Space and Society
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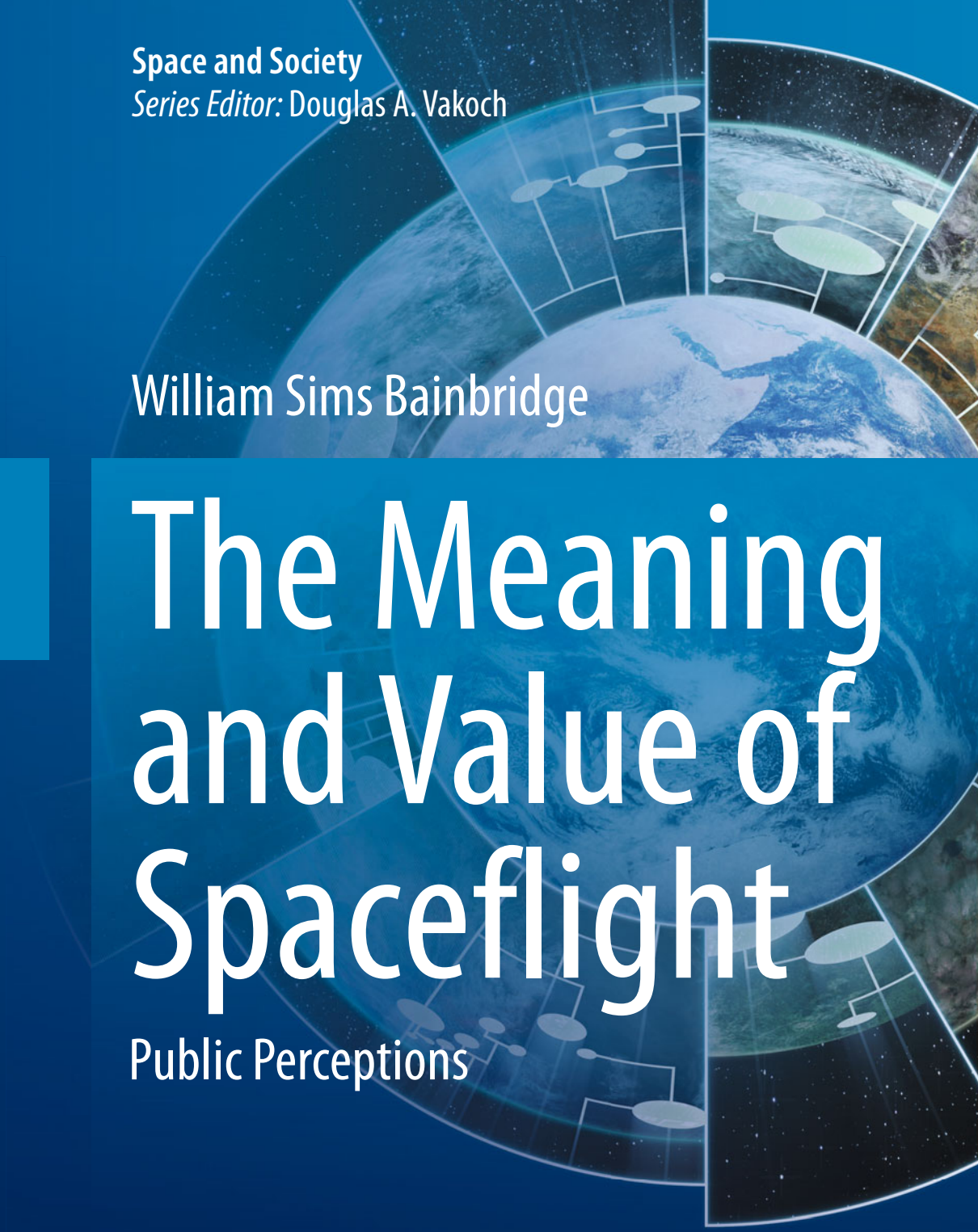

William Sims Bainbridge

The Meaning and Value of Spaceflight

Public Perceptions

Springer

Space and Society

Series editor

Douglas A. Vakoch, SETI Institute, Mountain View, CA, USA
and California Institute of Integral Studies, San Francisco, CA, USA

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William Sims Bainbridge
Arlington, VA
USA

ISSN 2199-3882 ISSN 2199-3890 (electronic)
ISBN 978-3-319-07877-9 ISBN 978-3-319-07878-6 (eBook)
DOI 10.1007/978-3-319-07878-6

Library of Congress Control Number: 2014945347

Springer Cham Heidelberg New York Dordrecht London

Cover illustration: by Paul Duffield

Printed on acid-free paper

Springer is part of Springer Science+Business Media (www.springer.com)

Preface

The conquest of outer space is in suspension, whether temporarily or permanently we cannot be sure. Great accomplishments of the past were the Apollo missions to the Moon, 1968–1972, and the first space probes to the planets, Mariner 2 to Venus in 1962 and Mariner 4 to Mars in 1964. Even the marvelous Hubble Space Telescope dates from more than two decades ago, 1990 to be exact. Human activity continues in near Earth orbit, although its value is open to debate, and astronomy continues to progress through use of space probes and space telescopes. While we cannot predict the future in space, and it seems quite problematic at the present time, research on the values of spaceflight for human beings can inform the important decisions that must be made, and illuminate the position of humans in the universe. This book draws upon a huge corpus of American public opinion data, and similar social science information, to explore the multiple meanings that exploration beyond the boundaries of our world may have.

The first chapter introduces the main methodologies and theories that must be employed to extract valid meaning from questionnaire data, using a few specific polls as illustrations. Two very different questionnaire methods must be combined: (1) administration of a few simple questions to random samples of the general population, to extrapolate with some confidence the balance of opinions in the society as a whole and (2) administration of much more complex questionnaires to specialized populations, placing the methodological emphasis on statistical analysis of how ideas fit together, using formal theory and empirical replication as validity checks. Two specific social-scientific theories are introduced that will feature throughout the book: (1) the standard observation that some individuals serve as opinion leaders, shaping the beliefs and attitudes of the general public and (2) technological determinism that analyzes any particular kind of technology in the context of the more general status of science and engineering of the particular historical period.

The next three chapters survey the development of public opinion using three different kinds of questionnaire study: (1) ordinary episodic public opinion polls like Gallup and Harris, (2) the General Social Survey (GSS) that systematically polled the US public for four decades, and (3) a specialized study of students at

Harvard University that explored their opinions about spaceflight more deeply than the two other approaches could afford to attempt. Chapter 2 focuses on the great Space Race between the United States and the Soviet Union, roughly in the decade and a half during 1957–1972, which is the period in which public opinion polls for the first time asked many questions about spaceflight, and popular awareness consolidated. Chapter 3 considers the period 1972–2012, using data from the GSS to see how support for space program funding correlated with support for other government programs and with variables describing respondents' age, social class, occupation, education, and political ideology. Chapter 4 employs data collected by the author at Harvard University in 1986, in the wake of the Challenger space shuttle disaster, through a pair of questionnaires that asked about a very large number of possible meanings spaceflight might have, employing the factor analysis statistical technique to identify underlying values, and determining how each affects overall support for space program funding.

The next two chapters employ the full range of kinds of questionnaire studies to place spaceflight in the context of world events and scientific progress. Chapter 5 returns to general public opinion polls to examine the meaning of events that took place after Apollo, especially policy decisions about the Strategic Defense Initiative and the recovery from the Challenger disaster, or might take place sometime in the future, notably the possible human return to the Moon and expeditions to Mars. Chapter 6 considers how spaceflight relates to various perspectives on science, beginning with a poll of scientists carried out in 1964 that found them rather unenthusiastic about the space program. This observation leads to the question of how science should be defined, whether as technical studies intended to provide information engineers can use to develop new technologies, or as philosophical explorations of the nature of reality as it really is, not as humans might wish it to be. Among the aspects of American culture that shape public perceptions of science, quite apart from factual news about space accomplishments are religion and pseudoscience, which do appear to militate against realistic appraisal, at least for significant minorities of citizens.

Three chapters then use questionnaires and comparable research techniques that have been developed recently to explore the popular culture of spaceflight, called *science fiction* or *sci-fi*. Chapter 7 examines the emergence of spaceflight fiction late in the nineteenth century, the launch of the first science fiction magazine in 1926 that established the genre, and the complex multidimensional set of genres that had consolidated half a century later, each with its own distinctive appraisal of spaceflight. Chapter 8 examines two more popular media, movies and television, given that cinema began depicting spaceflight as early as 1902, and a very significant number of films and programs continued to do so, especially after about 1950, using recommender system data on recent movie preferences to identify multiple mass media conceptions of interplanetary travel. Chapter 9 considers the newest mass medium that depicts spaceflight, computer games, especially massively multiplayer online (MMO) virtual worlds, in which users experience simulated spaceflight, including questionnaire-like data from two of these MMOs that suggest the human goals that the respondents seek beyond the boundaries of the Earth.

The concluding chapter looks back at all the findings of earlier chapters in the context of general explanatory theories. Its starting point is the frontier metaphor repeatedly associated with space exploration, especially in the light of the theory of what happens when a frontier closes, enunciated over a century ago by American historian Frederick Jackson Turner. A larger context can be provided by several theories, primarily European in origin, about the fall of civilizations, that would consider the end of space exploration to have dire consequences for humanity. The chapter then considers how the spaceflight social movement competes with other cultural traditions within western societies, giving some attention to the links between spaceflight support and gender, and with education analyzed by gender. Some questionnaire data suggest that the worldwide explosion in popular use of the Internet may be creating a new world culture that is more favorably disposed toward space exploration. Technological determinist theories suggest that spaceflight may experience a second acceleration phase, so long as popular interest has some degree of strength, once other fields of technology advance to the point at which new means of interplanetary travel become possible.

Contents

Chapter 1
Background

Over a brief period of time, within the entire context of human history, men have visited the Moon and robot spacecraft have explored the full width of the solar system. Yet the future of spaceflight is uncertain, and plans for an expedition to Mars dating back as much as seven decades are far from realization. Both to identify the basis for possible future progress and to understand one of the great human challenges, we need to know what spaceflight means. It may mean many things, serving different values for different people, so research on the meaning of spaceflight can become a tool for understanding human meaning in general.

This is a book of history, charting and analyzing public opinion, political ideology, and artistic expression related to space exploration, using data from 1938 until 2012. Included are many standard public opinion polls, not merely reporting responses to individual questions but often analyzing raw data from Harris Polls and the General Social Survey, to identify factors that shape perceptions of space. Other questionnaire surveys of special populations, often using far more questions about space than are found in any ordinary poll, were carried out by the author. In addition, the proliferation of new online forms of data analogous to opinion polls enable new forms of analysis, some of which have never been tried before.

Unfortunately, social science has tended to ignore spaceflight as a research topic, leaving the field to advocates and historians, so one function of this book is to bring together information from many sources that have not previously been considered as a whole in the light of theory. Many potential insights will be offered, more as hypotheses than as confident findings, in hopes that social scientists will begin serious work on issues crucially important for the future of humanity. Only after each idea has been debated in the journals, and tested through replication with new datasets, can we be sure what the real meaning of spaceflight is, and how it illuminates the shape of things to come.

W.S. Bainbridge, *The Meaning and Value of Spaceflight*,
Space and Society, DOI 10.1007/978-3-319-07878-6_1

1.1 A Time of Indecision

On July 21, 2011, during the 42nd anniversary of the Apollo 11 flight to the Moon, the landing of Atlantis ended the space shuttle program. Historian Roger Launius has called the shuttle, "a vehicle filled with contradictions and inconsistencies" (Launius 2006). While we cannot know how American spaceflight would have developed without the shuttle, it had over-optimistically promised to render spaceflight cheap and safe. The fatal disasters that ended the last flights of Challenger and Columbia contradicted the hope of safety, and the failure of the United States to develop a second-generation shuttle reflected the economic realities. The Bush and Obama administrations launched their own new spacecraft, using the words *launch* and *new* only in a figurative sense, because neither the Constellation nor the Space Launch System had left the Earth by the time this book was published, and both seemed to be remakes of the antique Saturn rockets that first flew half a century before the last flight of Atlantis.

What did this final shuttle flight mean? Reporting results from a public opinion poll administered during the last Atlantis mission, *The Christian Science Monitor* sought to answer this question about the space shuttle program: "Were Americans sad to see it go?" Of the 904 people who were asked, 56 % opposed cancellation of the shuttle program, and 52 % felt it had justified the cost. Yet when asked what should happen with NASA funding, only 10 % wanted it increased. A plurality of 49 % were happy to see it stay the same; 28 % wanted it decreased, and 8 % wanted to end NASA (Sappenfield 2011). Using data from the same poll, *Investor's Business Daily* reported that only 9 % of respondents believed that "the current administration has a clear plan for space exploration," 18 % were not sure, and fully 72 % were convinced it did not (Merline 2011).

A CNN poll of 1,009 Americans, carried out during the flight and released at the time of the landing, focused on the future, asking about the national impact of the termination of the shuttle and the prospects for a successor. It must be admitted that the poll's introduction may have biased the pattern of responses: "As you may know, the current space shuttle mission will be the final time that the U.S. will send astronauts into space using the shuttle. Until the U.S. develops a replacement for the shuttle, all manned U.S. space flights will take place in spacecraft that are owned by other countries. Overall, do you think the end of the space shuttle program will be good for the U.S., bad for the U.S., or not have any effect on the U.S. at all?" Just 16 % were willing to resist this suggestion that cancellation would be bad, calling it good, 33 % said it would have no effect, and 50 % gave the expected response that this situation would be bad. In response to other questions, fully 87 % predicted the US will develop "a replacement spacecraft that will be capable of sending U.S. astronauts into space and returning them to Earth," and 75 % said the US should indeed do so (CNN/ORC Poll press release 21 July 2011).

The highly respected Pew Research Center conducted its own poll of 1,502 adult residents of the US a month before the last Atlantis flight, using somewhat better methodologies of data collection and analysis to explore the meaning of

the shuttle program (Pew Research Center 2011). The first space-related question in the Pew poll asked, "Do you think the space shuttle program has been a good investment for this country, or don't you think so?" While 9 % declined to answer, 55 % called it a good investment. In its report of results, Pew contrasted this fraction with the 70 % who called it good investment in June 1986, after the January 1986 Challenger disaster, and 66 % who did so in August 1981, 4 months after the first shuttle orbital mission. It is noteworthy that the earlier polls used slightly different wording, "is a good investment" rather than "has been a good investment," reflecting the fact that the shuttle had a future during the earlier years.

The Pew survey also asked several questions about the respondent, for example finding that 59 % of men thought it was a good investment, versus 52 % of women. Republicans were more supportive than Democrats, 63 % to 48 %, and there was a similar difference between those with annual family income more than $75,000 versus less than $30,000, 67 % compared with 44 %. The difference by education was about the same, 66 % of colleague graduates calling the shuttle a good investment, compared with 47 % of those with high school educations or less.

Four questions sought to learn what values the space program served for many Americans. One asked, "In your view, is it essential or not essential that the United States continue to be a world leader in space exploration?" While 4 % expressed no opinion, 58 % felt it was essential, and 38 % felt it was not. The three other value questions began: "Thinking about the space program more generally, how much does the U.S. space program contribute to…" Here are the percents who answered "a lot:"

38 % Scientific advances that all Americans can use
34 % This country's national pride and patriotism
39 % Encouraging people's interest in science and technology.

During the years around the end of the shuttle program, the Gallup Poll measured public support for the space program more generally, for example in July 2009 finding that 58 % of Americans felt the space program had been worth the investments in it. One demographic variable influencing attitudes was age, and the Gallup report remarked, "Notably, those old enough to remember the historic moon landing are actually somewhat less likely than those who are younger to think the space program's costs are justified. Among Americans aged 50 and older (who were at least 10 years old when the moon landing occurred), 54 % think the space program's benefits justify its costs, compared with 63 % of those aged 18–49" (Jones 2009). In later chapters we shall consider both changing public opinions about space exploration over six decades of history, and the influence of age.

In May 2013, Gallup asked poll respondents to rate the performance of nine US federal government agencies, including NASA, finding that 42 % rated "the job being done by" the space agency excellent or good, and an identical 42 % rated it fair or poor (Jones and Saad 2009). Gallup calculated a summary "net positive" rating by subtracting the poor responses from the combined excellent-good responses, which in this case was $42 - 10 = 32$. This was way below the net positive rating for the Centers for Disease Control, which was 52, and a

significant drop from NASA's net positive rating back in 2009, which had been 51. Net positive ratings of six of the nine agencies had dropped from 2009 to 2013, perhaps reflecting increased doubts about the competence of government in general, but the NASA decline could reflect the impact on public opinion of the end of the shuttle program in the absence of much publicity about the Space Launch System or what its real goal might be.

When opinion poll data are reported in the journals, books, or websites devoted to spaceflight, they tend to be seen as a resource for understanding how to increase public support and thus public funding for NASA. Social scientists unconnected to the space program almost never look at these data, let alone analyze them in the contexts of theory and of data about other variables. That will be our job here. The best of the past space scholars who wrote about public opinion data, notably Roger Launius but also Alan Steinberg and Wendy Cobb, published in the journal *Space Policy*, thereby providing expert advice for people who wanted to build the future human presence in space (Launius 2003; Steinberg 2011; Cobb 2011). They debated the impact of events on public opinion, and the characteristics of people who were more or less enthusiastic, but they generally reported that the public did not understand the realities of NASA funding, let alone the technical details of spaceflight itself.

It would be wrong to conclude that public opinion does not matter, because at the very least a complete loss of public support could lead politicians to downgrade NASA even further in their funding priorities, while a surge of interest coming at a decision point about some new project could tip the balance in favor of funding it. For our purposes here, public opinion data are the gateway to deeper understanding of the meaning of spaceflight, especially as we explore the data rather more intensively than has been done before, and begin to investigate the thoughts not only of random samples of the general population, but of groups and subcultures that may understand spaceflight better than the average. We shall consider vast troves of questionnaire data in this book, along with other kinds of data that are similar in the ways they can be analyzed statistically and understood conceptually. Prior to entering that treasure house of information, we will need several kinds of scientific orientation, beginning with an overview of the history and methodology of opinion polls, which underwent the most rapid progress in the 1930s.

1.2 The First Spaceflight Opinion Poll

Arguably the very first American opinion poll about spaceflight was conducted immediately after Halloween in 1938. It did not concern Robert Goddard's ideas about liquid fuel rockets, nor the early discussions of building a 200-inch reflecting telescope on Mount Palomar, but the Orson Welles radio dramatization of *The War of the Worlds* by H. G. Wells. In style, the program was a series of increasingly frantic news reports about a Martian invasion in New Jersey, and apparently

people who tuned in late were unaware it was a drama but thought it reported real events. A Gallup Poll indicated that as many as 1,700,000 listeners believed this, and 1,200,000 were frightened by it. A questionnaire administered to school principals suggested that perhaps a quarter million children were frightened. News media widely reported frantic behavior in their areas (Cantril 1940, 1941). This may seem bizarre and substantively unimportant, but the incident is significant for three reasons.

First, it seemed to demonstrate the power of the mass media to shape public opinion. At the time, radio was a growing industry, and opinion polls were also new, so the results of this poll supported the economic interests of both broadcasters and pollsters by apparently demonstrating that both were important. However, reports of mass panic may have resulted from both errors and media hype, and no real panic may have occurred. A chance to test this possibility came in 1973, when Swedish radio broadcast a fictional news report indicating that a nuclear power plant had just exploded and was spreading lethal radiation all over a wide area. News reports of panic were triggered by the fact that a few citizens reasonably enough called the local police or news outlets asking what was happening. One radio station leapt to the erroneous conclusion there was a panic, and other news agencies picked up that false story. A scientific poll determined that only 2 % of the population had taken any action, under the impression the news was correct, such as shutting their windows (Rosengren et al. 1975).

Second, the Martian invasion poll data indicated that some people worried by the radio program had very reasonably sought further information, for example calling the police, or simply changing to a different radio station to see if it also was reporting an invasion. This may seem obvious, but findings like this led over the following decade to the emergence of a sophisticated two-stage theory of the spread of information through the general public (Katz and Lazarsfeld 1955; Pooley and Socolow 1972). First, local opinion leaders who are attentive to the news collate information in their own minds, often better educated than the average. Then, these opinion leaders influence others in the community, who are less inclined to develop their own interpretations of the news. This perspective will greatly inform this book, as we shall often consider the views of people who may be opinion leaders, without entirely disregarding the views of the majority. With specific reference to spaceflight, opinion leaders in government and in social movements have been especially influential, and it is an open question whether any of the steps in the development of space technology were shaped by the opinions of the general public. Given that our theme is the meaning of spaceflight for human beings, the views of the public are still important, but as indicators of a variety of meanings.

Third, the Martian invasion episode suggests two ways in which spaceflight may have meaning. First, it was broadcast at the end of October 1938, half a year after Germany had annexed Austria, and just days after Germany took the Sudetenland from Czechoslovakia. War worries were rampant, so the invading Martians became symbols for Germans, or for military dangers more generally. Often in subsequent years spaceflight may have taken on meaning as a symbol for

something else. Second, the Martian invasion was a fantasy, and future human colonization of Mars may also be a fantasy. To feel that Martians might exist required one to believe Mars was more similar to the Earth than the robot orbiters and landers sent there discovered, beginning with Mariner 4 in 1964. Another way to express this is that spaceflight may become a metaphoric vehicle for humanity's fears and hopes, both of which may be misplaced.

During the Second World War, the American public was certainly not well informed about the rocket technology developments taking place in Germany. In July 1944, 2 months before the first military use of the V-2 rocket, the Gallup poll asked a pair of rather ambiguous questions, ultimately triggered by rumors based on fact: "A Swedish newspaperman says the Germans are now building robot bombs which can hit cities on our East Coast. Do you believe this is true? Do you think that in another 25 years such flying bombs will be able to cross the Atlantic Ocean?" (Gallup 1972). It is left unspecified whether these "robot bombs" or "flying bombs" were V-2 rockets or V-1 unmanned pulse-jet aircraft, but the rumor was probably based on V-2 tests carried out over the North Sea from the German rocket development base at Peenemünde. Neither machine had the range to reach the United States, but either technology could have been developed to do so. Just 20 % of American respondents to the Gallup Poll felt the Germans were already developing such long-range robot weapons, but 70 % believed they could be developed before 1970, which proved to be correct.

Gallup asked a question specifically about spaceflight in October 1947: "How long do you think it will be before man will be able to fly to the moon?" Of those who selected a specific range of years, the median chose 20–29 years. However, 16 % failed to respond to the question, 23 % said they could not guess, and the largest group, 38 %, answered "never." In December 1949, Gallup asked the question a different way: "In the next 50 years, do you think men in rockets will be able to reach the moon?" Just 15 % of respondents confidently answered "yes," a fraction that had increased to 38 % when the question was asked again in January 1955 (Gallup 1955). Clearly, awareness of the real possibility of space travel was growing, but extensive public opinion polling on the subject did not really begin until the launch of Sputnik 1 in 1957, as we shall chart in the second chapter of this book.

1.3 Principles of Public Opinion Polling

As rocketry was developing from the first liquid-fuel launch by Goddard in 1926, public opinion polling was also developing. In business and government, the equivalents of questionnaires have existed for centuries, and by the middle of the nineteenth century the US Census was collecting rather detailed information about each household, through questionnaire-based interviews conducted by enumerators who went door-to-door. Arguably, social-science was the leader in the development of electronic computing, when Herman Hollerith developed technology

for analyzing data from the 1890 US Census and founded The Tabulating Machine Company in 1896, a precursor of IBM (Bainbridge 2004).

A census seeks information about every individual person within its geographic scope, and is exceedingly expensive to do with large populations. Therefore, public opinion polls must find a way of describing the entire population on the basis of a representative sample, and issues of sampling have posed problems for the field throughout its history. The most famous example is the debacle associated with the 1936 US presidential election that discredited simplistic polling methods.

In the elections of 1920, 1924, 1928 and 1932, a popular magazine called *The Literary Digest* had correctly predicted the winner, through commercial polling methods, using for example telephone directories to identify people to whom paper questionnaire should be mailed. By October 31, 1936, ten million questionnaires had been sent out, and 2,376,523 had been returned. Before we consider the results, four things should be noted. First, these are huge numbers, far larger than covered by the many other polls reported in this book. Second, the poll was really the equivalent of a sophisticated advertising campaign for the magazine and its clients, thus affordable on grounds other than obtaining scientifically valid data. Third, less than a quarter of the people who received a questionnaire filled it out and sent it back, a severe example of non-response bias, the likelihood that those who answered are atypical in motivations and thus attitudes. Fourth, 1936 was the middle of the Great Depression, which disrupted many people's lives, thus rendering obsolete some of the lists used to draw the sample of respondents, and rendering problematic many assumptions about the coherence of the American body politic.

The 1936 Literary Digest Poll confidently predicted that president Franklin D. Roosevelt would be thrown out of office, but in fact he was re-elected. This proved to be a marvelous advertising coup for George Gallup, who had founded his polling firm the year before. Gallup had sent 3,000 postcard ballots to a random sample of people on the lists of *The Literary Digest*, getting the same result the magazine did. But he also sent 3,000 postcard ballots to his own sample of voters, correctly predicting the outcome of the election (Gallup 1976).

From Gallup's day until now, conventional public opinion polls have actually combined methods in various ways, balancing cost against representativeness against the kinds of information that can be obtained. Gallup used combinations of *random* and *quota* sampling. To do a proper random sample, one needs to have essentially a list of everybody in the population, and use some random number system to identify the individuals who will be polled. In the case of voters, such lists exist, but may be out of date, and one cannot expect all the people who receive questionnaires to answer the questions and send them back. For example, Chap. 4 will report on a pilot study of voters in the Seattle, Washington, area, in which the response rate was 45 %, and assess whether that was sufficient given the goals of the study.

Quota sampling attempts to compensate for the fact that perfect random samples cannot really be obtained, by making sure that the sample has the same distribution as the population on some key variables, that are believed to affect

the estimates of the opinions in question. For example, when Barak Obama was running for the presidency, it would have seemed important to make sure the respondents to a poll included the same fraction of members of minority groups who belonged to the electorate. A kind of geographic quota system may be necessary in presidential election polls, if the goal is to predict the outcome of the electoral college as well as the popular vote, because the votes of people in low-population states count more than those in high-population states. An alternative to quota sampling is to weight responses by different groups in the sample, using statistical procedures, although this weighting can be especially inaccurate when a group is heavily underrepresented in the sample.

This book will find merit in questionnaire data that were obtained following a wide range of methodologies, even in the later chapters in data that only resemble questionnaire data. One reason is that the public opinion model of questionnaire research is not the only one that has proven valuable for social science. Another model, primarily developed in personality and social psychology, does not attempt to predict elections or describe the average views of the general public, but to seek and test theories about the alternative sets of values and conceptualizations held by diverse groups of people.

The two approaches can also be distinguished in terms of the kinds of questions they ask. Public opinion polls ask very simple questions, which almost anyone can understand and might have an opinion about, usually a very small number of questions about any topic that are rather superficial. Social psychological questionnaires typically use batteries of many items in the same general area, investing its statistical analysis not in sampling issues, but in exploring how these many items fit together in respondents' minds. Validity is achieved not through the sampling procedures, but through careful examination of how the results compare with the theories of interest to the scientists, and the ability of the results to be replicated in other studies that use different sets of respondents.

This book brings together a vast amount and diversity of data about people's perceptions of spaceflight, and uses a diversity of methods to make some sense of it. The chief challenge, and the opportunity that made this book both possible and necessary, is the fact that social science has ignored this topic, so we lack a well-developed scientific literature about the meaning of spaceflight to human beings. Many of the results reported here may seem obvious once they have been stated, and many of them may be found scattered across existing reports about single opinion polls. Yet it is useful to bring all these insights together, and compare information from many sources. But we shall also derive many fresh hypotheses by interpreting particular patterns or anomalies that arise in this comprehensive analysis.

Intentionally, this book avoids very complex statistical analysis of the kind that might be needed to test hypotheses and resolve scholarly disagreements. The reason is not merely that the intended readership is broad and few readers would possess the necessary training in statistical analysis. Rather, intensive quantitative analysis is best presented through scientific journals, and subjected to debate among many competent social scientists. Thus, each of the arguments in

favor of an hypothesis presented here is intended to render the hypothesis clear and plausible, but not in most cases to prove whether it is true. My own view is that most cogent hypotheses about human attitudes are true in at least a few cases, and the real problem is to weigh their relative strength while a diversity of social forces play out in our culture. That requires a scientific community devoted to exploring the human meaning of spaceflight in the context of more general research and debates about the human future. This book is a step toward creation of that community.

1.4 The Final Frontier

Many different publics hold a variety of views on the meaning of spaceflight, and social science itself does not speak with one voice. Writing in the *International Encyclopedia of Social Science*, I pointed out that the facts of the history of space exploration to date are clear, on the basis of a huge library of technical and scholarly publications, but the social-scientific interpretation is hotly debated (Bainbridge 2008). The view around 1960 was that international propaganda competition was the main driver, as has been summarized by Vernon van Dyke (van Dyke 1964). Sociologist Amitai Etzioni argued in 1965 that the American space program was a useless extravagance through which the military-industrial complex looted the national treasury (Etzioni 1965). Then in 1970, John Logsdon argued that President John F. Kennedy's decision to go to the moon was a means for reviving the political spirit of his New Frontier program after foreign policy defeats in 1961 with the aborted Bay of Pigs invasion of Cuba and being browbeaten by Soviet leader Nikita Khrushchev in a summit meeting (Logsdon 1970).

In my 1975 sociology doctoral dissertation and first book, I suggested a very different analysis that placed world politics in a secondary role: In Germany and the Soviet Union, as well as in the United States, leaders of the transcendental spaceflight movement had cleverly manipulated beleaguered political leaders to invest in space as a symbolic solution to their inferiority in competition with other leaders (Bainbridge 1976). Michael Neufeld has argued against this thesis in the case of Germany, asserting that technically competent military engineers possessed a correct estimation of the military potential of the technology (Neufeld 1995). Walter McDougall argued against this view in the case of the Soviet Union, stating that Marxist ideology naturally supported visionary technological projects (McDougall 1985). More recently, John Logsdon has argued that the American space program has been trapped in a vicious circle, as members of the movement convince political leaders to undertake technically demanding projects, but the public is not willing to invest enough to make them successful (Logsdon 2006).

Clearly, human spaceflight is in something like a holding pattern, and to a great extent has been since the last Apollo mission to the Moon over four decades ago. Two kinds of project have served to fill the gap, orbiting manned space stations and the space shuttle, but the original concept of "space station" would be orbiting

platforms from which to launch human missions far from Earth, and the space shuttle took its last flight in 2011. Unmanned spaceflight has shown the capacity for constant progress, with ever more sophisticated deep space probes, landers, and Earth-orbit telescopes. A key question, therefore, will be whether the public can shift its interest from human space adventures to scientific research carried out by means of machines. However, a classic theory in social science called *technological determinism* discounts both public opinion and the behavior of societal elites, and thus would analyze space development as the reflection of more general technological progress.

While small, solid-fuel military rockets had existed for centuries, rockets capable of achieving orbit could not have been built before the twentieth century. The kind most suitable for spaceflight, liquid-fuel rockets employing high energy propellants, required the development of technologies for super-cooling at least oxygen and perhaps hydrogen as well to store these gasses as liquids in the fuel tanks. Many launch vehicles have used liquid oxygen as the oxidizer, combining in the combustion chamber with a more mundane fuel such as alcohol, gasoline, or kerosene. Storable but less energetic liquid propellants, such as hydrazine, have applications for spaceflight, such as in thrusters to control the orientation of a spacecraft, or to land on a distant moon or planet. But like gasoline, hydrazine required the development of industrial chemistry in the nineteenth century, and was not available much before the twentieth century.

Historians and social scientists with the technological determinist perspective often study the emergence of specific technologies, but do so in the much broader context of all technologies that had been developed prior to the particular point in time. The classic example is that the rise of cities could not occur until after the development of systematic agriculture. This occurred at what V. Gordon Childe called the *Neolithic Revolution*, in which the term *Neolithic* refers to the new stone age in which stone tools had developed considerable sophistication and diversity (Childe 1951). Farming required not only tools, storage facilities, and skill in using natural resources to construct them, but also domestication of plants and animals. As a complex socio-technical system developed during the Neolithic Revolution, human population began to increase, specialization in skills and tools initiated the division of labor in which individuals began to perform distinguishable jobs, and increasingly complex political and religious institutions emerged to manage the growing societies. As villages evolved into cities, entirely new forms of technical and social systems were required to sustain them.

Technological determinists often wrote essays seeing to refute common notions about human progress, which they criticized as overly romantic. For example, Leslie White dismissed the significance of the Dark Ages after the fall of the Roman Empire, asserting that technological progress continued during that period despite the decline of elite culture (White 1959). Robert K. Merton minimized the importance individual inventors, noting that new ideas were typically invented many times, and separate invention only ceased when the innovation became widely known (Merton 1973). S. C. Gilfillan put the point thus: “There is no indication that any individual’s genius has been necessary to any invention that has

had any importance. To the historian and social scientist the progress of invention appears impersonal" (Gilfillan 1963).

Gilfillan's views are especially relevant here, because much of his own research on the history of technology concerned sailing ships, which are an obvious metaphor for spaceships. Even before the introduction of steam engines early in the nineteenth century, ocean-going vessels were extremely complex, requiring application of a variety of manufactured materials and crew skills. Another metaphor for space travel is the railroad, which was the focus of an edited volume of essays by many authors, titled *The Railroad and the Space Program: An Exploration in Historical Analogy* (Mazlish 1965). Although that book chiefly looked at the socio-economic impact of the railroad as a source of insights about the impact of the space program, both steamships and railway trains illustrate the fact that radically new transportation technologies require a very large number of prior technical developments. Thus, spaceflight is not really a single invention, but a bundling together of many existing inventions, adding just a few new ones to achieve a new goal.

Some technological determinists did not dismiss human initiative altogether in their theories of how technology developed, but did place it in a subordinate position to other factors. The clearest example is the theory of social change published way back in 1922 by William F. Ogburn, that views human history as the result of a complex interaction among four discernable processes (Ogburn 1922):

1. Invention: A new technical innovation emerges, not because one inventor has a brilliant idea, but because society reaches the point at which the knowledge and other factors required for the invention have collected.
2. Accumulation: The general stock of technological capabilities grows, because new things are invented more rapidly than old ones are forgotten.
3. Diffusion: Innovative ideas spread from one cultural group to another, given that groups may invent in different areas, depending upon accidents of history and natural resources.
4. Adjustment: Non-technical aspects of a culture respond to invention, sometimes with difficulty because new social institutions are required, and old ones may become obsolete.

Note that diffusion feeds into accumulation, and both increase the basis for invention. Ogburn said that social movements can play noteworthy roles, but chiefly in the society's adjustment to new innovations. He specifically referred to *cultural lag*, a maladjustment that comes about because the various parts of culture are not changing at the same rate. Rapid progress in one area may demand progress in another area related to it, but the adjustment is delayed, perhaps for many years. It may be that public ignorance about or indifference to spaceflight is an example of cultural lag, which could be overcome simply by the passage of time, or the educational efforts of the spaceflight social movement. Social scientists in the technological determinist tradition often write about cultural lag, but they less often consider that if technology determines itself, then some conceivable development cannot occur until certain other developments have already been achieved.

Perhaps, therefore, the current stasis we see in spaceflight development has nothing to do with public indifference or the ignorance of political leaders. It may instead reflect the need to wait for other fields of technology to advance until they could enable a new wave of astronautical innovation. The most obvious example is controversial, but clear enough in its technical aspects to make it worth mentioning here: Nuclear propulsion during launch from Earth to orbit (Bussard and DeLauer 1965; Gross 1970). It is one thing to use modest radioisotope thermoelectric generators to produce the electric power required by the two Voyager probes that were launched by ordinary chemical rockets back in 1977 to explore the outer solar system, and quite another to use high-power nuclear rockets to launch heavy payloads, with all the hazard to the environment that would pose (Maharik and Fischoff 1993). Rocket engines based on nuclear fission were developed but abandoned over 40 years ago, and controlled nuclear fusion has defied attempts to develop it for any purpose. But if some new and vastly more efficient means were developed to lift payloads into orbit, a new Age of Space could dawn (Coopersmith 2011).

The concluding chapter of this book will reconsider the full range of relevant social-scientific theories, in the light of the empirical findings of all the other chapters, but a few points deserve quick mention here. After Ogburn, sociologists tended to focus primarily upon diffusion of innovations, just one of his four points. Economists tended to focus on none of the four, because they assumed innovation would continue so long as free markets motivated entrepreneurs to innovate, or perhaps the accumulation of capital was a subprocess within Ogburn's accumulation concept. Technological determinism was brought into doubt by environmentalists and social scientists from many fields who happened to be concerned about sustainability, but they almost invariably thought within the confines of a limited Earth, rather than imagining that colonization of other planets could transcend all resource limitations. Environmentalists hold a wide range of views, but one is that we should transition from wrongly named technological "progress" to appropriate technology, which may not change over the centuries after the world stabilizes in a sustainable system (Schumacher 1973). Visionary advocates of space exploration may also hold many divergent views about the future of society here on Earth, but continued technological development is required to expand humanity throughout the galaxy.

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