MISSION TO JUPITER:

A History of the Galileo Project

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Preface

The Galileo Project: Commitment, Struggle, and Ultimate Success

I am glad to see that someone has followed through and done a really comprehensive and workman-like job capturing the history of the Galileo project. This book goes all the way back to the initiation of the project, when it was more or less just a thought in a few peoples' minds, and traces the whole evolution from there. I got a great deal out of reading it.

I have a vested interest in the Galileo project—I was deeply involved in it for over a decade. A lot of people know about the mission and its terrific science return, but they don't know about the struggle putting the project together, getting it started, and keeping it going through all of the reprogramming and restructuring. One of the arguments that we used with people on Capitol Hill to keep the program alive through delays in the congressional budgeting process was that Galileo would be a nonthreatening manifestation of our country's technological capabilities, and this would send a powerful message to the rest of the world. It did just that.

Galileo meant a lot to the United States, but it also meant a lot to our space science community, because at the time that we were going through the development of Galileo, it was the only major deep space project. There were Earth satellite launches going on, but nothing to the planets. It was Galileo that really helped NASA and the U.S. space science community maintain viability during a period of extreme drought in program development. A lot of capability would have disappeared over the course of the 10 years that Galileo was in development.

The commitment that individuals made to Galileo was extraordinary. Many individuals committed a third or more of their professional lifetimes to executing this project. Over the years, situations developed so many times where it looked like there was just no way out for the project, but we always managed to come up with a solution. The number of times we managed to pull the fat out of the fire was truly remarkable.

The Galileo project was complex in that it required funding for science instrument and spacecraft development from numerous sources, including NASA and its Centers, the Department of Energy, U.S. universities, and the Europeans (especially the Germans). Just how the pieces of the fabric were woven together into what turned out to be a very successful program—one that required an investment of almost two decades of preparatory and execution work to bring about—is an interesting story. Revisiting the program from a historical point of view is what motivated me to read this book. I think that people who are interested in the space program, its science achievements, and its contribution to technology in general will really appreciate this history. It's comprehensive, it's complete, and it seems to me to be pretty even-handed. I'm very appreciative of what Michael has done.

—John Casani, First Galileo Project Manager

Foreword

We Are All Standing on the Bridge of Starship *Enterprise*

This book details the history of the Galileo mission. Galileo had political ups and downs, technical challenges and hurdles, and was a multigenerational task. We had people starting the mission on advisory committees and senior management jobs who have now passed on. Many people went through parts of Galileo in stages of their careers. I have friends who still mark their anniversaries and the birthdates of their children in terms of, "That was when we were on the beginning stages of prelaunch preparation," or, "It was during our first Europa encounter when that happened." The Galileo team felt much more as a family than a pure professional enterprise. People worked together for long periods of time, through good times and bad, to accomplish this thing not just for them, but for everybody.

The Galileo mission to Jupiter was part of the grand sweep of solar system exploration. You can view planetary exploration as a human endeavor—a wave sweeping outward from Earth. We went to the close-in places first—the Moon, Venus, and Mars. The outer solar system was the next big frontier, and it was an order of magnitude more difficult to explore. The distances are truly staggering, and the problems of developing spacecraft that could survive on their own for long periods of time were major challenges.

The early explorations of the outer solar system were performed by relatively fast-trajectory spaceships, like the Pioneers and Voyagers. They and Galileo were major steps forward in being able to develop reliable craft that would operate for decades, continue to send data back without failing, and be smart enough to take care of themselves out of communication with Earth. At Jupiter, the time available to send a radio signal is typically 45 minutes, and another 45 minutes before you get an answer back. You are well beyond being able to do the types of things that can be done in Earth orbit.

NASA's outer solar system missions helped turn that region into a known place, rather than just the realm of astronomers. The outer solar system became someplace that can be talked about and thought about in geological and geophysical terms. The person on the street and kids in school can say, "Hey, I saw a picture of a moon of Jupiter the other day and it had volcanoes on it."

We planned the Galileo mission in that context. The scientific advisory committees to NASA and the U.S. government laid out an exploration strategy of fast reconnaissance missions followed by missions such as Galileo, in which we orbited planets and did more detailed studies. There was a leapfrogging characteristic to this type of exploration. The missions take so long to plan and execute that the next wave of exploration must be prepared even before the current one can be launched. We began work on Galileo in 1972 in its infant form, and we really got to work on it in 1974 with detailed studies, even before Voyager was launched in 1977.

On Galileo, we combined orbital and in situ exploration strategies. We believed that if we were going through so much effort and so many resources to get there, we ought to not only study the planet, its satellites, and magnetic fields, but that we also should understand the chemistry of the atmosphere in detail with an entry probe that actually went into the atmosphere, grabbed a sample, analyzed it, and sent the data back to the mother ship before burning up in the atmosphere. This was very ambitious.

We had a strategic plan that said we were going to go orbit Jupiter, get into its atmosphere, and then inform that plan with tactics derived from Voyager results. It is a good example of the way exploration progresses. You learn things that lead to new questions you want to answer, and so forth. We were preparing to follow up and understand Jupiter's miniature planetary system at a very detailed level, even as Voyager was continuing on from Jupiter to Saturn, opening up the rest of the outer solar system.

People frequently ask, "Why should the average person be interested in what's going on in the Jupiter system?" There are answers to that on all levels, ranging from the visibility of high technology to developing new things that have spinoffs to enhancing national prestige to satisfying pure curiosity. But really, it is all about changing the way we look at the universe and the world. We want to know how planets tick and understand the processes that control us here on Earth—everything from geophysics to climatology to global warming. The universe is effectively a laboratory waiting for us to study these things.

Most of the people who have worked on Galileo over the years probably regard their biggest contribution as having changed the textbooks. Kids today learn about such things as the moons of Jupiter, and they know what they're talking about. To them, the planets become not just dots in the sky that you can barely see with a telescope. The planets become real places, and kids know their characteristics.

There is always a tension in the national debate about how much robotic exploration (such as Galileo) we should do versus so-called human exploration (such as Apollo). This misses the point! What we call robotic exploration is in fact human exploration. The crews sitting in the control room at Jet Propulsion Laboratory as well as everyone out there who can log on to the Internet can take a look at what's going on. So, in effect, we are all standing on the bridge of Starship *Enterprise*.

It is important to note that Galileo was an international mission. Science is, by its nature, international. We had people contribute from countries all over the European community and other countries as well. This was one of the first missions in which the analysis of data more or less continued around the clock, around the globe. We'd wake up in the morning and hear that one of our colleagues in Berlin had processed some images overnight and brought new data to the table—and we could look at it immediately, while they had a chance to sleep.

The intellectual children, grandchildren, and great-grandchildren of the people who worked on Galileo have now spread through the crews operating the Cassini spacecraft at Saturn and the MER Rovers, Spirit and Opportunity, on the surface of Mars. It is an ongoing spirit of exploration and, to me, that's really the bottom line of what Galileo was all about. It is important to record the history of these types of things, both because of the intrinsic interest that the public has and because there are always lessons to be learned. I sure hope people will read this book and get that feeling from it.

—Torrence V. Johnson, Galileo Chief Scientist

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Torrence V. Johnson, who related with eloquence how decisions were made and operations were carried out on the mission.

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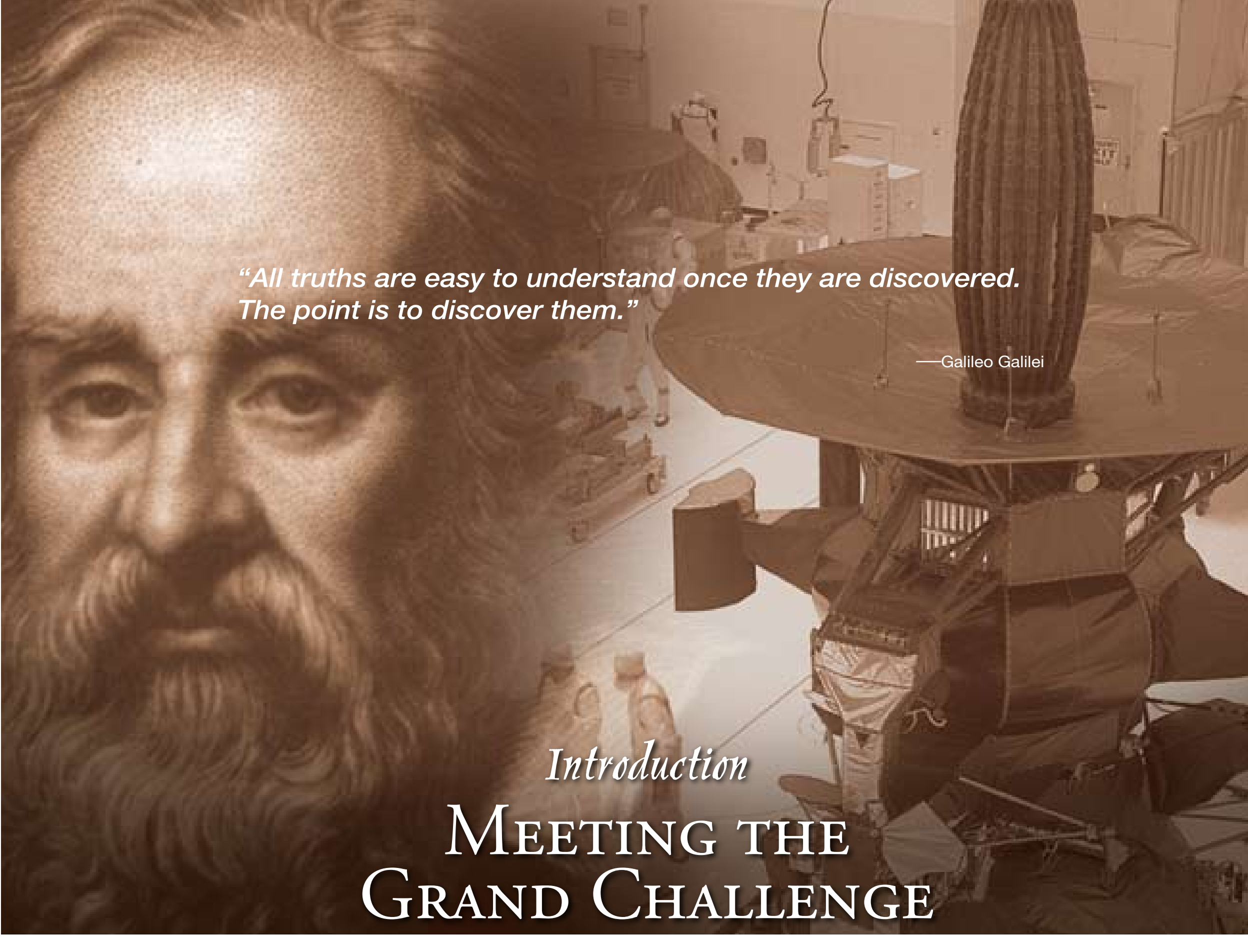

"All truths are easy to understand once they are discovered. The point is to discover them."

—Galileo Galilei

Introduction

Meeting the Grand Challenge

IN AN ADDRESS TO THE U.S. SENATE SUBCOMMITTEE ON Science, Technology, and Space, author James Michener asserted that "it is extremely difficult to keep a human life or the life of a nation moving forward with enough energy and commitment to lift it into the next cycle of experience . . . . There are moments in history when challenges occur of such a compelling nature that to miss them is to miss the whole meaning of an epoch. Space is such a challenge."[1]

The Galileo mission to Jupiter successfully explored a vast new frontier, had a major impact on planetary science, and provided invaluable lessons for the design of subsequent space vehicles. In accomplishing these things, Galileo met the challenge of "such a compelling nature" that Michener envisioned. The impact of the mission was felt by those who worked on it, the country that supported it, and the people from other parts of the world who were deeply impressed by it. In the words of John Casani, the original Project Manager of the mission, "Galileo was a way of demonstrating . . . just what U.S. technology was capable of doing."[2] An engineer on the Galileo team expressed more personal sentiments when she said, "I had never been a part of something with such great scope . . . . To know that the whole world was watching and hoping with us that this would work. We were doing something for all mankind . . . I'd walk outside at night and look up at Jupiter, and think, my ship's up there."[3]

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[1] James A. Michener, "Space Exploration: Military and Non-Military Advantages" (speech delivered before the U.S. Senate Subcommittee on Science, Technology, and Space, Washington, DC, 1 February 1979). Published in Vital Speeches of the Day (Southold, NY: City News Publishing Company, 15 July 1979).

[2] John Casani interview, tape-recorded telephone conversation, 29 May 2001.

[3] Nagin Cox interview, tape-recorded telephone conversation, 15 May 2001.

Like other grand voyages of discovery, Galileo altered the way we view our surroundings (in this case, our planetary surroundings). It is thus fitting that this mission to the Jovian system was named after a man whose own astronomical observations radically challenged the way that people of his time viewed their universe. The discoveries of both Galileo the man and Galileo the spacecraft brought us new perceptions of our planetary system, made our lives richer and more interesting, and breathed new vitality into our quest to understand ourselves and our universe.