Section I

Societal Impact of Spaceflight in Context

Chapter 1

Has Spaceflight Had an Impact on Society? an Interpretative Framework

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As a person who works with political scientists, I must confess that the effort to assess the societal impact of spaceflight reminds me a bit of the story about the mayor who reduced crime. You may recall that Rudolph Giuliani, the get-tough-on-crime U.S. attorney for southern New York State, narrowly defeated incumbent David Dinkins for the New York City mayoralty post in 1993. At the time, crime in New York City seemed to be out of control. Giuliani embraced the "broken window" theory of crime prevention, drawn from a 1982 article by James Q. Wilson and George L. Kelling and promoted by William J. Bratton, Giuliani's head of police. In essence, the theory suggests that tolerance of low-level vandalism (broken windows) encourages additional petty crime and eventually more serious offenses. Giuliani and Bratton adopted a "zero-tolerance" policy toward petty crimes such as graffiti marking, subway turnstile jumping, and "squeegee men" who demanded payment for cleaning the windshields of automobile drivers stuck in traffic. Upon implementation of the policy—a turning point in the history of New York City—crimes rates dropped suddenly and dramatically and continued to fall thereafter.[1]

The story set off a frenzy of methodological investigation among social scientists interested in the societal impact of Rudolph Giuliani's policy toward crime. From the scientific point of view, Giuliani had proposed a theory. As good social scientists, analysts used the tools of statistical analysis and econometrics to compare the explanatory power of Giuliani's theory relative to other theories of crime. The findings become elaborate at this point, but in general were not kind to the idea that Giuliani's zero-tolerance policy affected crime. For example, economist Steven D. Levitt with co-author Stephen J. Dubner suggest that the drop in crime could more easily be explained by demographic factors such as a decline in the number of angry young males.[2]

1. James Q. Wilson and George L. Kelling, "Broken Windows," *Atlantic Monthly* (March 1982), pp. 29–38.

2. Steven D. Leavitt and Stephen J. Dubner, *Freakonomics: A Rogue Economist Explores the Hidden Side of Everything* (New York: William Morrow, 2005); see also George L. Kelling and Catherine Coles, *Fixing Broken Windows: Restoring Order and Reducing Crime in Our Communities* (New York: Martin Kessler, 1996).

I was reminded of the Giuliani story while scanning back issues of NASA's *Spinoff* publication. For the past 30 years, NASA's Commercial Technology Program has produced a book-sized publication that annually lists 40 to 50 space technologies adopted by the commercial sector. The effects imputed to the Apollo flights to the moon alone are impressive. According to the publication, Project Apollo contributed to the development of computed axial tomography (CAT) scan machines, kidney dialysis, cordless power tools, athletic shoe designs, freeze-dried foods, and the cool suits worn by National Association for Stock Car Auto Racing (NASCAR) race drivers. In total, NASA officials have identified 1,400 space technologies that have "benefited U.S. industry, improved the quality of life and created jobs for Americans." I must admit that I approach such claims of societal impact with the same degree of skepticism that social scientists direct at Giuliani's theory of crime prevention. Perhaps the NASA Space Flight Program gave us freeze-dried foods and other such benefits; perhaps it did not. Without extensive investigation of a scientific sort, it is difficult to tell.[3]

In some ways, claims of societal impact tell us more about ourselves than they do about the societal changes we think we observe. Giuliani's theory, embraced by the few Republicans remaining in a hugely Democratic city, might say more about the social preference of upper-middle-class Americans for neatness and order than the prevention of crime. Giuliani's zero-tolerance policy may or may not have affected a drop in crime, but it did make New York City a friendlier place for middle- and upper-middle-class families. In a similar way, images of the space program reveal much about the fabric of American society. The images tell us a great deal about who we think we are and where we believe we might like to go.

In preparing *Space and the American Imagination*, I concentrated on the latter.[4] I tried to place visions about space travel, which are plentiful, into the broader context of the social movements upon which they draw. Thus, efforts to view space as the "final frontier" could be viewed as an attempt to revitalize the values thought to flow from the experience of westward migration in North America. The fact that so many advocates of spaceflight emphasize the frontier analogy says something about the impact they would like to have upon American society. The next step, obviously, requires an examination of the impact that the experience actually produces relative to the expectations proffered.

Both subjects—the study of impacts and the examination of expectations—present methodological challenges. In this chapter, I will comment upon those challenges and the manner in which they affect our effort to understand the societal impact of spaceflight. The chapter deals with the methodological challenges presented by efforts to understand the material consequences of spaceflight, its cultural effects, and its unanticipated consequences.

3. NASA Scientific and Technical Information (STI), "Apollo's Contributions to America," 21 October 2005, *http://www.sti.nasa.gov/tto/apollo.htm* (accessed 27 August 2006).

4. Howard E. McCurdy, *Space and the American Imagination* (Washington: Smithsonian Institution Press, 1997).

Assessing Impacts

Among the 1,400 spinoffs ascribed to the U.S. civil space program, one of the most interesting involves the relationship between spaceflight and the computing industry. The relationship illustrates the difficulties of assessing impact. NASA scientists and engineers installed integrated circuits (ICs) in their lunar and planetary spacecraft prior to the widespread use of these devices. The people designing the Apollo flight computer, for example, incorporated ICs—an achievement driven by their realization that clunky, universal automatic computer (UNIVAC)-type computing machines would be too large for a spacecraft with severe mass constraints. The consequent utilization of ICs for a wide range of Earthly applications has been called "one of the most significant occurrences in the history of mankind."[5] It is tempting to see a relationship between spaceflight and the IC/personal computer (PC) revolution, and one can find occasional references to PCs as a spinoff of the space program, along with Teflon® and Velcro® straps.[6]

As might be anticipated, the actual relationship between spaceflight and computing is more complex. No simple cause-and-effect relationship can be shown. As the author of one NASA History Office publication concludes:

> Since NASA is well known as an extensive user of computers—mainly because spaceflight would not be possible without them—there is a common sense that at least part of the reason for the rapid growth and innovation in the computer industry is that NASA has served as a main driver due to its requirements. Actually, the situation is not so straightforward. In most cases, because of the need for reliability and safety, NASA deliberately sought to use proven equipment and techniques . . . [G]eneralizations cannot be made, other than that there was no conscious attempt on the part of NASA in its flight programs to improve the technology of computing.[7]

Social scientists view statements about impacts arising from historical events with a great deal of suspicion. Methodologically, such statements take the form of interrupted time-series analysis. This is one of the weakest forms of policy analysis and one that social scientists often urge investigators to avoid. When done in a retrospective fashion, the technique can be quite misleading. Knowing that a change in society followed a

5. Wikipedia, "Integrated Circuits," *http://en.wikipedia.org/wiki/Integrated_circuit*, 25 August 2006 (accessed 27 August 2006).

6. See John Savard, "Microcomputers as a Space Spinoff," *http://www.gatago.com/sci/space/policy/21491345.html*, 27 June 2006; and Eleanor A. O'Rangers, "NASA Spin-offs: Bringing Space Down to Earth," http://www.space.com/adastra/adastra_spinoffs_050127.html, 26 January 2005 (both accessed 27 August 2006).

7. James E. Tomayko, *Computers in Spaceflight: The NASA Experience*, NASA History Office, Contractor Report 182505, March 1988, p. 2.

turning point in no way verifies that the event caused the change. The change could be due to other factors or it could have occurred in the absence of the intervening event. Absent statistical controls or experimental methods, it is quite impossible to know.

Policy analysts utilize a number of techniques that compensate for the limitations of interrupted time-series analysis. They engage in comparative studies; insist that statements about cause and effect be grounded in theory; and require analysts to derive predictions from the hypotheses proposed.

Comparative analysis helps to remove many of the shortcomings associated with the study of societal impacts. Conclusions drawn from a single set of events in a single society are the equivalent of hypotheses tested using a sample of one. Such tests have a wide margin of error. The incorporation of information from other settings can broaden the analysis and enhance its reliability. What may appear to be anomalies in one setting may seem common when viewed comparatively. The unexpected difficulties of producing a large, cheap, reliable space shuttle in the United States were repeated with the Soviet Buran spacecraft, which turned out to be so expensive that Soviet officials abandoned the program. Conversely, what appears to be common may turn out to be unique. One of the universal benefits of human spaceflight, for example, is thought to be national prestige. This has both external (impressing other nations) and internal (building national confidence) dimensions.[8] Assessing whether such activity actually produces such effects can be enhanced by examining the process in many nations, including the reactions of those that do not engage in human space travel. What seems to be generally believed (that spaceflight confers prestige) can be tested for its effects. Comparative work of this sort is underway by Asif Siddiqi, James T. Andrews, James Hansen, and Margaret Weitekamp, and much of it appears in this publication.

Grounding statements in theory and making predictions based on those theories also helps. The history of spaceflight suffers from no lack of predictions; notoriety often flows to those persons whose predictions turn out to be true. One of the most notable is Arthur C. Clarke's anticipation of communication satellites, famously presented in a 1945 edition of *Wireless World*. In that publication, Clarke pointed out that a communication station placed in geostationary orbit "could act as a repeater to relay transmissions between any two points on the hemisphere beneath" and that three such stations would provide "complete coverage of the globe." Clarke did not actually predict the use of such stations—"[S]uch an undertaking may seem

8. See John M. Logsdon, *The Decision to Go to the Moon: Project Apollo and the National Interest* (Chicago: University of Chicago Press, 1976) and Roger D. Launius, "Compelling Rationales for Spaceflight: History and the Search for Relevance," in *Critical Issues in the History of Spaceflight*, Steven J. Dick and Roger D. Launius, ed. (Washington, DC: NASA SP-2006-4702, 2006), pp. 37–70.

fantastic," he said—but, rather, pointed out its feasibility and advantages relative to ground-based transmitters. Nonetheless, the article is generally credited as having anticipated the use of communication satellites and is often presented as part of narratives assessing the impact of such.[9]

Regrettably, such statements are not very helpful in assessing societal impact—even when the statements are true. A correct prediction offered in the absence of a supporting theory is as unreliable as an ex post facto statement about cause and effect. Such a prediction is subject to a number of methodological pitfalls, the most striking being what is known as the "Jeane Dixon effect." Dixon was a psychic who famously predicted the election and assassination of President John F. Kennedy. John Allen Paulos, a Temple University professor and commentator on the general public's misunderstanding of mathematic principles, noted how the science of probabilities ensures that someone like Dixon will make a fair number of correct predictions if that person makes a sufficiently large number of forecasts. Adding to the accumulated tally of her errors, Dixon predicted that World War III would begin in 1958; that labor leader Walter Reuther would run for president in 1964; and that the Soviet Union would win the race to the Moon.[10] The Dixon effect refers to the tendency of observers viewing events with the advantage of hindsight to overlook false forecasts while applauding the ones that did come true.

By grounding a prediction in theory, the suggestion of cause and effect can be assessed twice. The effect can be checked on the basis of whether or not it occurred and the theory can be checked for its underlying logic. A correct prediction, such as those that Dixon did make, cannot be judged to reveal an effect if the underlying theory is flawed. Dixon derived her predictions from the practice of astrology, a clearly misdirected theory. Clarke offered his speculations regarding communication satellites without regard to any theory at all. Like numerous other pieces anticipating some development in spaceflight, Clarke's article speculates neither on the likelihood that his proposal might be adopted nor on the possible impact of worldwide communication. He merely comments on the technical feasibility of orbiting communication stations and predicts that the coverage they would provide would be cost-effective relative to the ground-based systems the stations would replace. It should be noted, in this respect, that Clarke also predicted that his communication platforms would take the form of space stations with people on-board and that their development would be expedited by the use of nuclear-powered rockets by 1965.[11]

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9. Arthur C. Clarke, "Extra Terrestrial Relays: Can Rocket Stations Give World Wide Radio Coverage?" *Wireless World* (October 1945), p. 306. See also Irving Fang, *A History of Mass Communication: Six Information Revolutions* (Boston: Focal Press, 1997), p. 210, and Donald H. Martin, *Communication Satellites*, 4th ed. (El Segundo, CA: Aerospace Press, 2000).

10. John Allen Paulos, *Beyond Numeracy: Ruminations of a Numbers Man* (New York: Alfred A. Knopf, 1991), p. 40.

11. Clarke, "Extra Terrestrial Relays," pp. 306, 308.

A sound assessment of societal impact is enhanced to the degree that the analysis is rooted in sound theory, derives testable predictions from the theory, and utilizes more than one case as a basis for testing the statements proffered. Such standards are hard to apply to the material effects of spaceflight, such as commercial products or applications in the realm of national defense. Assessing cultural impacts is even more challenging.

CULTURAL EFFECTS

Events in spaceflight have social, cultural, and ideological effects. In many ways, these are more interesting than the material spinoffs from the space program, since they involve both imagination and effect. In an odd sort of way, the effects of spaceflight influence their causes. Put more simply, what people imagine might happen in space serves as a basis for making it occur. The anticipation of cultural impacts thus provides the motivation to undertake the activities necessary to produce the change. Many chapters in this book are concerned with the social, cultural, and ideological effects of events in space.

The cultural effects of spaceflight (a term meant to also include social and ideological effects) bounce between the relativism inherent in postmodern analysis and the reality of space physics. Postmodern analysis postulates the notion that people ultimately determine the types of worlds in which they live through the thoughts they have; physics presents principles that are hard to violate. One is relative, the other deterministic.

By imagining space or, more specifically, anticipating the events that will occur there, people may shape their future. The direction of that shaping can be conservative or radical. I would like to suggest that the dominant forms of spaceflight anticipation, especially in the United States, are conservative. In America, expectations about space have been offered as a means of reinforcing the dominant values in society, including many that existed before space travel began. This may help to explain why modern conservatives are more supportive of space exploration than are American liberals.

Expectations regarding the cultural effects of spaceflight are often expressed metaphorically. Metaphors are figures of speech that contain an implied comparison, easing the challenge of explaining strange and often unfathomable phenomena to an often inattentive public. The comparison of spaceflight to terrestrial expeditions of discovery, for example, casts the complexity of interplanetary travel in terms the general public can more readily understand. In the United States, spaceflight has been described using metaphors that characterize the most salient features of American life. The metaphors are many. The exploration of space, we are told, will be like frontier life—resurrecting the experience of westward migration in an extraterrestrial realm. The exploration of space will provide sources of business opportunity in the same way that industrial and postindustrial developments gave the United States the most prosperous economy in the history of the world. Space

will be the new military "high ground," similar to the Roman roadways and the aviation hardware that conferred national power upon the nations that pursued the supporting technologies. Spaceflight—or at least the investigative part of it—will help to maintain the scientific revolution that made empiricism the primary means for studying natural phenomena. Spaceflight will continue to serve as a demonstration of national prowess, in the same manner that expositions and world fairs have provided national demonstrations of technology. Spaceflight will allow a "revenge of the nerds," elevating the status of people who did not have much social standing during their adolescent years. These metaphors confer expectations regarding the impact of spaceflight, especially in America.

Although the use of metaphors eases the task of explaining prospective impacts of spaceflight, it also gives those expectations a distinctly conservative flavor. If spaceflight continues over many centuries, it might produce transformations as radical as those that the Renaissance imposed on the medieval world. Spaceflight might lead to fundamental alterations in the human species, or to scary new discoveries that result in a total reorganization of society. It might be like nothing we have ever experienced before. Science fiction writers such as H. G. Wells, Isaac Asimov, and Arthur C. Clarke have explored some of these possibilities.[12] The dominant metaphors (at least those presented in the United States) do not anticipate radical change. Instead, the American vision of spaceflight promises to conserve the values associated with the continental frontier, our business civilization, the scientific revolution, national security, overall progress based on technology, and the tendency to elevate scientists, engineers, and other experts to positions of power in society. Collectively, these are distinctly American values.

The rhetoric of spaceflight demonstrates the presence of these expectations, at least in the United States. America is thought to be a frontier nation, with many of its characteristics shaped by the presence of open land and the absence of established institutions such as those found in feudal Europe. The innovative spirit, the preference for democracy, and the absence of social barriers that would otherwise impede cooperation and perpetuate inequality are all thought to flow from the American frontier. At least, that is how it has appeared to many of the people whose European ancestors arrived in America after 1600.[13] Space travel is commonly presented as a means of extending

12. See the concepts of evolutionary biology in H. G. Wells, *The Time Machine and War of the Worlds*, Frank D. McConnell, ed. (New York: Oxford University Press, 1977); global transformation in Arthur C. Clarke, *Childhood's End* (New York: Harcourt Brace & World, 1953); and psychohistory in Isaac Asimov, *Foundation* (New York: Gnome Press, 1951). For an analogous view, also see Ray Kurzweil, *The Singularity Is Near: When Humans Transcend Biology* (New York: Viking, 2005).

13. Frederick Jackson Turner, "The Significance of the Frontier in American History," in John M. Farager, *Rereading Frederick Jackson Turner* (New York: Henry Holt, 1994).

these traditions. "Without a frontier from which to breathe new life," Robert Zubrin argues, "the spirit that gave rise to the progressive humanistic culture that America has represented for the past two centuries is fading." Zubrin advocates the settlement of Mars as a means of perpetuating the values associated with the American frontier.[14]

According to political scientist Dwight Waldo, America is a distinctly business-oriented civilization. This is a central feature of American life. Wealth and power flow from the strength of business enterprise and the corporations around which the economy is structured. Not surprisingly, Americans advocate corporate methods as the best means for organizing the global economy and the government bureaucracies that regulate it. Americans also anticipate the extension of business activities into space. In 2001, journalist Lou Dobbs announced that space will provide the next great business frontier; it will create "entirely new forms of technology, new forms of manufacturing, new forms of recreation, and even new materials," he said. According to this prophesy, space commerce will provide business opportunities as large as those emerging from the Internet revolution, and will cease to be the province of government agencies interested primarily in science and exploration. In this sense, spaceflight serves to extend the values associated with corporate capitalism.[15]

America's status as a world superpower is largely based on a military apparatus that relies upon technology to project force and reduce risk. In this context, the cosmos is consistently represented as the new military "high ground." Senate Majority Leader and later President Lyndon B. Johnson embraced this point of view when he helped launch America's entry into space by declaring that "control of space means control of the world." Advocates of both robotic and human spaceflight continue to use national security arguments as a justification for U.S. supremacy in this realm.[16]

Americans are quintessential progressives, generally accepting the Promethean notion that progress as a whole is good for humankind and that such progress typically occurs through advances in science and technology. Historically, not all cultures have embraced the doctrine of progress through technology. Some groups elevate the attainment of spirituality through religious faith and salvation, a perspective that exhibits mosques and cathedrals rather than rocket ships as symbols of perfection. In the eighteenth century, the doctrines of natural rights and reason formed the basis for the concept of human perfection. Space travel and its various

14. Robert Zubrin, *The Case for Mars: The Plan to Settle the Red Planet and Why We Must* (New York: Free Press, 1996), p. 297. See also National Commission on Space (Thomas O. Paine, chair), *Pioneering the Space Frontier* (New York: Bantam Books, 1986).

15. Dwight Waldo, *The Administrative State: A Study of the Political Theory of American Public Administration* (New York: Ronald Press, 1948), p. 5; Lou Dobbs with H. P. Newquist, *Space: The Next Business Frontier* (New York: Pocket Books, 2001), p. 2.

16. Statement of Democratic Leader Lyndon B. Johnson to the Meeting of the Democratic Conference on 7 January 1958, Statements of LBJ Collection, Box 23, Lyndon Baines Johnson Library, Austin, Texas; see also Office of Science and Technology Policy, Executive Office of the President, The White House, "U.S. National Space Policy," 31 August 2006.

spinoffs emphasize a view of progress rooted in the Age of Enlightenment and the scientific revolution that accompanied it. These are cultural choices, unattached to any absolute requirement that human civilizations advance in one particular way.

The cultural manifestations of spaceflight also help to answer the classic social question: Who should rule? Throughout history, this question has been answered in different ways. In some societies, priests rule; in others, hereditary monarchs. Plato favored Guardians, who ruled on the basis of their innate understanding of the Good. The doctrine of technological progress favors rule by experts, in which scientists, engineers, and other experts employ objective methods to discover the "one best way" of organizing social affairs, typically accompanied by an emphasis on the need for efficiency in a machine-based civilization. The concept that experts should build and operate the machinery of a technological society seems intuitively obvious, but it is not a choice that has been pursued by all civilizations at all times.[17]

Two concepts help frame the use of metaphors as a means of explaining both past and anticipated impacts of spaceflight. One is the doctrine of American exceptionalism; the other is the vocabulary of postmodern analysis. The doctrine of American exceptionalism, rooted in works such as those by Alexis de Tocqueville, Frederick Jackson Turner, Louis Hartz, and Aaron Wildavsky, traces the power of the American experience to relatively unique material and social conditions. These include the absence of feudal institutions and the existence of an open frontier—conditions thought to encourage equality, cooperation, creativity, democracy, and a liberal tradition as the term is used in its classical, Lockean sense.[18] Spaceflight, in this regard, is presumed to provide an analogous force, encouraging the perpetuation of traditions thought to have made America unique. Without such a continuing force, advocates of the doctrine suggest, America will become more like the rest of the world. The doctrine of American exceptionalism is speculative and controversial, but serves as a larger framework through which the presumed impact of spaceflight can be examined.

Postmodern analysis provides a number of concepts useful for examining the manner in which imagination shapes future events. Proponents of this perspective emphasize the roles that the broadcast media and similar technologies play in decentralizing power and framing ideas within the public at large. Under these conditions, ideas are thought to take shape in the minds of the beholders and lack an

17. See Sylvia D. Fries, *NASA Engineers and the Age of Apollo* (Washington: NASA SP-4104, 1992); Homer H. Hickam, *Rocket Boys: A Memoir* (New York: Delacorte Press, 1998); Jeff Kanew, *Revenge of the Nerds* [film] (20th Century Fox, 1984), and Waldo, *The Administrative State*.

18. Alexis de Tocqueville, *Democracy in America* (New York: Vintage Books, 1954); Turner, "The Significance of the Frontier in American History"; Louis Hartz, *The Liberal Tradition in America: An Interpretation of American Political Thought Since the Revolution* (New York: Harcourt, Brace & World, 1955); Aaron Wildavsky, *The Rise of Radical Egalitarianism* (Washington: American University Press, 1991). See also Seymour Martin Lipset, *American Exceptionalism: A Double-Edged Sword* (New York: W.W. Norton, 1996).

objective reality. This is not a totally new concept and may be associated with periods other than the postmodern one. In separate works, Joseph Corn and Roderick Nash demonstrate the manner in which mental images have shaped the development of aviation and the American environmental conservation movement. Nash, in particular, shows how modern conservation required for its birth and sustenance a reformulation of the popular conception of wilderness. By reframing "wilderness" from a condition of savage peril to a citadel of spiritual renewal, writers and artists made new government policies possible. A similar process guided the history of aviation. People imagined effects from aviation that far exceeded the material benefits of this new technology and which, in turn, helped to elicit government support.[19]

Expectations regarding spaceflight are expressed through a number of forms familiar to people engaged in postmodern analysis. One is hyperreality, or the reappropriation of familiar cultural symbols through the mass media. Thus, Gene Roddenberry presented the original Star Trek television series not so much as a work of science fiction but as a reinterpretation of the Hollywood Western in an extraterrestrial setting. As his director's notes reveal, this was a deliberate decision. The Hollywood Western was a proven product; resetting it in space helped to ensure an audience for what might have otherwise been a quickly forgotten series.

The concept of simulacrum also guides postmodern analysis. This concept characterizes the process of making imperfect copies of original forms, as a paint-by-numbers kit might reproduce a work of art by Vincent Van Gogh. Visions of spaceflight abound with simulacrum, from winged spaceships that resemble jet fighters to robots that often resemble human beings.

Postmodern analysis provides a framework through which visions of spaceflight may be examined in a context that is larger than the subject itself. The postmodern concept of cultural relativism rejects the traditional notion that societies progress in predictable ways, as from agrarian to industrial, in favor of the more existential belief that people become what they choose to be. This directly contradicts the dominant interpretation in which spaceflight is seen as moving along a forward line of progress that nature provides.[20] The postmodern framework accepts aspirations for space travel as social creations that vary according to the predispositions of the beings that create them. These contrasting points of view add conceptual depth to what might otherwise remain a relatively narrow assessment of impacts in a single field.

19. Joseph J. Corn, *The Winged Gospel: America's Romance with Aviation, 1900–1950* (New York: Oxford University Press, 1983); Roderick F. Nash, *Wilderness and the American Mind*, 4th ed. (New Haven: Yale University Press, 2001).

20. See Arthur C. Clarke, *2001: A Space Odyssey* (New York: New American Library, 1968).

Implemented visions of spaceflight eventually confront physical conditions; the laws of physics provide the ultimate methodological check on anticipated effects. Some of the more interesting checks occur in the social realm. Take, for example, the widespread belief that space represents some sort of "final frontier." This line of reasoning draws heavily on the American mythology of frontier life. Yet many other societies have confronted physical frontiers – and not always with the same results. An obscure but interesting article in the *Journal of the British Interplanetary Society*, using a comparative perspective, suggests that the conditions present in extraterrestrial colonies may lead to social and political effects quite different than those remembered from the American frontier. In America, frontiers are thought to have promoted equality, cooperation, and rural independence. Conditions in space, however, may lead to the creation of societies that are autocratic, corporate, and feudal in nature. This is certainly the history of civilizations, such as ancient Egypt, that employed hydraulic technologies to open barren lands. In this respect, any extraterrestrial colonies that actually arise may less resemble the mythical conditions thought to exist on the American frontier than the Egyptian-like civilization presented in Roland Emmerich's classic science fiction film *Stargate*.[21]

In presenting the ultimate justification for spaceflight, advocates such as Carl Sagan and Robert Goddard argued that it would be necessary for the survival of humankind. Carl Sagan insisted that no technological civilization could expect to live long without moving onto other planets, whereas Robert Goddard observed that humans would eventually need to disperse Earthly life forms before the Sun grew cold. Asked to address the British Interplanetary Society, philosopher and science fiction writer Olaf Stapledon posed a critical challenge in this regard. "If one undertakes to discuss what man ought to do with the planets," Stapledon said, "one must first say what one thinks man ought to do with himself."[22]

Put another way, exactly what aspects of human society do the advocates of spaceflight propose to preserve? The answer, taken generally from the words of spaceflight advocates, is that they plan to conserve the values associated with American exceptionalism and capitalist democracy. These are the frames through which spaceflight is most commonly viewed in America and they tend to create the principal expectations regarding the societal impacts that spaceflight is presumed to have.

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21. David Sivier, "The Development of Politics in Extraterrestrial Colonies," *Journal of the British Interplanetary Society* (September/October 2000); see also Karl A. Wittfogel, *Oriental Despotism* (New Haven: Yale University Press, 1957) and Roland Emmerich, *Stargate* [film] (Metro-Goldwyn-Mayer, 1994).

22. Carl Sagan, *Pale Blue Dot: A Vision of the Human Future in Space* (New York: Random House, 1994); Esther C. Goddard and G. Edward Pendray, ed., *The Papers of Robert H. Goddard* (New York: McGraw-Hill, 1970) Vol. 3, p. 1612; Olaf Stapledon, "Interplanetary Man?" in Robert Crossley, *An Olaf Stapledon Reader* (Syracuse, NY: Syracuse University Press, 1997), pp. 232–233.

UNANTICIPATED CONSEQUENCES

Finally, how does one deal with unanticipated impacts? Some effects appear outside the cultural anticipation imposed on spaceflight and do not receive a decent share of predictions in advance. Commenting on the nature of the universe in general, British geneticist, biometrician, and physiologist J. B. S. Haldane suggested that in some respects it "is not only queerer than we suppose, but queerer than we *can* suppose."[23] For some of its ultimate effects, the impact of spaceflight may turn out to be stranger than people are able to imagine in advance.

Two recent developments help to illustrate this situation. The first is the so-far disappointing pursuit of extraterrestrial life. The widespread expectation that spaceflight will result in the discovery of extraterrestrial life permeates the early literature on spaceflight, from the contemplation of environmental conditions on Mars to the presentation of alien forms in science fiction.[24] In a fashion similar to other metaphors imposed on space travel, the vision of a universe teeming with life derives much of its force from the widespread expectation that expeditions in the extraterrestrial realm will be similar to earlier ventures in the terrestrial one. Terrestrial explorers returned with tales of exotic species and strange cultures, fueling expectations that extraterrestrial journeys would reveal the same.

Throughout the first 50 years of spaceflight, at least, this expectation has not been fulfilled. Confounding widespread expectations, robotic spacecraft have revealed the surface of Mars to be essentially sterile, not the "abode of life" that writers such as Percival Lowell and Willy Ley portrayed. Inspection of Venus, which was often portrayed in pre-Space Age writings as a Paleozoic planet, has exposed a hellish place much too warm to permit the development of complex life.[25]

Just as the anticipation of observed impacts can be checked with reference to their underlying theories, so the significance of unexpected effects can be gauged by the emergence of new hypotheses. Grand experiments, including those taking the form of government policy, often produce results unanticipated by previous theory or experience. Such results, where significant, commonly prompt the presentation of new theories which, in turn, can be tested in conventional ways. The appearance of a new theory serves as an important marker for the presence of a significant unanticipated result or event.

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23. J. B. S. Haldane, *Possible Worlds and Other Papers* (New York: Harper & Row, 1927), p. 298.

24. See Steven J. Dick, *Life on Other Worlds: The 20th-Century Extraterrestrial Life Debate* (New York: Cambridge University Press, 1998).

25. See Percival Lowell, *Mars as the Abode of Life* (New York: Macmillan, 1908); Isabel M. Lewis, "Life on Venus and Mars?" *Nature Magazine* (September 1934), p. 134.

During the early stages of space exploration, statements anticipating the ubiquity of extraterrestrial life forms were common. Defending the search for extraterrestrial life in a 1975 issue of *Scientific American*, Carl Sagan and Frank Drake announced that "Our best guess is that there are a million civilizations in our galaxy at or beyond the earth's present level of technological development." By 1990, this expectation had been sufficiently degraded to allow Peter Ward and Donald Brownlee to issue a contrary hypothesis. Life on Earth, they suggested, might be a result of a combination of events with a very low probability of occurrence. Simple life forms might be widespread in the universe, they allowed, but "[C]*omplex* life—animals and higher plants—is likely to be far more rare than is commonly assumed."[26]

The emergence of another new theory accompanied a different impact that was largely unanticipated in early writings about spaceflight. Prior to the Space Age, few people wrote extensively about the effect that viewing the whole Earth from a distance would have on human conceptions of their home planet, in spite of the obvious analogy provided by the intellectual shift accompanying the movement from the Aristotelian to the Copernican vision of the cosmos. With the advent of spaceflight, new images of Earth appeared. Apollo astronauts provided the most dramatic ones, from the 1968 photograph of Earth rising over the Moon to the iconic 1972 whole Earth image that decorates the Earth Day flag.

These images coincided with the emergence of the Gaia hypothesis—the strange new suggestion that the whole Earth and its biota might have the capacity to regulate conditions in such a manner as to produce conditions favorable to the maintenance of life. James Lovelock formulated this hypothesis in the early 1960s partly as a response to requests from NASA to develop instruments that could detect signatures of life in planetary atmospheres.[27] The Gaia hypothesis did not receive much attention until images of the whole Earth began to appear. Imagining Earth as a single, self-regulating system is much easier when one sees the whole planet as it appears from afar. In addition to sponsoring the research that spawned this theory, spaceflight might have created a perspective that hastened its acceptance. Again, this particular effect had not been much anticipated.

26. Carl Sagan and Frank Drake, "The Search for Extraterrestrial Intelligence," *Scientific American* (May 1975), pp. 80–89; Peter D. Ward and Donald Brownlee, *Rare Earth: Why Complex Life Is Uncommon in the Universe* (New York: Copernicus, 2000), p. xiv.

27. See James Lovelock, "Gaia As Seen Through the Atmosphere," *Journal of Atmospheric Environment* 6 (1972), pp. 579–580; Lynn Margulis, *Symbiotic Planet: A New Look at Evolution* (New York: Basic Books, 1998).

SUMMARY

The assessment of societal impacts arising from the interjection of any new set of events can be quite challenging, no matter where it is conducted. The temptation to draw connections where none exist, or to ignore the implications of unanticipated effects, is strong, outweighed (one hopes) by the desire of analysts to tell the story as truthfully as possible.

This chapter offers a number of methods for deepening the study of societal impacts insofar as they arise from the spaceflight venture and improving the reliability of the conclusions drawn. The use of interrupted time-series analysis—commonly characterized as turning points—contains weaknesses that can be partly overcome through comparative analysis. The examination of predictions can be enhanced by insisting that they be examined in the context of supporting theories. In a similar manner, the significance of unanticipated societal impacts can be measured through the acceptance rate of new theories suggested by the precipitating events. When assessing the cultural effects of spaceflight, findings can be strengthened by observing the material and ideological characteristics of the societies in which those effects are presumed to occur. As noted in this chapter, many of the cultural effects ascribed to spaceflight in the United States have the quality of conserving values thought by Americans to distinguish their nation. It would be interesting to know whether the promotion of spaceflight in other nations has reinforced social values different than those found in the United States.

Section II

Turning Point Impacts