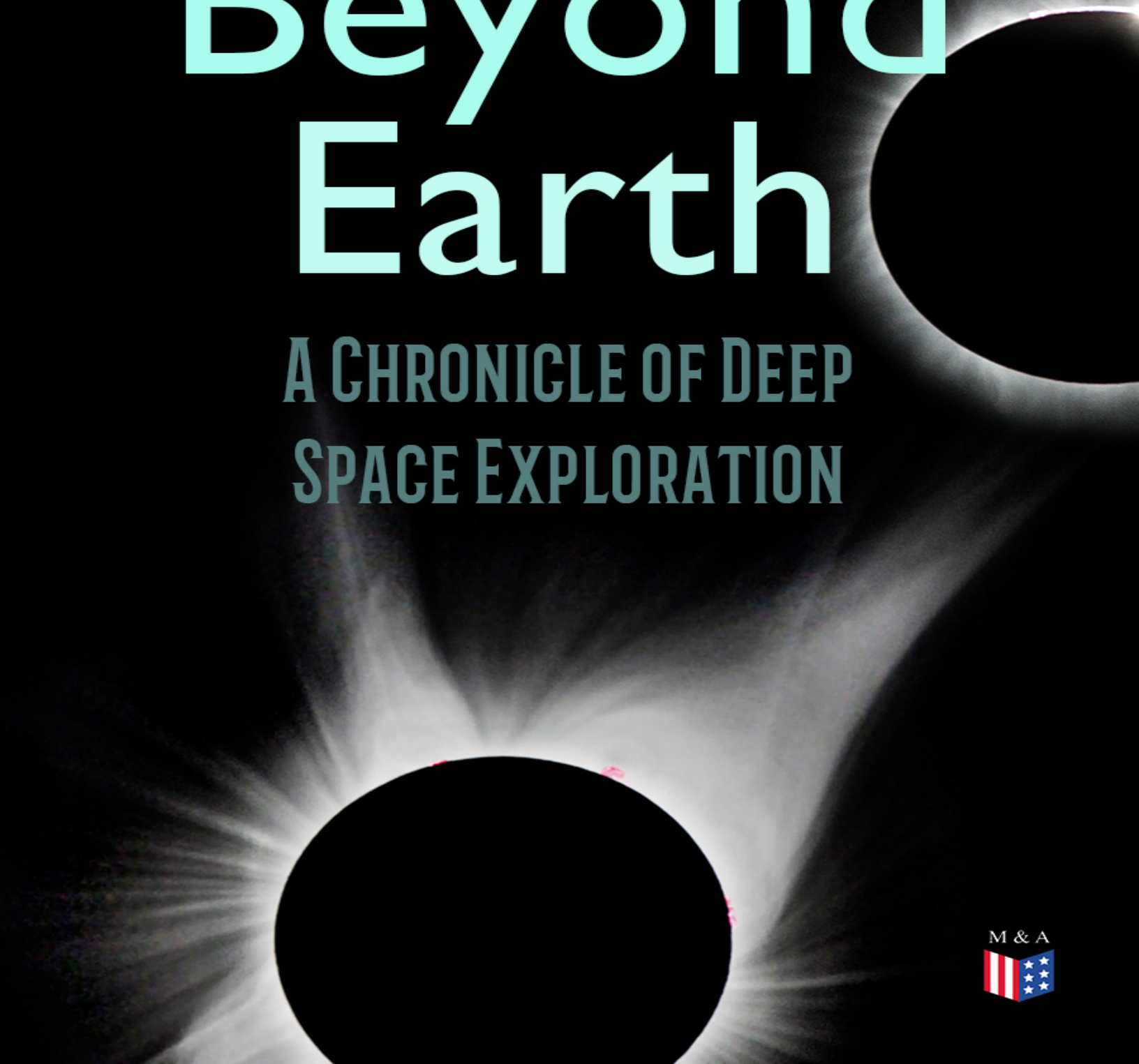
Asif A. Siddiqi, National Aeronautics and Space Administration

Beyond Earth

A Chronicle of Deep Space Exploration



M & A

Asif A. Siddiqi, National Aeronautics and Space Administration

Beyond Earth: A Chronicle of Deep Space Exploration

Contact: info@madisonadamspress.com

EAN

4066338125927

This is a publication of Madison & Adams Press. Our production consists of thoroughly prepared educational & informative editions: Advice & How-To Books, Encyclopedias, Law Anthologies, Declassified Documents, Legal & Criminal Files, Historical Books, Scientific & Medical Publications, Technical Handbooks and Manuals. All our publications are meticulously edited and formatted to the highest digital standard. The main goal of Madison & Adams Press is to make all informative books and records accessible to everyone in a high quality digital and print form.

Table of Contents

17 Able VA [Pioneer]
18 [Mars, 1M no. 1]
19 [Mars, 1M no. 2]
20 Able VB [Pioneer]

1961

21 Heavy Satellite [Venera]
22 Automatic Interplanetary Station [Venera 1]
23 Ranger I
24 Ranger II

1962

25 Ranger III
26 Ranger IV
27 Mariner I
28 [Venera, 2MV-1 no. 3]
29 Mariner II
30 [Venera, 2MV-1 no. 4]
31 [Venera, 2MV-2 no. 1]
32 Ranger V
33 [Mars, 2MV-4 no. 3]
34 Mars 1
35 [Mars, 2MV-3 no. 1]

1963

36 [Luna, Ye-6 no. 2]
37 [Luna, Ye-6 no. 3]
38 Luna 4
39 Kosmos 21 [Zond]

1964

- 40 Ranger VI
- 41 [Zond, 3MV-1A no. 4A]
- 42 [Luna, Ye-6 no. 6]
- 43 Kosmos 27 [Venera]
- 44 Zond 1 [Venera]
- 45 [Luna, Ye-6 no. 5]
- 46 Ranger VII
- 47 Mariner III
- 48 Mariner IV
- 49 Zond 2

1965

- 50 Ranger VIII
- 51 [Atlas Centaur 5]
- 52 Kosmos 60 [Luna]
- 53 Ranger IX
- 54 [Luna, Ye-6 no. 8]
- 55 Luna 5
- 56 Luna 6
- 57 Zond 3
- 58 Surveyor Model 1
- 59 Luna 7
- 60 Venera 2
- 61 Venera 3
- 62 Kosmos 96 [Venera]
- 63 Luna 8
- 64 Pioneer VI

1966

92 Pioneer VIII

1968

93 Surveyor VII
94 [Luna, Ye-6LS no. 112]
95 Zond 4
96 Luna 14
97 [Zond, 7K-L1 no. 7L]
98 Zond 5
99 Pioneer IX
100 Zond 6

1969

101 Venera 5
102 Venera 6
103 [Zond, 7K-L1 no. 13L]
104 [Luna, Ye-8 no. 201]
105 [N1 launch test, 7K-L1S no. 2]
106 Mariner VI
107 [Mars, M-69 no. 521]
108 Mariner VII
109 [Mars, M-69 no. 522]
110 [Luna, Ye-8-5 no. 402]
111 [N1 test flight, 7K-L1S]
112 Luna 15
113 Zond 7
114 Pioneer
115 Kosmos 300 [Luna]
116 Kosmos 305 [Luna]

1970

- 117 [Luna, Ye-8-5 no. 405]
- 118 Venera 7
- 119 Kosmos 359 [Venera]
- 120 Luna 16
- 121 Zond 8
- 122 Luna 17 and Lunokhod 1

1971

- 123 Mariner 8
- 124 Kosmos 419 [Mars]
- 125 Mars 2
- 126 Mars 3
- 127 Mariner 9
- 128 Apollo 15 Particle and Fields Subsatellite
- 129 Luna 18
- 130 Luna 19

1972

- 131 Luna 20
- 132 Pioneer 10
- 133 Venera 8
- 134 Kosmos 482 [Venera]
- 135 Apollo 16 Particles and Fields Subsatellite
- 136 [N1 launch test, 7K-LOK no. 6A]

1973

- 137 Luna 21 and Lunokhod 2
- 138 Pioneer 11
- 139 Explorer 49

- 140 Mars 4
- 141 Mars 5
- 142 Mars 6
- 143 Mars 7
- 144 Mariner 10

1974

- 145 Luna 22
- 146 Luna 23
- 147 Helios 1

1975

- 148 Venera 9
- 149 Venera 10
- 150 Viking 1
- 151 Viking 2
- 152 [Luna]

1976

- 153 Helios 2
- 154 Luna 24

1977

- 155 Voyager 2
- 156 Voyager 1

1978

- 157 Pioneer Venus 1
- 158 Pioneer Venus 2
- 159 ISEE-3

- 160 Venera 11
- 161 Venera 12

1981

- 162 Venera 13
- 163 Venera 14

1983

- 164 Venera 15
- 165 Venera 16

1984

- 166 Vega 1
- 167 Vega 2

1985

- 168 Sakigake
- 169 Giotto
- 170 Suisei

1988

- 171 Fobos 1
- 172 Fobos 2

1989

- 173 Magellan
- 174 Galileo

1990

- 175 Hiten and Hagoromo

176 Ulysses

1992

177 Geotail
178 Mars Observer

1994

179 Clementine
180 Wind

1995

181 SOHO

1996

182 NEAR Shoemaker
183 Mars Global Surveyor
184 Mars 8 / Mars 96
185 Mars Pathfinder

1997

186 ACE
187 Cassini-Huygens
188 Asiasat 3 / HGS 1

1998

189 Lunar Prospector
190 Nozomi
191 Deep Space 1
192 Mars Climate Orbiter

1999

193 Mars Polar Lander and Deep Space 2
194 Stardust

2001

195 2001 Mars Odyssey
196 Microwave Anisotropy Probe (MAP)
197 Genesis

2002

198 CONTOUR

2003

199 Hayabusa
200 Mars Express and Beagle 2
201 Spirit
202 Opportunity
203 SIRTF / Spitzer Space Telescope
204 SMART-1

2004

205 Rosetta and Philae
206 MESSENGER

2005

207 Deep Impact
208 Mars Reconnaissance Orbiter
209 Venus Express

For my
beloved father

Dr. Hafiz G. A. Siddiqi
Whose achievements I can only hope to emulate

Preface

Table of Contents

January 31, 1958 marked a significant beginning for space exploration. More than the historic and successful launch of Explorer 1, the first U.S. satellite, it was the beginning of an unprecedented era of exploration and understanding of our own planet and the distant worlds beyond. The more we uncover about the mysteries and beauty of space, the more we are inspired to go farther. Yet, with all we have learned, we still cannot even imagine what future generations will find.

Spacecraft from NASA and others have shown us the intricacies within clouds and terrain of distant planets that were only a dot in an astronomer’s telescope a few decades ago. We have seen the birth of stars, black holes, and found exoplanets orbiting stars in systems remarkably similar to ours. Future missions will take us forward in history, as we seek to uncover the very origins of our universe.

We may not know precisely what—or who—we will find out there, but we can be sure that space exploration will continue to surprise and inspire us, as it did for those who came before and those who will follow. Along the way there will be missteps, some more devastating than others. That is the price of doing what’s never been done before—a price that sometimes is tragically paid at the highest cost by the courageous. But like those early days of the space program, we are as motivated to succeed by the missions that do not

make it as those that do. And we learn from them, coming back stronger and smarter.

In this book, the history of NASA's six decades of exploration beyond Earth and its Moon to other planets and their moons is laid out. The story follows spacecraft to the Sun, comets, minor and dwarf planets and, ultimately, beyond our solar system. As we marvel at the ingenuity of the early pioneers of the Space Age, we realize how much they achieved with what, comparatively, was so little. Computers were human, and when the machines did take over calculations, they also took up entire rooms with processing capability less than smartphones in your pockets today.

Yet some of NASA's greatest achievements took place during this period: Mariner IV, which took the first pictures of the surface of Mars in 1965; the global view of Mars from Mariner 9 in 1971; and the Viking landers of the 1970s, which executed the first planetary soft-landings of American spacecraft. The crowning achievements of America's mid-century robotic space exploration were the Pioneer and Voyager missions which were sent to the far boundaries of our solar system using early 1970s technology. As this is being written, Voyager 1 and Voyager 2 continue to send us data from beyond the outer planets from the boundary region of the Sun's sphere of influence, the heliosphere. But space does not belong to the United States alone. We have evolved from the earliest days of the Space Race, when being "first" brought serious geopolitical consequences, to our current era of international partnerships that have taken us farther together than we could have gone alone.

In the modern era of exploration, which itself will look outdated in a generation, we have discovered the extraordinary rings and moons of Saturn with NASA's Cassini spacecraft and the Huygens lander built by the European Space Agency. We marvel at images of the swirling storms on Jupiter sent back to Earth by our Juno mission. And we constantly find new science from the Curiosity rover that's been trekking across the surface of Mars for more than five years.

Our robotic emissaries have made tremendous journeys over the past six decades. They carry the vision and inspiration of humankind beyond our physical ability to make the trip—yet. This book celebrates the extraordinary men and women who have looked up and wondered what's out there and then found the answer. In only 60 years, our technology has evolved from a simple, modified Geiger counter launched into Earth orbit to sublime technologies sending full-color, high-resolution images and data from the edge of the universe. The next 60 should be exponentially rewarding.

– Dr. Thomas H. Zurbuchen
NASA Associate Administrator at Science Mission Directorate

Introduction

Table of Contents

Humans abandoned their nomadic habits and moved into settlements about 40 to 50 thousand years ago. We have been using tools even longer. But our ability to send one of our tools into the heavens is of much more recent origin, spanning only the past 60 years. Yet, in that time, we have created new tools—we call them robotic spacecraft—and sent them into the cosmos, far beyond Earth. Of course, many never got very far. That's the cost of hubris and ambition. But most did. And many never came back to Earth and never will. In that sense, we as a species have already left a mark on the heavens; these small objects that dot the cosmos are a permanent legacy of our species, existing for millions of years, even if we as a planet were to disappear. This book that you hold in your hands (or are reading in digital form) is a chronicle of all these tools, both failed and successful, that humans have flung into the heavens beyond Earth.

The text in front of you is a completely updated and revised version of a monograph published in 2002 by the NASA History Office under the original title *Deep Space Chronicle: A Chronology of Deep Space and Planetary Probes, 1958–2000*. This new edition not only adds all events in robotic deep space exploration after 2000 and up to the end of 2016, but it also completely corrects and updates all accounts of missions from prior years. The

information in the monograph is current as of mid-2017 when I completed writing.

What Does This Publication Include?

This monograph contains brief descriptions of all robotic deep space missions attempted by humans since the opening of the space age in 1957. The missions are listed chronologically in order of their launch dates (i.e., not their target body encounters). Different people have different criteria for which kind of spacecraft to include in a list of "deep space probes." In the list that follows, I have included all spacecraft that satisfied the following guidelines:

1. Any probe that was launched to an "encounter" with a "target."
    a. An "encounter" includes the following events:
        i. flybys
        ii. orbiting
        iii. atmospheric entry and impacts
        iv. soft-landing
    b. "Targets" include the following:
        i. the planets of the Solar System (Mercury, Venus, Mars, Jupiter, Saturn, Uranus, and Neptune)
        ii. the Earth's Moon
        iii. minor planets or asteroids
        iv. natural satellites of the planets and asteroids
        v. comets
        vi. dwarf planets (such as Pluto)
2. Any probe that was deliberately sent into heliocentric (solar) orbit.

3. Any probe that was sent into a halo (Lissajous) orbit around any of the libration points involving Earth, the Moon, and the Sun.
4. Any probe that was launched as part of a science, lunar, or planetary program to at least lunar distance in order to simulate a deep space trajectory (such as, for example, Geotail, Zond 4, and a few early Surveyor Model mockups).

I have included probes whether they succeeded in their objectives or not. Thus, some probes never got a few meters beyond the launch pad while others are heading into the outer reaches of the solar system.

It should be noted that the criteria for inclusion in this volume does not always coincide with NASA's own programmatic distinctions about what constitutes a planetary science mission. For example, this volume includes missions such as Wind, ACE, MAP, and SIRTF, none of which was funded through NASA's solar system exploration line. The criteria for inclusion here is simply whether the mission was intended to operate *beyond* Earth orbit and satisfied the above four requirements, regardless of who funded it or what kind of science it generated.

Where Is the Information From?

For statistical data on U.S. probes (such as launch vehicle numbers, launch times, list of instruments, etc.), I have used original NASA sources such as Public Affairs releases, press kits, postflight mission reports, and official histories. These records are deposited in the NASA Historical Reference

Collection at NASA Headquarters in Washington, DC, or are available online at various NASA or government databases. For missions after approximately 2000, there is a proliferation of official mission websites, hosted by the organization sponsoring the missions, including, for example, the Jet Propulsion Laboratory (JPL), the Applied Physics Laboratory (APL), and the S. A. Lavochkin Scientific-Production Association (or NPO imeni Lavochkina). I have used these as primary sources of information. For some of the initial Earth orbital parameters of many deep space probes, a very useful source has been the online newsletter "Jonathan's Space Report" prepared by Jonathan McDowell.

For Soviet/Russian sources, I have used only Russian-language sources, such as the journal *Kosmicheskaya issledovaniya* (Space Research), official organizational histories, reliable memoirs, or the semi-official journal *Novosti kosmonavtiki* (News of Cosmonautics).

In the bibliography at the end of the monograph, I list a few published secondary sources that have been useful in verifying or framing data. Every attempt has been made to present accurate information, but with a project of this size and scope, there will naturally be errors.

I have avoided as much as possible using unofficial amateur Web sites (such as Wikipedia) or secondary history books, such as Andrew Wilson's otherwise quite wonderful *Solar System Log*. These sources are good for a quick overview but they often reproduce errors (especially in timings, details, and distances) that have now been repeatedly and erroneously propagated in the Internet era. The one exception is Don Mitchell's excellent website on

Soviet lunar and planetary exploration, found at *http://mentallandscape.com/V_Venus.htm*. I highly recommend it.

What Kind of Information Have I Included?

In terms of the mission descriptions, I have kept the focus on *dynamic* mission events (course corrections, orbital insertion, reentry, landing, equipment deployment, etc.) rather than mission planning or *scientific* results, although in many cases I have included brief summaries of both. But I do not make any claim to comprehensiveness in terms of the scientific outcomes of the missions. This monograph is more about *what happened* rather than what was discovered. In the interest of space, the mission descriptions have been kept relatively short, filled with detail, and to the point.

Conflicting Information

There are many, many areas where different sources have supplied different information, especially for some early Soviet probes launched between 1960 and 1965. The precise instrument complement of these probes (1M, 1V, 2MV, and 3MV series) is not known very well because in many cases, scientific instruments that were meant for the spacecraft were removed before launch. I have listed all the *originally* slated instruments meant for those vehicles even if they were later removed before launch. Undoubtedly, there are mistakes and inconsistencies in the lists presented here but I have made every effort to be as accurate as possible.

A Note About Terminology

Table of Contents

Mission Designations

I have made every attempt to use the names of spacecraft and missions that were contemporaneous to the time of the mission and assigned by the agency or organization implementing the missions.

In the 1960s, NASA routinely used Roman numerals for missions (Mariner IV, Mariner V, etc.) in their official documentation, but these were discontinued in the 1970s. Readers will note that I have used this convention for all missions until and including 1970 but after that switched to Latin numbers (Mariner 9, Mariner 10, etc.). This division is somewhat arbitrary but was necessary not to confuse readers.

The practice of giving spacecraft “official” names is complicated by the fact that beginning with the launch of Sputnik in 1957 and until the late 1980s, the Soviet Union never announced or acknowledged a mission if it failed to reach Earth orbit. In addition, for those lunar and planetary probes that *did* reach Earth orbit but failed to leave it, the Soviets adopted two strategies:

- between 1960 and 1963, the Soviets simply never admitted their existence and made no announcement; and
- beginning November 1963, the Soviet media began to give these stranded-in-Earth-orbit spacecraft

> “Kosmos” numbers. So, the deep space vehicle launched on 11 November 1963 that reached Earth orbit but failed to leave for deep space was simply given the “next” Kosmos number, in this case “21.” By giving it such a nondescript name (“Kosmos 21”), Soviet officials sought to draw attention away from such failures. This practice was followed well into the late 1980s.

For both of these three types of missions, I have used the following convention:

> [Program, Spacecraft design designation, serial number]
> OR
> Kosmos number [Program]

I do *not* use terms such as “Marsnik 1” or “Mars 1960A” (listed in the National Space Science Data Center, for example, to denote the spacecraft launched on 10 October 1960). Since the Soviets never used such names, it would be entirely inaccurate to ascribe such designations. Such fictitious names (such as “Sputnik 27”) unfortunately proliferate online but are Western inventions.

Launch Sites

For Soviet and Russian launch sites, the following conventions apply:

“Site A / B” implies that the probe was launched from Site A, Launch Unit B

Mission Goals

There are good reasons not to use terms such as “flyby” or “flight” since spacecraft do not fly. As one of the reviewers for this manuscript pointed out, these terms are remnants of the era of aeronautics. As such, more appropriate terms would be “swingby” (instead of “flyby”) and “mission” (instead of “flight”). However, because terms such as “flyby” and “flight” are still widely used by many space agencies globally, this manuscript has retained their use, despite their imprecise nature.

Acknowledgments

Table of Contents

I wish to thank all at the NASA History Division who were patient with me throughout this process, particularly Chief Historian Bill Barry and Steve Garber. A special note of gratitude to Roger Launius who conceived the original project in 1999.

For help with the manuscript itself, I need to acknowledge the comments and criticisms of Jason Callahan, Dwayne Day, Chris Gamble, Marc Rayman, and Randii Wessen. Their comments were immensely helpful to this project and made this a much better manuscript than I alone could have made it. I would also like to thank Don Mitchell, Sven Grahn, and Timothy Varfolomeyev for sharing images from their collection. Also, a note of gratitude to Jonathan McDowell for sharing his insights. Despite the help of all these individuals, any mistakes are, however, mine.

A very special note of thanks to Ariel Waldman for kindly providing the source image for the cover of this publication.

Thanks also go to the Communications Support Service Center (CSSC) team of talented professionals who brought this project from manuscript to finished publication. J. Andrew Cooke carefully copyedited the detailed text, Michele Ostovar did an expert job laying out the design and creating the e-book version, Kristin Harley performed the exacting job of creating the index, and printing specialist Tun Hla oversaw the production of the traditional hard

copies. Supervisor Maxine Aldred helped by overseeing all of this CSSC production work.

Firsts in the History of Deep Space Exploration

Absolute Firsts

First attempt to launch a probe into deep space:
USA / **Able 1 [Pioneer 0]** / 17 August 1958

First probe to reach escape velocity:
USSR / **Soviet Space Rocket [Luna 1]** / 2 January 1959

First spacecraft to impact on another celestial body:
USSR / **Second Soviet Space Rocket [Luna 2]** / 14 September 1959 (Moon)

First successful planetary mission:
USA / **Mariner II** / 14 December 1962 (Venus)

First spacecraft to impact another planet:
USSR / **Venera 3** / 1 March 1966 (Venus)

First spacecraft to make a survivable landing on a celestial body:
USSR / **Luna 9** / 3 February 1966 (Moon)

First spacecraft to orbit a celestial body other than Earth or the Sun:
USSR / **Luna 10** / 2 April 1966 (Moon)

First successful planetary atmospheric entry probe:
USSR / **Venera 4** / 18 October 1967 (Venus)