilize it we had to learn how to obtain the proper tools to capture the essence of an artifact and to understand how it represents an amalgam of interests, motivations, ideas, questions, and techniques that are representative of the culture that conceived of it, paid for it, built it, and used it. At least, that is what some participants took away from his commentary.[9] Hughes's remark embodied the perennial challenge facing curators of objects, or things, to find ways to unpack all the forces and drives that brought that artifact into existence and played a part in its lifetime of use. Curators trained as historians have certainly done much of this. The literature of space history is rich in the study of the technologies and the objects representing them that made space travel possible. But the question in my mind then and now is, where is the survival of the artifact itself in all this effort? And what is its role in history: as historical evidence leading to new knowledge, or as a commodity, an ornament that somehow illustrates or celebrates, but does not necessarily inform the past?

Kranzberg's assertion that the history of technology focuses on human actions did not prevent almost half of the articles in *Technology and Culture* scanned by Corn from dealing somehow with devices: tools, weapons, instruments, objects with a function. But historical studies of things are subject to a wide variety of perspective: "What's nuts and bolts to one historian is 'congealed culture' to another," Larry Owens once observed, implying that things can be described in terms of their "brute facts" of existence, to excruciating detail, but they also "embody conceptual schemes and logical strategies for dealing with the world." The historian's task, ideally, is to employ interpretive and descriptive tools that present an integrated portrait of the machine/object/thing and the ideas and aspirations it embodies. Owens's very definition of a good historian [of technology] was someone with sensitivity to "socioeconomic and institutional environments."[10]

8. John S. Duffield, "Political Culture and State Behavior: Why Germany Confounds Neorealism," *International Organization* 53 (1999): 765–803, noting Jepperson and Swidler describing institutions as "congealed" culture; John D. Kelly, "Nature, Natives, and Nations: Glorification and Asymmetries in Museum Representation, Fiji and Hawaii," *Ethnos* 65, no. 2 (1 July 2000): 195–216; Shaun Gray, quoted in "Aesthetics of Computer Graphics," *pixxelpoint*, *http://www.pixxelpoint.org/2001/article-01.html.*

9. Discussions with Pamela Mack over the years.

10. Larry Owens, "Book Review," *Isis* 78 (1987): 625–626 (review of Michael R. Williams, *A History of Computing Technology* [Englewood Cliffs, NJ: Prentice-Hall, 1985]).

A machine can certainly embody ideas and assumptions. First, implicit in its design are ideas about the way nature works, as well as assumptions of the ways humans work, as well as assumptions about how a particular human goal can be met. Take the telescope: it definitely embodies basic assumptions about how nature works. Although invented before systematic rules in geometrical optics provided guidance, empirical or experimental exploration soon showed how to build telescopes with greater magnification, resolution, and light-gathering power. Following the development of astronomical telescope technology, then, how it changed over time, has the potential of revealing how technical limitations, intellectual drives, and social issues influenced the development of each of these powers or inhibited their growth for one reason or another. Yet, with but few exceptions, histories of telescope technology in the past tended not to be organized this way and instead were chronological and periodized, or centered on observatory development. And with even fewer exceptions, mainly the work of Albert van Helden and others noted below, histories of telescope technologies have not required the survival of the telescopes themselves. Yet telescopes are lovingly preserved and beautifully displayed throughout European culture as an enduring legacy of human achievement and curiosity. Faced with this situation, any curator of things must, at some point in life, pause and ask, "Why?"

This essay, then, is an exploration of these questions: Is the existence of an artifact useful to history, or does its value reside elsewhere? Is there a sensible difference, in researching and writing history, having the actual artifact involved in that history at hand or not? We will begin by looking at institutional rationales for collecting, then at individual arguments, and finally we will sum up by suggesting some alternative ways to justify the effort.

ADDRESSING THE ISSUE: RATIONALES FOR COLLECTING

It is surprising that there doesn't appear to be a literature critical of the act of formal collecting. There is a literature defending and rationalizing collecting and a smaller literature looking into the psychological motives that stimulate collecting on both individual and collective bases, but there appears not to be one questioning the value or importance of collecting. Of course, I raise this as an observation in the hopes that a reader who has read more widely than I have at this point will offer a correction and direct me to what I have missed. Until that happens, however, I will labor under the assumption that collecting is a core act of human culture, bound up some way in a search for identity and even for power and transcendence.[11] But I will also

11. Werner Muensterberger, *Collecting: An Unruly Passion* (Princeton, NJ: Princeton University Press, 1994).

accept the possibility that formal collecting, by institutions and nations, is a self-conscious act that in and of itself is artificial enough to warrant rationalization. Therefore, we should begin by looking at the rationalizations people and organizations have given for collecting.

Institutions and organizations are, first and foremost, composed of individuals, and these individuals act singly and collectively out of both personal and professional motivations. Personal motivations to collect derive from a wide variety of impulses and drives: collecting can provide a sense of identity, personal exploration, security and validation, self-worth, transcendence, and power. All manner of people collect all imaginable things, from stamps, coins, and baseball cards to M&M items, cars, telescopes, and phonograph records.[12] It is one of our more basic instincts and seems to be shared among many cultures. Styles vary, of course, from astute collectors to indiscriminate hoarders. Individuals rarely rationalize why they collect, nor do they need to. But institutions, especially public ones or those existing on private or corporate philanthropy, typically try to, because of the costs involved.

Historians, museum professionals, anthropologists, geologists, biologists, collectors of all types, and their institutions have presented numerous and varied arguments for preservation. In the cultural arena, possibly the most pervasive effort was established by the National Park Service emerging from the Historic Sites Act of 1935: "To preserve places of national significance that retain exceptional value as commemorating or illustrating the history of the United States for the inspiration and benefit of the people."[13] The 1946 enabling legislation that ultimately gave life to the National Air and Space Museum in 1976, which we always cite in the various editions of the introduction to our "Collections Rationale," calls upon us to "memorialize the national development of aviation and space flight." Our charge is to "serve as the repository for, preserve, and display aeronautical and space flight equipment and data of historical interest and significance to the progress of aviation and space flight, and provide educational material for the historical study of aviation and space flight and their technologies."[14]

In order to carry out its designated task, the Park Service has mounted numerous "theme studies" and has created a standardized "National Register

12. Ibid.; Igor Kopytoff, "The Cultural Biography of Things: Commoditization as Process," in *The Social Life of Things: Commodities in Cultural Perspective*, ed. Arjun Appadurai (Cambridge: Cambridge University Press, 1986), pp. 64–91; Frederick Kunkle, "A Heart Melts at Sight of All Things M&M's," *Washington Post* (10 February 2005): Montgomery Extra, pp. 16–17.

13. National Historic Landmarks Survey, "Surveying American History," June 2003, *http://www.cr.nps.gov/nhl/*, p. 1 (accessed 10 February 2005).

14. Public Law 79-722, chap. 955, 70th Cong., 2nd sess., 12 August 1946. "Initially the legislation did not mention 'space,' but this was added and now serves as basis for the Museum's Mission Statement, as promulgated July 29, 1996," according to the Division of Space History, "Collections Rationale," 2005, NASM Curatorial Files, Washington, DC.

Nomination Form" that contains room for not only describing the candidate, but for including a narrative statement of historical, cultural, and architectural significance and how these characteristics meet a set of criteria maintained by the NPS. Reproduced in full, it reads:

> The quality of significance in American history, architecture, archeology, engineering, and culture is present in districts, sites, buildings, structures, and objects that possess integrity of location, design, setting, materials, workmanship, feeling, and association, and:
>
> A. That are associated with events that have made a significant contribution to the broad patterns of our history; or
>
> B. That are associated with the lives of significant persons in or past; or
>
> C. That embody the distinctive characteristics of a type, period, or method of construction, or that represent the work of a master, or that possess high artistic values, or that represent a significant and distinguishable entity whose components may lack individual distinction; or
>
> D. That have yielded or may be likely to yield, [*sic*] information important in history or prehistory.[15]

Commemorating, validating, and illuminating historical events, lives of note, or objects of construction or manufacture within their original environments is thus the domain of an agency concerned with such diverse issues as land use and national identity. An entity of the Department of the Interior, it promotes programs in public recreation and education, with preservation at its core: more than half of the parks represent land management "set aside as symbols and evidence of our history and prehistory."[16]

The process followed by curators at the National Air and Space Museum is somewhat different than the National Park Service, though many of its criteria map onto those of the NPS. Symbolism and national identity pervade the collection. Although collecting activity ranges over the whole of the 20th century, collecting in space history itself was heavily augmented

15. National Register Bulletin, "How to Apply the National Register Criteria for Evaluation," *National Register Publications, http://www.cr.nps.gov/nr/publications/bulletins/nrb15/nrb15_2.htm* (accessed 10 February 2005).

16. "History," National Park Service Web site, *http://www.cr.nps.gov/history/hisnps/* (accessed 10 February 2005).

by an agreement between NASA and the Smithsonian set out in 1967 and modified on numerous occasions. This special agreement was set up because NASA realized that it was rapidly becoming responsible for "a growing number of artifacts, many with great historical value and others with great value for educational, exhibition, and other purposes, relating to the development, demonstration, and application of aeronautical and astronautical science and technology of flight."[17]

NASA decided that the Smithsonian was a more appropriate place to take on this responsibility since NASA did not really want to be in the business of managing a large collection of iconic objects that attracted wide public and political attention. Further, it sought out both a political buffer and a means of historical validation. Left unsaid but implicit in the act of agreement was the fact that in making this arrangement, the Smithsonian was also tacitly agreeing to a formal method of removing objects from the commodity sphere (commercial trading and speculation in space artifacts) and placing them into a singularized and sacralized sphere, to adopt (for the moment) the notions and rhetoric of the economic anthropologist. If one views the NASA/NASM Transfer Agreement as a cultural act from this perspective, one can see it as an example of culture counteracting commoditization (in fact, curators in the department have made this point repeatedly)—since the essence of culture is discrimination, and societies typically set aside or set apart certain objects they deem to be sacred. Anthropology teaches us that culture demands that certain things be singular, unexchangeable, and "publicly precluded from being commoditized."[18] Typically, such constraints are imposed by the state, seeking to create a symbolic inventory akin to the crown jewels of monarchies and reflecting the power of the state itself. National museums, then, can be likened to agencies of the state and mechanisms through which the state imposes its eminent domain to sacralize particular objects. To my knowledge, however, no other federal agency has this form of continuing formal agreement with the Smithsonian. Therefore, the existence of the act itself defines NASA as a unique cultural entity, and it would be useful if, sometime in the future, someone examined the agreement in that light.

This agreement, however, does not compel the Smithsonian to collect a NASA object but gives it first right of refusal. In addition, this arrangement does not limit the Smithsonian's interest to collecting NASA artifacts, since significant programs exist elsewhere within our culture and our focus is space history, not NASA history. Our department has thus identified issues of

17. "Agreement Between the National Aeronautics and Space Administration and the Smithsonian Institution Concerning the Custody and Management of NASA Historical Artifacts," signed 10 March 1967, in the introduction to Division of Space History's "Collections Rationale," 2005.

18. Kopytoff, "Cultural Biography of Things," p. 73.

concern when evaluating any object for inclusion in the national collection, independent of national origin or the part of the government, academe, or industry responsible for it. These are placed within a context that we hope and expect will somehow illuminate and inform space history generally. Choices are made based upon

1. the unique qualities of [the object]
2. the relationship of flown items to engineering prototypes, backups, and models
3. the place for ground support equipment such as simulators, operational consoles, test stands, and the like, and
4. the different metrics of culture, history, and technology that come into play when assessing the historical value of a space artifact.[19]

Within the agreement set forth by the two agencies, one also finds rhetoric describing what should be collected, again offering some guidance on how and why, and overall it attests to NASA's view that these objects possess cultural and educational, as well as technical, value. We maintain no other agreement with any other agency or institution in this country or with any nation. However, although there is a tacit understanding that the criteria we utilize to collect any object remain independent of the originating institution, our special agreement with NASA creates an institutional bias that we cannot and should not ever forget or ignore. The quotation from Jim Bennett at the outset of this paper should always be kept in mind: that collections represent choices made and therefore should not be construed as history but as part of history.

Thus far, looking at the rhetoric of these two very different collecting agencies, NASM and the Park Service, one finds consistent appeal to the need to memorialize, display, educate, or stimulate. These goals are presumed by museum professionals and, again, are the results of choices, both individual and collective. Even though these choices are socially conditioned, one can easily find in the rhetoric of museology a presumption of warrant: the International Council of Museums offers, for instance, a "Code of Ethics" for museums that identifies their collective purpose and their unique responsibilities.[20] Excerpting relevant elements, we find that according to ICOM, "Museums preserve, interpret and promote the natural and cultural inheri-

19. "Preface," Division of Space History, "Collections Rationale," 2005.

20. ICOM, "ICOM Code of Ethics for Museums," 2004, *http://icom.museum/ethics.html* (accessed 20 February 2005).

tance of humanity" and hold their collections "in trust for the benefit of society and its development." Museums are, in effect, social institutions that exist to "acquire, preserve and promote their collections as a contribution to safeguarding the natural, cultural and scientific heritage." ICOM sees these collections as a "significant public inheritance" that must be protected by law and international legislation. Throughout its ethics statement, there is a strong and explicit sense of stewardship "that includes rightful ownership, permanence, documentation, accessibility and responsible disposal."

Central to ICOM's warrant is that "museums hold primary evidence for establishing and furthering knowledge." Professional staff within museums are responsible not only for collections care and public accessibility, but for the interpretation of the collection as "primary evidence." Indeed, the notion of "primary evidence" stands at the very core of ICOM's ethics statement. ICOM, which represents all types of museums, including art, technology, and the natural sciences, asserts without example or citation that what museums collect constitutes primary evidence. It recognizes that the designation of primary evidence should not be "governed by current intellectual trends or museum usage" and offers out hope that primary evidence will be used to make a "contribution to knowledge that it would be in the public interest to preserve." Thus, according to ICOM, museums should regard collections as both a present and a future potential resource for knowledge production. The overall policy of the Smithsonian Institution reflects this sensibility, reaffirmed by its Board of Regents in 2001: "Collections serve as an intellectual base for scholarship, discovery, exhibition, and education."[21]

From the standpoint of the collecting institution, then, whose statements are largely bureaucratic and organizational, to say nothing of being self-serving, one finds arguments that still presume the value of collecting, rather than demonstrate value. Once again, it would be easy to reinterpret ICOM's assertions using the perspective of the economic anthropologist: "Power often asserts itself symbolically precisely by insisting on its right to singularize an object, or a set or class of objects."[22] Taken together with ICOM's view, these two interpretations offer copious evidence for rationalizing why we collect.

Each assumes that collections will be useful to "memorialize" or to "educate" and "inform" and even to "inspire." Each also assumes that collections constitute "primary evidence" for historical and scientific inquiry. Indeed, the economic anthropologist goes to considerable and quite convincing lengths to

21. Board of Regents, "Smithsonian Collections Management Guidelines," SD-600, 26 October 2001, p. 37.

22. Kopytoff, "Cultural Biography of Things," p. 73. Sometimes that power is tested. When a National Park Service theme study promised to designate a number of observatories as potential candidates for landmark status, observatory directors objected, fearing that such a designation would limit their power to modify their equipment and buildings. Landmark status was not conferred.

argue how a biography of a thing reveals new knowledge about culture. One can learn a lot, for instance, about inheritance rules and practices, as well as family structure, by following how a particular object moved through a family down through the generations. The biography of a thing, therefore, is not only contained in its production, but in its use and treatment as a commodity, and if that thing is somehow removed from the world of commerce and deified as a sacred object, its biography needs somehow to be preserved and made accessible in order for it to illuminate the culture involved.[23] Historians acting as curators might see this as a new way to appreciate the importance of the "provenance" of an object, the history of who owned the object and the conditions of transfer from one hand to another. But few, to my knowledge, have knowingly explored how provenance informs us about the overall culture—its values, priorities, and stability—within which the object moved. Economic anthropologists have long used these techniques to map out change among generations. Historians might take a cue from this and look for ways to apply provenance.

WHY PRESERVE OBJECTS? THE VIEWS AND ACTIONS OF INDIVIDUALS

In his survey of a decade's worth of articles in the journal *Technology and Culture*, Joseph Corn also identified ways that a few historians used objects as primary evidence, showing that indeed there is potential knowledge if the right questions are asked. He points to five different ways scholars have used objects as primary source material:

1. Looking at the object in use or (if a machine) in motion can reveal information about the tacit shop practices and techniques of the culture that produced it.
2. Performing a technical analysis of a manufactured object can reveal the process of manufacture, through contemporary accounts as well as retrospective accounts by producers and users.
3. Simulating an object can test behavior and evaluate design expertise through models.
4. Testing actual objects through use can reveal norms of precision.
5. Microscopic analysis of surface markings and looking for consistency in dimension and weight may be evidence of skill and motive.

23. Kopytoff, "Cultural Biography of Things," p. 66.

Corn identified each of these methods in specific case studies, mainly of objects from periods where other forms of documentation were not plentiful. Using a case study of a pin-making machine by Steve Lubar to illustrate the first modality, Corn argues that documentary sources (patent records) showed that there were many ways to make a pin machine, but the way the sample was made indicates choices based upon "specific beliefs and practices" because it mimicked manual assembly-line practices.[24] This was only apparent when Lubar experienced the machine functioning, which underscores an argument recently made by Deborah Jean Warner that objects—scientific and technological artifacts and instruments—are interesting because they are functional and therefore should be interpreted in terms of their "performance characteristics." Performance characteristics include all aspects of the building and use of the objects—the skills of design and manufacture involved, the ways to operate them, repair them, and finally, how they are disposed of after their production life.[25]

None of Corn's methodologies apply across the board, and there is significant overlap between some of them. Still and all, it is a useful exercise in articulating how objects have been found to increase historical knowledge and understanding. One finds examples from the history of astronomy that fit one or more of these methods. For instance, there is the famous case of the Antikythera mechanism that significantly improved understanding of the complexity obtained by the Greeks in gearing and clockwork.[26] Modern interferometric studies of optical elements of 17th-century telescope makers like Torricelli, Divini, and Campani revealed the level of their optical polishing technologies and improved understanding of the limits of telescopic knowledge of that time.[27] However, once we get beyond the 17th and into the 18th and 19th centuries, it is typically archival investigation that yields the most telling information about technological capabilities, as in Robert Smith and Richard Baum's excellent study of William Lassell's reflectors, whose optical imperfections led him to believe that he had detected a ring around the planet Neptune even though he was aware of those imperfections.[28] But examples are harder to find when one moves into the contemporary era. This trend is

24. Corn, "Object Lessons/Object Myths?" p. 37.

25. Deborah Jean Warner, "A Matter of Gravity, with reflections on the differences between Gizmos and Works of Art" (unpublished manuscript; text kindly provided by Warner in advance of presentation, March 2005).

26. Derek De Solla Price, *Gears from the Greeks: The Antikythera Mechanism—A Calendar Computer from ca. 80 B.C.* (New York: Science History Publications, 1975).

27. Mara Miniati, Albert Van Helden, Vincenzo Greco, and Giuseppe Molesini, "Seventeenth-century Telescope Optics of Torricelli, Divini, and Campani," *Applied Optics* 41 (February 2002): 644–647.

28. Robert W. Smith and Richard Baum, "William Lassell and the Ring of Neptune: A Case Study in Instrumental Failure," *Journal for the History of Astronomy* 15 (1984): 6–15.

likely similar for all types of collecting. The history of the technical museum in Western culture reflects this trend.

Originally collections of antique instruments, machines, patent models, and industrial products, in the 20th century, technical museums became venues to commemorate "native scientific and technological genius" as well as to supplement the academic program attendant to a technical education: if there was a trend, it was toward commemoration and pedagogy. Thus the technical museum became what Robert Multhauf has described as "a laboratory course extended in space rather than in time, arranged in some historical sequence to exploit the value of historic apparatus." These museums were also initially regarded as repositories of knowledge and inspiration insofar as they acted as places where inventors, designers, and engineers could go to get new ideas or to solve specific problems in design and manufacture. This application, however, closest to Corn's ideal methodologies, proved to be transitory; it was merely a passing interest through the early 20th century. And so the trend moved on once again, when technical museums returned to promote industrial products and act as places for the "preservation of our cultural heritage and to the inspiration of young people with an interest in science and technology."[29] Multhauf's goal in this 1958 essay was to highlight the limitations of perspective: "Unlike the engineer of the last century," he pointed out, "we begin our training, and rest our work, upon a basis of knowledge much of which is outside our own experience."[30] Therefore, for Multhauf, technical museums were the best places where one could explore, through utilizing all available primary and secondary source material, the many ways that discovery and invention happen, the very human artificial element in the inventive process.

Like Kranzberg, Multhauf did not actually regard the thing itself as embodying knowledge, but rather as a locus for the gathering in of knowledge in all forms and with increasing and changing perspective over time. His allusion to how the experience of the engineer of the last century differs from our experience offers testimony to how one needs to read an artifact: a worker who experienced the development of a technology before it was successful and before the principles upon which it was based were fully worked out would see that artifact very differently than someone looking at it years later, after it had proven itself and the principles it embodied. All the doubt, uncertainty, and promise congealed within the artifact can only be assumed, unless one has at hand numerous accounts of attempts made in that day to solve the same functional problem or goal, like attaining the facility of traveling in space and then having to learning how to work in that new theater, or how to build a

29. Robert P. Multhauf, "The Function of the Technical Museum in Engineering Education," *Journal of Engineering Education* 49 (December 1958): 200.

30. Ibid., p. 200.

pin machine that would be acceptable to piece workers, or a rifle that could be assembled, disassembled, and made reliable in the field.

To a certain extent, episodes in the recent history of the National Air and Space Museum's space history collection bear out this transitory phase, but they also show that it lingers even today and no doubt will be present in the future. The NASA/NASM Transfer Agreement explicitly states that if NASA decides that an object it had transferred to the national collection somehow reacquired its usefulness to the space program, it would be recalled. Sometimes this works, sometimes not. When the Viking 1 lander failed to call home from Mars in November 1982, NASA engineers came to the Museum to inspect the computer inside the engineering model we display in the Milestones of Flight gallery, hoping that their inspection might help them figure out how to regain communication with the lander. Unfortunately, the box holding the on-board computer in our example, although real, was empty of its contents. Our *Skylab* orbital workshop, originally built for flight, has been on display since 1976, though modified to allow visitors to walk through the living quarters. In the early 1980s, Marshall Space Flight Center engineers requested the return of a set of circulating air fans and, a few years later, came to inspect the toilet systems, since surviving documentation was apparently unobtainable when they were looking for ways to adapt these designs for new human space initiatives. And on occasion, engineers and scientists have expressed interest in everything from our Saturn F-1 engines to the backup Hubble Space Telescope mirror now on display. In the case of the engines, the engineers sought out the technical documentation we held in our archives rather than the object itself.

Multhauf's views on the use of objects in pedagogy were reflected in at least one of Corn's methodologies, as well as by some of the presentations at a 1975 conference at the Winterthur Museum held to explore how material objects are useful to the study of American history. Historians, archaeologists, ethnologists, American studies specialists, and even a molecular chemist spoke from their perspectives and experiences. James V. Kavanaugh suggested how a course in American studies could be augmented by using anthropological techniques upon "accumulated material evidence" to more fully explore the culture of invention in American life.[31] Cary Carson, Saint Mary's City Commission, echoing Corn's later observations, argued that artifacts have not contributed at all to "developing the main themes of American history" but have, in their design and arrangement, especially in the buildings of surviving early communities, certainly helped to fill in the details and provided new

31. James V. Kavanaugh, "The Artifact in American Culture: The Development of an Undergraduate Program in American Studies," in *Material Culture and the Study of American Life*, ed. Ian M. G. Quimby (New York: W. W. Norton, 1978), pp. 65–74.

insights. Facing the allegation that things "have seldom been a source of ideas for historians," he argued that by looking differently at objects, the mind is certainly capable of thinking up questions that they can answer or contentions they might prove or disprove. Embracing Kranzberg's "New History," Carson argues that "bottom up" history can often best be reconstructed by looking at the details of living environments, and thereby it can pose new questions. The experience of life, of "society as a working organism," can best be appreciated by somehow encountering the material vestiges of that experience. Although he applied his methodology to 17th- and 18th-century life on the Eastern Shore of Maryland, showing how "architecture became the instrument of segregation" and other insights, one might map these concepts into an exploration of the contemporary dwellings of scientific instruments and space operations.[32] Building upon a recent comment by Pam Mack, it is one thing to examine graphic profiles or even photographs of the interior of a Mercury capsule. But it is quite another to actually experience that tiny space, looking from the outside, of course.[33] Possibly someday someone might ask the crowded and complex chamber specific questions relating to the actual role of the astronaut in the Mercury, Gemini, and Apollo eras that cannot be answered as completely or as poignantly by other forms of indirect documentation. One might also find such reminiscences in debriefing documents after the flights. Definitely riding in a machine and being part of its operation is a most valuable experience. Many historians have expressed how important it has been for them to fly in an aircraft they have studied; Ron Davies at NASM recently commented that it was an essential experience, even though his primary data came from airline timetables.[34]

Probably the most eloquent argument for the value of experience at the 1975 Winterthur Conference was Brooke Hindle, who was the lead speaker. Hindle was then Director of the National Museum of American History, and he took the occasion to explore the essence of material culture in his now-classic "How Much Is a Piece of the True Cross Worth?" Hindle identified the factors that led him to what we today might call "priceless." Pondering Lenin's body, Dolley Madison's gown, Ben Franklin's printing press, he first stated that artifacts provide "direct, three-dimensional evidence of individuals who otherwise exist only as abstractions in words, paintings, or monuments."[35] In order to utilize them properly, however, one has to know how

32. Cary Carson, "Doing History with Material Culture," in *Material Culture and the Study of American Life*, ed. Quimby, pp. 42–50.

33. Telephone conversations with Pamela Mack, February 2005.

34. Ron Davies, personal communication in response to informal questionnaire sent to NASM curators, February 2005.

35. Brooke Hindle, "How Much Is a Piece of the True Cross Worth?" in *Material Culture and the Study of American Life*, ed. Quimby, p. 6.

to apply "linguistic models to the nonverbal, three-dimensional world." This, however, was not a simple matter for Hindle, who felt that language "floats on top of the material world" and so remains separate from it. One must walk the battlefields, cruise the oceans, make landfall as explorers did, to find the words appropriate to the experience. Only in this experiential way, Hindle felt, "the abstractions of language are penetrated by direct knowledge of life's complex multidimensional and instantaneous character."[36]

Hindle's concept of the importance of experiential reality underscores what is, in fact, both a compelling but essentially still abstract circumstance. He did not describe any one set of analytical tools one must bring to the experience in order to sense it and then reduce it to language. He provided examples, as all writers of this genre tend to do, and many of those are compelling, such as Eugene Ferguson's attempt to reconstruct the methods of artisans by showing how they thought in pictures, suggesting that one might do the same for the builders of machinery. His strongest suit, of course, is how the techniques of industrial archaeology have radically changed our view of Eli Whitney's role in the development of interchangeable parts. This was indeed a wonderful example of how, in a manner suggested by Carson and others, asking the right questions of a set of artifacts yielded new knowledge about their history and provided a correction to the broader history of industrial technology.

The success of the interchangeability study naturally raises the question of what is important about today's space technology, especially what is important that might be studied by examining artifacts in the ways Corn and others suggest. Is the ability to exchange parts important in the technology of space history, does it define modern capabilities and practice? Does it typify an era? The answer is probably no, at least not in the way rifles illuminated manufacturing techniques of their day. However, a modern counterpart might be the ability to ensure consistency and reliability across a very widely spread-out system or infrastructure. How sure is an instrument developer, for instance, that his instrument will work within the environment of a satellite housing that has been launched into space? What steps does that developer take to design his instrument to be as forgiving and robust as possible—resistive to vast swings of temperature, pressure, and acceleration, yet sensitive enough to get the job done effectively? This is only one of many questions about "integration" that has been an issue ever since scientific instruments were flown on vessels that were not under the direct control of the instrument maker or scientist.[37] The need to integrate a scientific instrument into a system used either remotely or by surrogates changes the way science is done and certainly

36. Ibid., pp. 9–11.

37. David DeVorkin, *Race to the Stratosphere: Manned Scientific Ballooning in America* (New York: Springer-Verlag, 1986).

changes the experience of the scientist, much as the telephone changed how we communicate. A more obvious approach might be to compare designs of instruments flown on different vehicles, looking for changes or shifts that are only understood in terms of the capabilities of the vehicle. These and other questions can be asked by historians of space artifacts, whether they be launch vehicles, manned or unmanned craft, subsystems, or instruments.

Historians of this contemporary scene might be more interested in issues such as how nations achieve new levels of capability or performance (as with Campani's lenses), how design variations reveal compromise, or how adaptations were made to existing technologies to make them work in the space environment or to survive launch or landing. But unlike the study of Campani's lenses, it is doubtful that the space historian will ask these questions of the artifacts themselves.

Indeed, one usually finds questions directed to the nature of the individuals or organizations that produced the technology. Among historians contributing to the *Osiris* volume "Instruments" in the early 1990s, Robert Smith and Joseph Tatarewicz represented space history, showing how the technical complexity of the Hubble Space Telescope not only symbolizes the complexity of the institutions and motivations involved in creating the thing, but also revealing how these motivations were often in conflict. It is clear from their study of how the largely untested charge-coupled device (CCD) became the detector of choice for the critical Wide Field/Planetary Camera that one can only hope to understand the ultimate technological artifact through the interactions of conflicting institutional priorities between science, the military, and NASA, each possessing different goals, different resources, and different agendas.[38]

This study of the CCD and the complexity of HST gets about as close to the artifact as I have seen in the literature of space history. It is typical of a small but hopefully growing literature that uses some characteristic of the hardware to inform a larger story. But the majority of the literature of space history is still rather far from this sort of treatment. Major characteristics include early practitioner histories, going into great detail describing examples of early rocketry and speculative space vehicles but asking few, if any, questions about them that informed broader historical interests. The NASA-sponsored histories of the 1970s, '80s, and '90s focused, correctly, on the elucidation of missions and the application of broad technologies, rarely focusing on specific examples of the technology and questions about their origin and application. Among the synthetic reviews and disciplinary histories, one often finds descriptions of objects, who built them and why, and what they did, but

38. Robert W. Smith and Joseph N. Tatarewicz, "Counting on Invention: Devices and Black Boxes in Very Big Science," *Osiris* 9 (1994): 101–123.

rarely, if ever, is an artifact in a collection at the center of attention or used in any explicit way in the analysis.

One can find this attitude explicitly stated in some of the papers from the XIX Scientific Instrument Symposium in September 2000, held in Wadham College, Oxford, where a session was devoted to "Instruments in the 20th Century," organized by Paolo Brenni. Speakers said the usual things, like how instruments might provide useful information when other documentation is lacking, but gave no hint in their abstracts of the kind of information one might extract from an instrument other than suggesting that one look at an instrument or actually use it in performing an experiment. The most refreshing remarks about the value of collecting were made by Roland Wittje, who pointed out that any collection of 20th-century instrumentation was for purposes of exhibition and not for the study of history.[39] In other venues, historians have said much the same thing. Marvin Bolt of the Adler Planetarium and Astronomical Instrument Collection, echoing a strong and persistent theme among educators, presented demonstrable evidence for how historical replicas can reveal physical and chemical processes more simply than modern devices. Others concentrated on how, reflecting Hindle, an encounter with an historical object can stimulate greater interest in the subject matter surrounding the actions of that device and the efforts of their human creators and users.

We have touched on Hindle's experiential argument before. It continues to appear in a wide range of studies. An excellent example is Paul Forman's recent study of three mechanical wave guides from I. I. Rabi's early research program that were part of the museum's accession of his materials after his death and his office was cleaned out at Columbia. Paul was already interested in Rabi, of course, but, stimulated by the existence of these relics, he realized that their survival after all these years confirmed that Rabi regarded these early experiments very dearly and saved the devices as a result, even though they were completely overshadowed by his later work that won him the Nobel Prize. This encouraged Paul to search out the nature of his early work, and he found it to be more significant than hitherto realized. These wave guides also confirmed designs previously known only from publications.[40]

At the same 1999 Artefact Conference where Paul Forman reported on Rabi's devices, Paul Ceruzzi recalled an incident where someone examining a circuit board recognized that it was probably designed by the legend-

39. Roland Wittje, "How Can Scientific Instruments Teach the Historian about 20th Century Physics?" in *Session VII A: Instruments in the 20th Century*, session abstract, *http://www.sic.iuhps.org/conf2000/ox_s07a.htm* (accessed 18 January 2005).

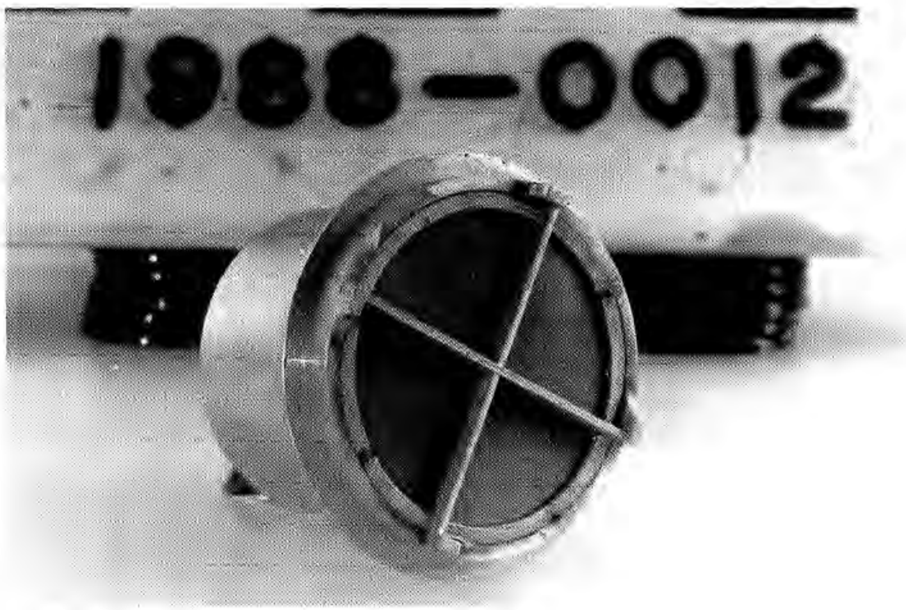
40. Paul Forman, "Researching Rabi's Relics: Using the Electron to Determine Nuclear Moments Before Magnetic Resonance," in *Exposing Electronics*, ed. Bernard Finn, Robert Bud, and Helmuth Trischler (Netherlands: Harwood, 2000), pp. 161–174.

ary Seymour Cray because it had specific design earmarks that Cray had pioneered, specifically his "cordwood packaging" technique that achieved greater densities than hitherto attained. There were no markings on the board other than the known fact that it was part of a military mainframe called the Naval Tactical Data System, or NTDS, built by Sperry. This was a highly specialized machine known only within military circles, and nothing was known about its design. It was also not generally known that Cray worked for Sperry, although he left Sperry before the NTDS was delivered. There is little in the published record linking Cray to the NTDS—no reference in the technical manuals or other contemporary descriptions. In presenting this analysis of a design style and using it to discern design origins in other computing devices, Paul examined a CDC 3800 acquired by the National Air and Space Museum, finding the same packaging design, even though no documentation has yet been found identifying it as a Cray design. Paul describes this as a "reading of the text of the machine itself" and is using it as a guide to search for traditional documentation.[41]

"Reading the text of the machine itself" includes many other areas beyond the survival, existence, or design style of a device, but quite frankly, it is a circumstance that is not as common as one might like. However, there are ways to increase the chances that a reading of an artifact will result in new, useful knowledge. Here I offer two examples from my personal experience: one involves documentation efforts, and the other involves exhibit preparation. Both, by their nature, required the survival, existence, and availability of artifacts.

The first example deals with the use of video to document objects. In the late 1980s, the Smithsonian decided to experiment with the use of video recording to better document its collections. This program, sponsored by the Sloan Foundation, brought together artifacts with their makers and users. As part of this effort, between 1988 and 1990, I interviewed sets of scientists and technicians who had been involved in space research at the Naval Research Laboratory from the 1940s through the 1980s. During the course of these interviews, sessions were devoted to voice-overs of a series of slow pans through laboratories and workspaces, followed by on-camera "enactments" and, following that, by direct examination of artifacts, mainly x-ray and ultraviolet detectors, collimators, and other elements of flight systems. I could fill many pages with examples of how this experience produced evidence that documented the interface between an instrument and its builder, as well as the interaction between the instrument and the laboratory environment within which it was designed and tested in prototype fashion. We documented design

41. Paul Ceruzzi, "The Mind's Eye and the Computers of Seymour Cray," in *Exposing Electronics*, ed. Finn, Bud, and Trischler, pp. 151–160.



Typical x-ray ionization chamber designed, built, and used by the Naval Research Laboratory team on sounding rocket flights in the 1950s and early satellite systems. *(File no. A1988-0012000, NASM Curatorial Files)*

choices, instrumental styles, experimental procedures, and testing methodologies, not merely through reminiscences, but through recording the tactical connection between instrument and builder. On one occasion, one scientist demonstrated the methods used to fill halogen Geiger counters with gas and then test them for sensitivity. He used a contemporary filling station as a backdrop, but his hands twisted invisible dials and stopcocks as if he was using one from the 1950s. They were literally imprinted in his tactile memory. These explorations of working environments gave body to other sessions where the people who built these detectors talked about them while they handled them. Edward T. Byram was faced with many detectors he had built, laid out on a table in front of him. He rarely took his eyes off the detectors during the interview, and when asked if his efforts making these devices work properly were frustrating, he replied: "I was never frustrated. I enjoyed fighting them. It wasn't a frustration, it was a challenge. It was mind over Geiger tube."[42] His behavior matched his rhetoric—throughout the interview, Byram's gaze

42. E. T. Byram, quoted in David H. DeVorkin, "Preserving a Tool-Building Culture: Videohistory and Scientific Rocketry," in *A Practical Introduction to Videohistory*, ed. Terri A. Schorzman (Malabar, FL: Krieger Publishing, 1993), pp. 125–137.

Early halogen counter with an entrance window of mica, capable of sensing ionizing ultraviolet radiation. Note the suspended anode just behind the mica window. This is a tube similar to the one Kreplin tapped during his video-history interviews. *(File no. A1988-0010000, author digital file, NASM Curatorial Files)*

remained on the tubes. Obviously, he was still very attached to them, attached to devising ways to adhere exotic radiation entrance windows onto their shells and ways to ensure that the halogen gas mixtures he was filling them with did not leak or cause the seals to deteriorate. And finally, one of Byram's colleagues, Robert Kreplin, was also asked to talk about the tubes he built. He held an early example while he talked, and in the review, I noticed that as he discussed ways to test the mechanical integrity of these detectors, which had to survive the launch of a rocket, he instinctively tapped the side of the tube and peered through the mica window at a small protruding wire anode. His tapping was reminiscent of the group's concern for the survival of the anode, which in later models was supported at both ends.[43]

Although my basic goal for these interviews was to produce a collective profile of what I deemed to be a tool-building culture at the Naval Research Laboratory and to explore aspects of that culture, I also came away with a better appreciation for how these people organized themselves, raised issues and

43. Image of Kreplin holding a tube, in DeVorkin, "Preserving a Tool-Building Culture," p. 134.

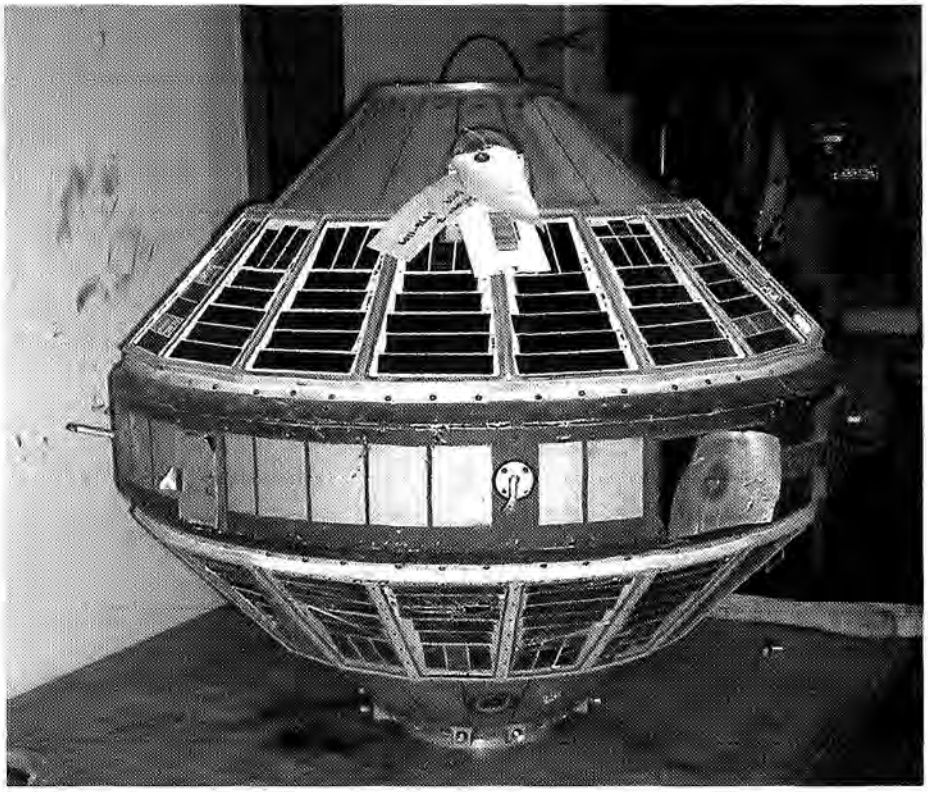
problems, and dealt with outside entities first in the Navy and then at NASA. In a very definite, though not explicit, way, I feel that the surviving artifacts that we interrogated, and which are now in the collection, stimulated memories and physical responses and led to discussions between team members that rekindled behaviors that I could actually discern. From this vicarious experience, I feel I gained a fuller portrait of this tool-building culture.

As my second example of the stimulus generated by a surviving artifact, I turn to recent activities preparing for NASM's new Udvar-Hazy Center. Curators had an unprecedented opportunity to examine a significant portion of the collections in a process that included improving documentation, preservation techniques, and methods of monitoring them, since from now on they will be on permanent display/storage. In the past, various factors have limited our access to these objects. They were stored off-site, sealed and boxed up, and required manpower and coordination for examination. One of the dozens of objects I had never had the chance to fully inspect was a model of the Explorer VII satellite identified as a "full scale replica." It had been acquired on paper in 1976, inventoried several years later, but never actually examined at the Alabama Space and Rocket Center, where it was presumably on display. It finally was shipped to the Garber Facility in 1989. It was quickly inspected, but the box was never actually opened, nor were the insides of the object inspected. As a replica, it was, frankly, not of great interest. As to documentation, we were left with hardly more than a shipping document.

In the years leading up to preparation for the Udvar-Hazy facility, our department's sensitivity for the critical importance of adequate documentation vastly improved. Udvar-Hazy afforded me a chance to acquire intimate knowledge of a set of early satellites and the scientific instruments they hopefully contained, so I opted to examine Explorer VII as part of a suite of first-generation geophysical satellites.

Typically, anything marked as a mock-up or replica or even reconstructed satellite is not going to contain actual flight hardware, so I was really not expecting much. However, many of those objects hauled out and destined for Udvar-Hazy labeled replica or model have turned out to be very real. Based upon my experience with the videotaping of NRL detectors, I quickly realized that the detectors in the skin of Explorer VII were, in fact, real. One detector had a clear entrance window revealing a small chamber that had a single wire on the cylindrical axis, just like the one Kreplin was tapping. Explorer VII may well have been a flight backup, which means that everything about it is real. Documents in our technical files in the NASM library confirmed that the detectors were indeed built by the NRL group, and other elements of the craft closely matched the descriptions in an extensive Technical Note.

None of this effort would ever have been made if I had not been compelled to answer detailed questions raised by an intimate inspection of an



Explorer VII before cleaning and evaluation. Note that the artifact inventory tags were tied to a damaged x-ray detector similar to those examined at the Naval Research Laboratory and recorded during video-history sessions. See the image on page 593 for an intact example. *(File no. A1978-1109000, author digital file, NASM Curatorial Files)*

artifact. Explorer VII is interesting as a representative of the state of technology available for multifaceted studies of solar radiation and the nature of the low-Earth-orbit environment in the late 1950s. As with any early flight, there were some technical "firsts" and at least one first for science: the detection of micrometeorite impacts. But whether or not the remnants of the craft itself reveal anything beyond what is still available from our technical files, at NASA, in our archives and oral histories (with people like Herbert Friedman and James Van Allen, another instrument principal investigator on Explorer VII), or from the published literature, it remains a fact that in the process of inspection and evaluation, more documentation was gathered and consistently filed away than was available before, and hence is likely to be retrievable in the future. Scattered documentation was collected, recorded, and filed away, hopefully someday to be of use in some unpredictable way, stimulated by motivations that we cannot predict. My contention is that the motivation would come either from the recognition someday that this was a watershed flight in space history (the first application of passive techniques of thermal stabilization) or that an artifact that has survived in a major collection calls out, by its very existence, for attention to the fine structure of nuts-and-bolts history, for only through such efforts is a full picture of the nature of the first years of true space research likely to emerge.

SO, WHY COLLECT?

As I prepared my remarks for the "Critical Issues" conference, I queried colleagues at NASM, asking them questions stimulated in part by Corn's findings but also by my inability thus far to find unequivocal evidence of how an object relating to space history has actually been used as a source of historical knowledge. I also queried aeronautics curators as a cursory check on a collecting area where documentation tends to be not as rich or institutionally based. In general, the responses confirmed the impressions I was getting from the literature and from experience. Curators (John Anderson, Michael Neufeld, Ron Davies, Tom Crouch, and Jeremy Kinney) typically felt that direct and personal experience with an artifact stimulated them to make historical inquiries. Neufeld, in particular, felt that an encounter with an historical object can stimulate intellectual interests and makes the past seem more real, less dry and distant even for academic historians, but how much they drive any historiography is questionable. Others, like Tom Crouch, felt that they learned from these inspections and gained important intellectual insights. For Crouch, "interpretation . . . was in large measure based on a combination of examining the objects and knowing the documentary record." Jeremy Kinney reported that what he learned from his detailed inspection of variable pitch propellers in the collection is reflected in his publications in significant ways, but that his physical inspections largely confirmed textual descriptions in primary sources. All felt more or less strongly that the survival of artifacts could be a stimulus to researching and writing history. Artifacts provide information on design and shop practices that run hand in hand with the intellectual methods of aeronautical engineering. As for the limits on collecting and the importance of the survival of the "real thing," Tom Crouch added that it is impossible to preserve all the details of a machine (the written and visual records are approximations); close examination always reveals more detail—small mechanical details. For Crouch, one of the museum's failings is the lack of attention to machine tools and production machinery—transitions from one medium (wood) to another (metal) and from metal to modern composite materials are always constrained by fundamental changes in tooling and production machinery. Reflecting issues raised by Warner and others, he also sees a problem with collecting "black boxes" if it is not possible to "turn them on" and examine their behavior. Finally, reflecting Jim Bennett's qualification cited under the title to this essay, he suggests that we all have to consider carefully what we collect for exhibit and what we collect for research—these are not necessarily the same class of object, and selection rules may tend to be very different.[44]

From the arguments so far reviewed from the literature, from the responses of my Museum colleagues here, and from my own experiences, what conclusions do I draw as to the value of collection and preservation? Here is a brief summary of my impressions. Objects can provide the following:

1. Validation—material proof that something happened in space history (Hindle). This requires solid information on provenance, however, and requires as well that the object that is experienced by the visitor was actually the very same one involved in the historical episode it preserves. Collections in space history are rather peculiar in that, as often is the case, the actual historical object that performed the act or the function deemed worthy of note is not accessible—it has been used up or lost in the process of conducting its business, or, simply put, it is still "up there" where we put it, and we have no known means or the wherewithal of retrieving it. There are very notable exceptions, of course: vehicles that have returned to Earth as part of their mission or, even rarer, have been returned to Earth through some conscious act unrelated to the historical event or process that made it noteworthy. For all the rest, we are left with some form of surrogate: an exact flight backup, just like the flight model in every way except that it, in and of itself, did not experience the final act of making history but was still very much a part of that history. It had a role in that process but definitely comes in second place. Third place are various levels of engineering models and mock-ups, reconstructed replicas using parts that were fabricated out of the same computer program, melt, or block. And a distant fourth is all sorts of replicas or reproductions. Are these approximations merely surrogates for the "True Cross," or does each and every one of them tell a particular story that is available no where else in quite the same way? What does their existence, and their survival today, reveal about the culture in which they were made?

2. Celebration—sense of transcendence promoted by physically encountering an object that made history. Accompanies commemorative

44. Responses to curatorial questionnaire, author files, copy available in chronological publication files, NASA Historical Reference Collection, Washington, DC.

or memorializing events, lends visibility and weight to these efforts (NASM legislation).

3. Inspiration—evidence of challenges met or exceeded, handicaps overcome, struggles vindicated. Promotes insight into ways to illustrate basic principles of science and technology (Multhauf, Corn, Bolt).

4. Illumination—preserves something about an historical event, era, or trend that, when means of interpretation are devised, provides additional knowledge that otherwise would not be available. Objects can survive for specific reasons, and searching out those reasons illuminates history (Corn, Lubar, Ceruzzi, Forman).

5. Stimulation—the preservation of an object stimulates interest in it and efforts to learn about it and the history it symbolizes or represents. It also obligates those responsible for its curation to ensure that adequate documentation is collected and preserved to understand it in the future (Explorer VII, Forman, curatorial questionnaire).

Of course, neither celebration nor inspiration actually requires the survival of an artifact, though it would clearly help. Even illumination and stimulation are possible without the real thing, though impact would be even more restrictive. Nothing but the actual object, however, can provide validation—no facsimile, replica, reproduction, or description will ever suffice, although the survival of any of these items still stands testimony at some level.

AFTERWORD

If the survival of an artifact is useful to history in any of the five categories listed above, one still has to look beyond history to the institutions that house and somehow represent it to ask how they react to the suggestion that collections are important to their own survival. In a recent Smithsonian survey cited as significant by the *Washington Post*, 60 percent of the respondents claimed that they were visiting the Mall museums to see "the real thing," whether it is Dorothy's red shoes or the Apollo 11 capsule.[45] The *Post* itself was concerned with what motivates programming at the Smithsonian in its efforts to overcome the tourist slump after 11 September 2001. Ironically, the part of

45. "Smithsonian Institution Office of Planning and Analysis Report" (internal document, 2004), quoted in J. Trescott, "The Smithsonian's Concession to the Bottom Line," *Washington Post* (13 April 2005): A1, A8.

the Smithsonian being covered by the *Post* reporter and as reported by her, its Business Ventures arm, responded as if this fact gave it a "mandate" to push IMAX films, simulators, jazz concerts, and anything else it could imagine would raise revenues. The irony was, unfortunately, lost on the *Post* reporter. Yet the fact remains, the public, when asked in this instance, reified "the real thing" just as Hindle argued it should. This runs counter to opinions voiced by museum watchers and critics in studies over the past several years, who have claimed that, in the face of theme parks and Disneylands, public tastes have shifted "to immersion in an environment, to an appeal to all the senses, to action and interactivity, to excitement, and beyond that to aliveness." And in response to this shift, many modern museums have "shifted their allegiance from real objects to real experience."[46] Oddly, these are just the sorts of experiences that, at least in the case of Smithsonian Business Ventures, a museum can charge money for. No one knows if it is a viable strategy for long-term survival of these institutions as collecting agencies.

46. Randolph Starn, "A Historian's Brief Guide to New Museum Studies," *American Historical Review* (February 2005): 92 (citing statements by David Lowenthal and Hilde S. Hein).