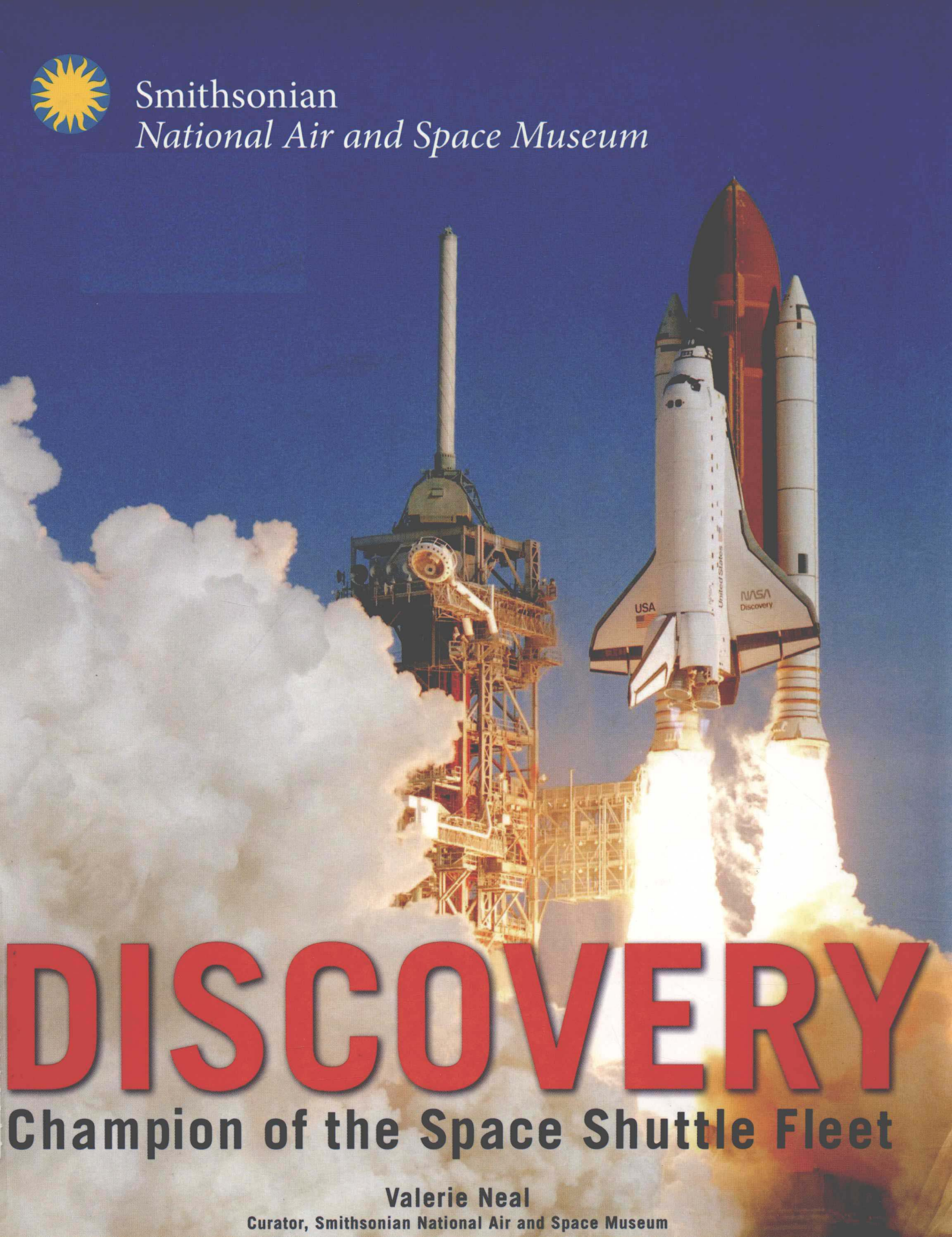

DISCOVERY

Champion of the Space Shuttle Fleet

Valerie Neal
Curator, Smithsonian National Air and Space Museum

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Smithsonian
National Air and Space Museum
Washington, D.C.

In association with

Zenith Press

Dedication

With appreciation to all the men and women who participated in the Space Shuttle program—especially those who designed, built, serviced, supported, and flew on *Discovery* and those who delivered this national treasure to the Smithsonian.

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On the back cover: Astronaut Carl E. Walz (foreground) holds a power ratchet tool and James H. Newman tests the portable foot restraint in preparation for the first Hubble Space Telescope servicing mission. *NASA*

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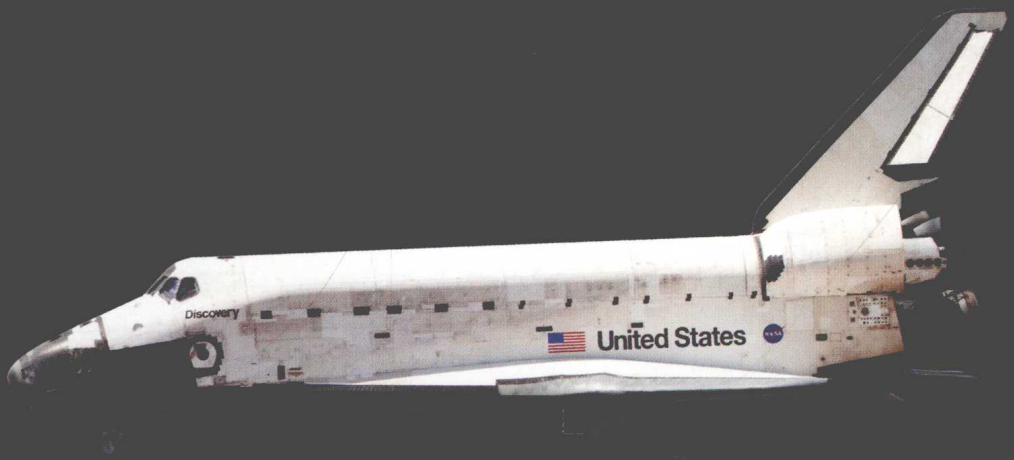

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ACKNOWLEDGMENTS

Without holding him responsible for the contents of this book, I freely admit that a "biography" of *Discovery* would not have come to fruition so well without the unfailingly generous attention of Dennis R. Jenkins, my informal collaborator and "quality control officer." He is an engineer and manager whose long career has been focused on the Space Shuttle, and he knows as much as, and probably more than, anyone about these remarkable vehicles. An author in his own right with many aviation and aerospace books to his credit, Dennis is now completing a three-volume technical history of the Space Shuttle, a work even more definitive than his classic earlier volumes on the history of the Space Transportation System.

Over the years, Dennis and I became acquainted through our work on *Enterprise* and *Discovery*, he as engineer-manager and I as curator. In the midst of concentrating on his *magnum opus*, Dennis graciously read my manuscript, gently guided me toward clarity on any matters needing correction, and helped me sort out credible data when sources differed. One might think that the number of orbits or maximum altitude of a shuttle mission would be a cold, hard absolute, but no; reports sometimes vary, so the numbers become slippery, and he helped me reconcile such discrepancies. He also gave me access to selected documents and images in his reference collection. Fortunately, we are both sticklers for details and patient in the effort to get things right, and this book is much more factually reliable due to his collegial involvement. Thank you, Dennis.

Thanks to NASA for putting so much information online, making it possible to write a book like this at all hours of the day and night, on weekends and holidays, without the constraints of office hours. Press kits, news releases, mission status reports, mission summaries, postflight videos, crew interviews, photographs, and much more are so readily accessible that one need hardly step away from the computer to do research. At times, I had up to ten NASA websites open as I was writing, fact-checking, and tracking down pesky details.

Mary J. (Jody) Russell, who works in the media resource center at NASA Johnson Space Center, deserves credit for her knowledge of the image collection and her impeccable customer service. She is a one-woman rapid response team in filling requests for high-resolution images that are not available online. Like Space Shuttle workers I have known, she always gives her best effort without delay. Margaret A. (Maggie) Persinger in the media archives at NASA Kennedy Space Center also assisted quite ably in locating certain desirable photos.

The staff of the National Air and Space Museum Archives, both the archivists and the photographers, are always a helpful resource, and I tapped them for aid in illustrating the last chapter, *Discovery*'s Final Mission. From the millions of images in the collection, they can find the perfect one or take a new one. For this project, archivists Amanda Buel, Allan Janus, Melissa Keiser, and Jessamyn Lloyd, as well as photographer Dane Penland, merit special notice. Almost everyone else on the museum's staff became involved in planning and executing *Discovery's* transfer and display; without their teamwork and enthusiasm, none of that would have happened.

Patricia J. Graboske, publications officer at the museum, offered this project to me and nurtured our relationship with the publisher. She, Lawana Bryant in the Smithsonian Office of Contracts, and Jo Ann Morgan in the Space History Department deftly handled all the administrative matters. Space history intern Lynn Atkin helpfully compiled mission and crew data for the mission summaries. The Zenith Press editorial and design teams assigned to this project turned their many talents to making Discovery's story into a beautiful book. As editorial director for Zenith Press, Erik Gilg was excited about the book from the outset and promoted it enthusiastically. It has been a pleasure to work with all of them to publish *Discovery*'s story.

Finally, I offer heartfelt appreciation to some people who are farther removed from this project but nevertheless merit acknowledgment. First are the two men who hired me in 1980 and put me to work on shuttle and Spacelab missions for a decade before I came to the National Air and Space Museum. Edwin C. Pruett of Essex Corporation and Charles R. (Rick) Chappell, a scientist at NASA Marshall Space Flight Center, saw potential in a newly minted PhD historian and encouraged me to write on spaceflight, space science, and space technology. It became my life's work, an adventure I never anticipated. Then, working on NASA and museum projects brought me into contact with many scientists, engineers, managers, and astronauts over the years who were generous in sharing their knowledge. They are too numerous to name, but I trust they know that our conversations made me smarter.

If I do justice to *Discovery* here, it is because these knowledgeable friends and colleagues influenced my growth as a writer and curator in the Space Shuttle era.


USA
NASA
Discovery

1 *DISCOVERY* AND THE SPACE SHUTTLE ERA

***Discovery* became the champion** of the Space Shuttle fleet not simply because it flew more missions—thirty-nine in all—than *Columbia*, *Challenger*, *Atlantis*, and *Endeavour*. It also served longer—twenty-seven years—spending altogether 365 days in space. Its flight history began in 1984 as the fleet was starting its busiest two years and ended in 2011 as the shuttle program wound down. Most distinctively, *Discovery* flew every type of mission and served every purpose for which the Space Shuttle was designed. *Discovery* had no rival in the variety of its missions and the range of "firsts" it attained.

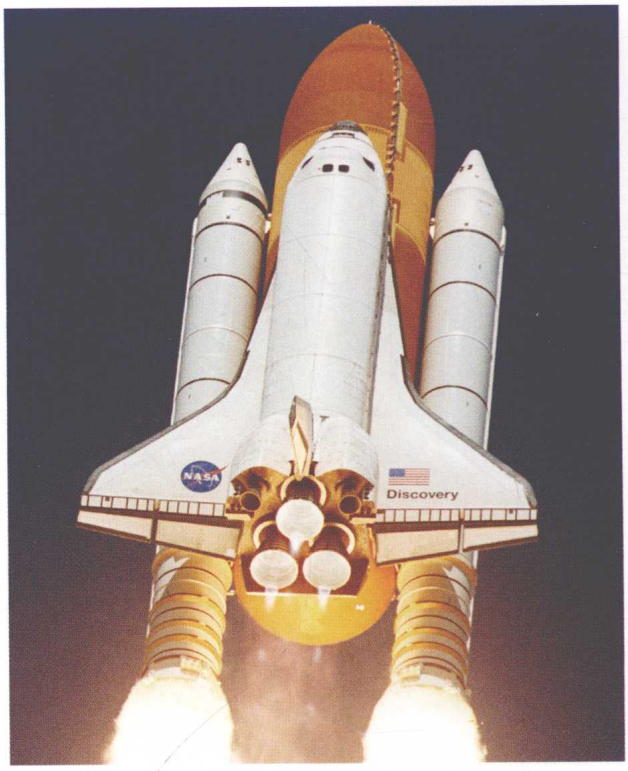
Discovery's story is the full Space Shuttle story in microcosm. Its thirty-nine-episode narrative traces high and low points in the four-decade quest by the United States to make human spaceflight in Earth orbit routine, practical, economical, and safe. *Discovery* alone lifts the story from tragedy back to triumph as the return-to-flight vehicle after both shuttle accidents. Its flight history makes *Discovery* a robust icon for the entire shuttle era.

The Space Shuttle came into being in the 1970s to continue American spaceflight after the space race and landings on the moon. With no national appetite for an expensive grand venture—a space station or a mission to Mars—and with social problems at home, the United States settled on a new Space Transportation System (STS): a fleet of shuttles designed for missions in Earth orbit. Flying often on various types of missions, shuttles presumably would reduce the cost of human spaceflight and expand its purpose. If they proved successful, shuttles

On August 30, 1984, ***Discovery*** launched on its first mission with a six-person crew to deploy three communications satellites and conduct science experiments. ***NASA***

might later pave the way to a space station or deep-space expeditions.

The key element, often called the workhorse or space truck or spaceplane, was a reusable orbiter, large enough to carry both people and payloads and versatile enough to keep dreams alive for a more exotic future. Attached to twin solid rocket boosters and pumping liquid hydrogen and oxygen propellants from an enormous external tank into its three internal launch engines, the vehicle streaked from Earth to orbit in eight and a half minutes. Shedding the boosters and tank during ascent, the spacecraft operated in the altitude range of 115 to 400 miles (185 to 645 kilometers) on stays ranging from two to eighteen days. Covered with a novel thermal protection system made of tiles and blankets, the orbiter descended from space



The Space Shuttle "stack" included the orbiter, its external propellant tank, and two reusable solid rocket boosters. Here, *Discovery* ascends on the STS-114 return-to-flight mission in 2005. *NASA*

Discovery set records in number of missions flown, total time and distance in orbit, and total number of crew members. *NASA*

Discovery made its final touchdown on March 9, 2011, to end the STS-133 mission to the International Space Station. The reusable Space Shuttle orbiter operated as a launch vehicle, crew ship, cargo carrier, and glider. *NASA*

to land on a runway. After several weeks of servicing, the orbiter was ready for its next mission.

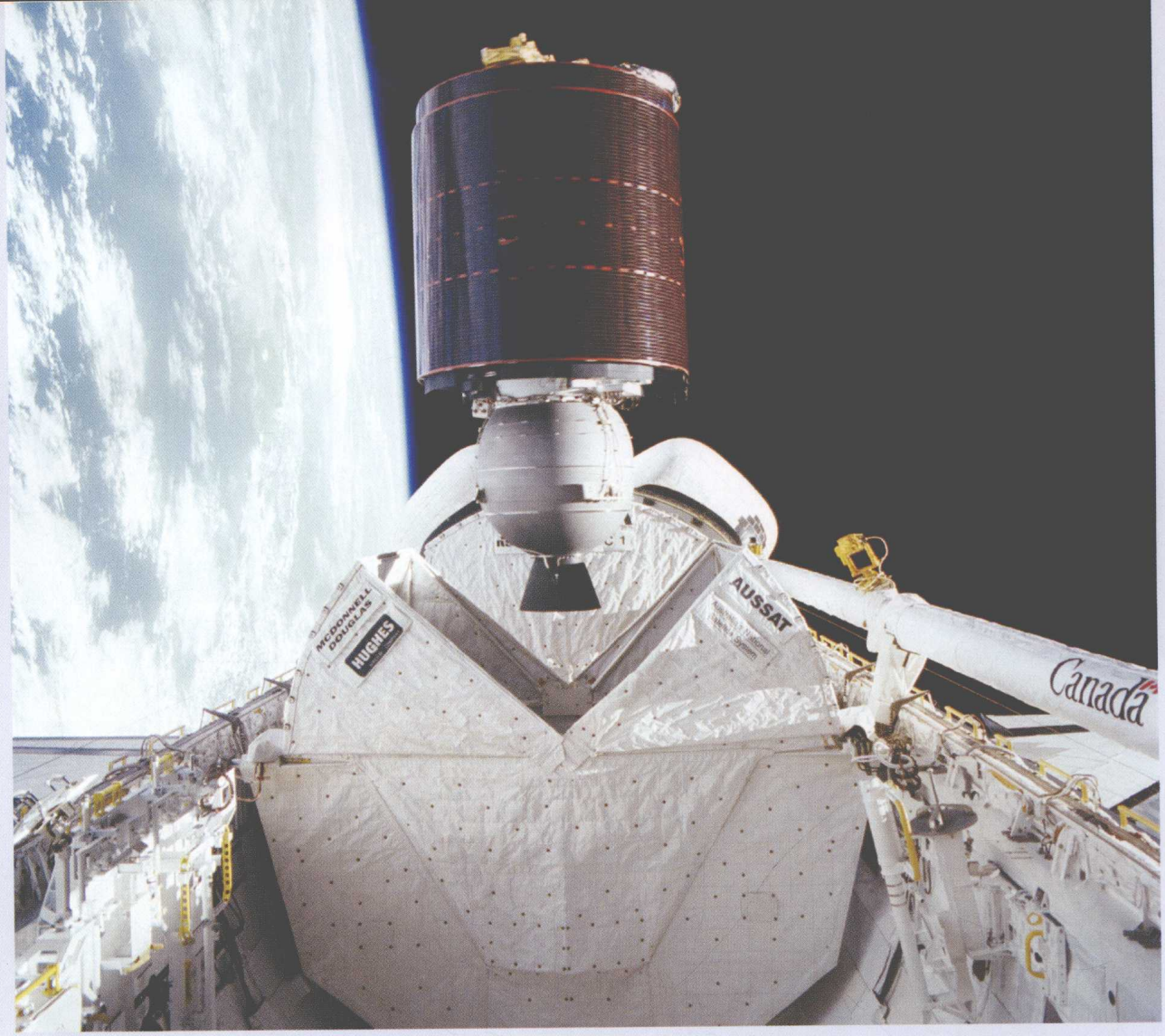
The reusable shuttle would enable humans to begin living and working in space on a routine basis and using space near Earth for practical purposes. In the heady early days of development, planners envisioned spaceflight service as regular as an airline, with a fleet of five or more orbiters launching from sites in Florida and California as often as once a week. This forecast proved overly optimistic for a variety of reasons.

The Space Transportation System was meant to serve all of the nation's launch needs for commercial, scientific, and national security access to space. The plan called for the shuttle to become the sole launch vehicle for all types of payloads. With more onboard engineers and scientists than pilots, shuttle crews offered retrieval of errant satellites, in-orbit servicing of balky or failed equipment, hands-on laboratory research, and the skills for assembly of large space structures. Although for various reasons a large customer base did not materialize, in its first decade the shuttle served the needs of government, industry, and the scientific community as planned.

Skeptics doubted the economic benefits of the Space Shuttle before it began service and continued to challenge the wisdom of this approach to spaceflight throughout its history. Yet from the successful first launch in 1981 to the 1986 launch tragedy, the shuttle ramped up in frequency and duration of flights. Nine missions launched in 1985, and 1986 was to have been even busier, with three orbiters and fifteen launches at an average rate of more than one per month. Spaceflight was beginning to seem routine. After the January 1986 *Challenger* accident brought shuttle flights to a halt for almost three years, the schedule gradually built up to seven and eight missions per year in the 1990s. Launches continued with few pauses for seventeen years until the *Columbia* accident temporarily grounded the shuttle again.

Discovery made its debut as the shuttle program was gaining momentum. Its first mission, STS-41D in August–September 1984, was twelfth in the program's schedule. *Discovery* immediately entered service for satellite deliveries and national security missions. In fewer than two years on duty until the first accident, *Discovery* flew six times, including three consecutive missions, rapidly approaching *Challenger*'s record of nine flights in three years. The future champion was proving its mettle.

The heart of this book is a mission log that presents *Discovery*'s missions in chronological order for easy reference, but first it is helpful to look at its history thematically to see trends and evolution in the

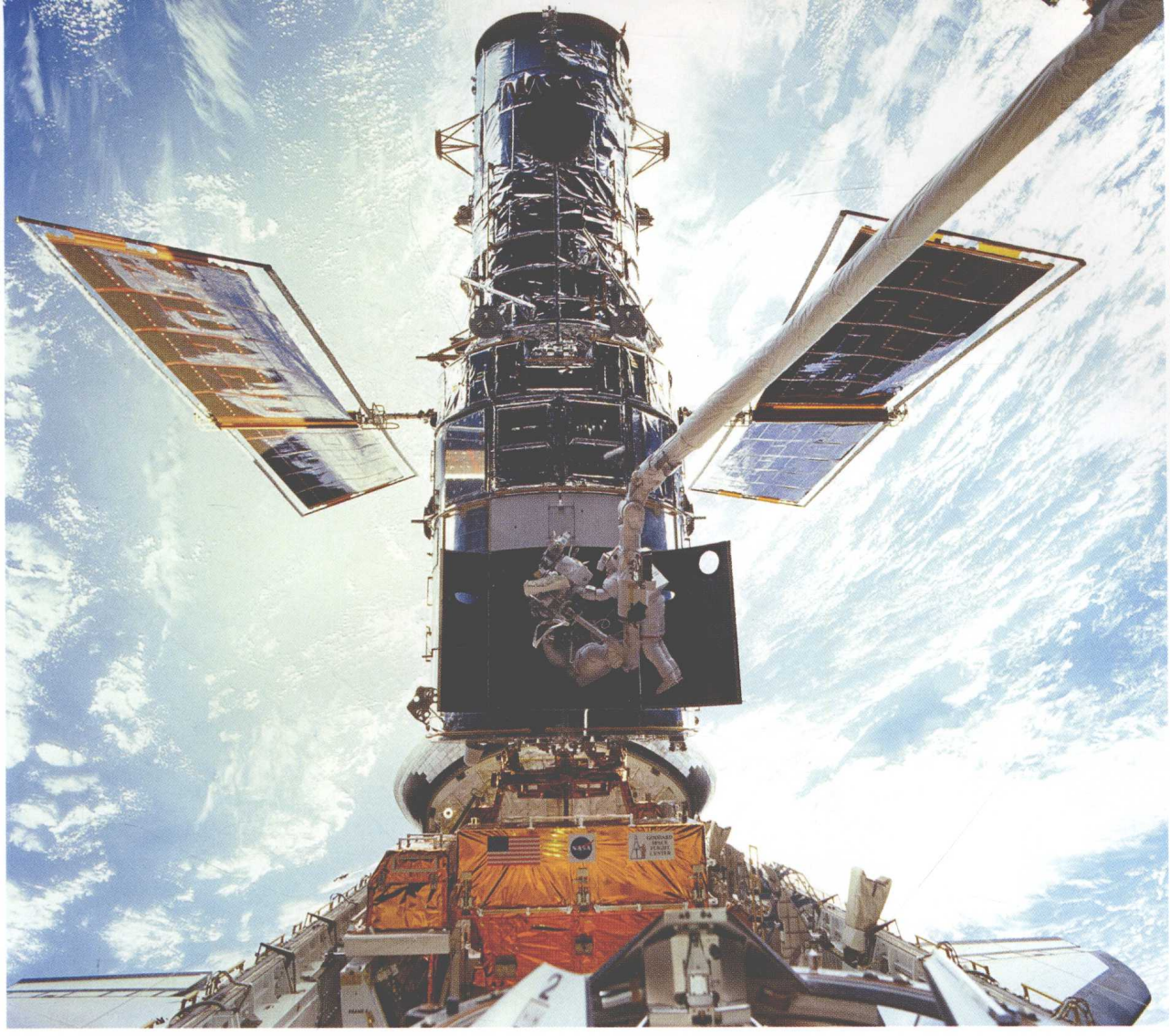


During the 1980s, most *Discovery* missions deployed communications satellites. In this view from the STS 51I mission in 1985, an Australian satellite with attached boost motor rises from the payload bay. Boost stages sent the satellites to geosynchronous orbit. *NASA*

shuttle program. Although every shuttle mission had several objectives, missions generally were designated by their primary purpose or payload into distinct types: commercial, national security, servicing, science, Mir visits, and International Space Station assembly or logistics. *Discovery* flew multiple missions of each type.

Discovery's first role was to deliver commercial satellites to low Earth orbit, from which they were propelled by attached stages to more distant geosynchronous orbits. Five of *Discovery*'s first six missions served customers from the communications satellite industry, and its first two post-*Challenger* missions deployed NASA Tracking and Data Relay System (TDRS) satellites. Some of the commercial missions also delivered a satellite for the U.S. Navy. For satellite deliveries, the shuttle truly served as a cargo truck; two or three satellites were packed in the payload bay to be released one at a time when the orbiter reached the proper altitude and alignment. *Discovery*'s first mission was the first shuttle flight to carry three satellites. In all, *Discovery* delivered sixteen communications satellites for the United States, Canada, Mexico, the Arab League, and Australia. They represented the growing market of non-spacefaring nations eager to join a global telecommunications network.

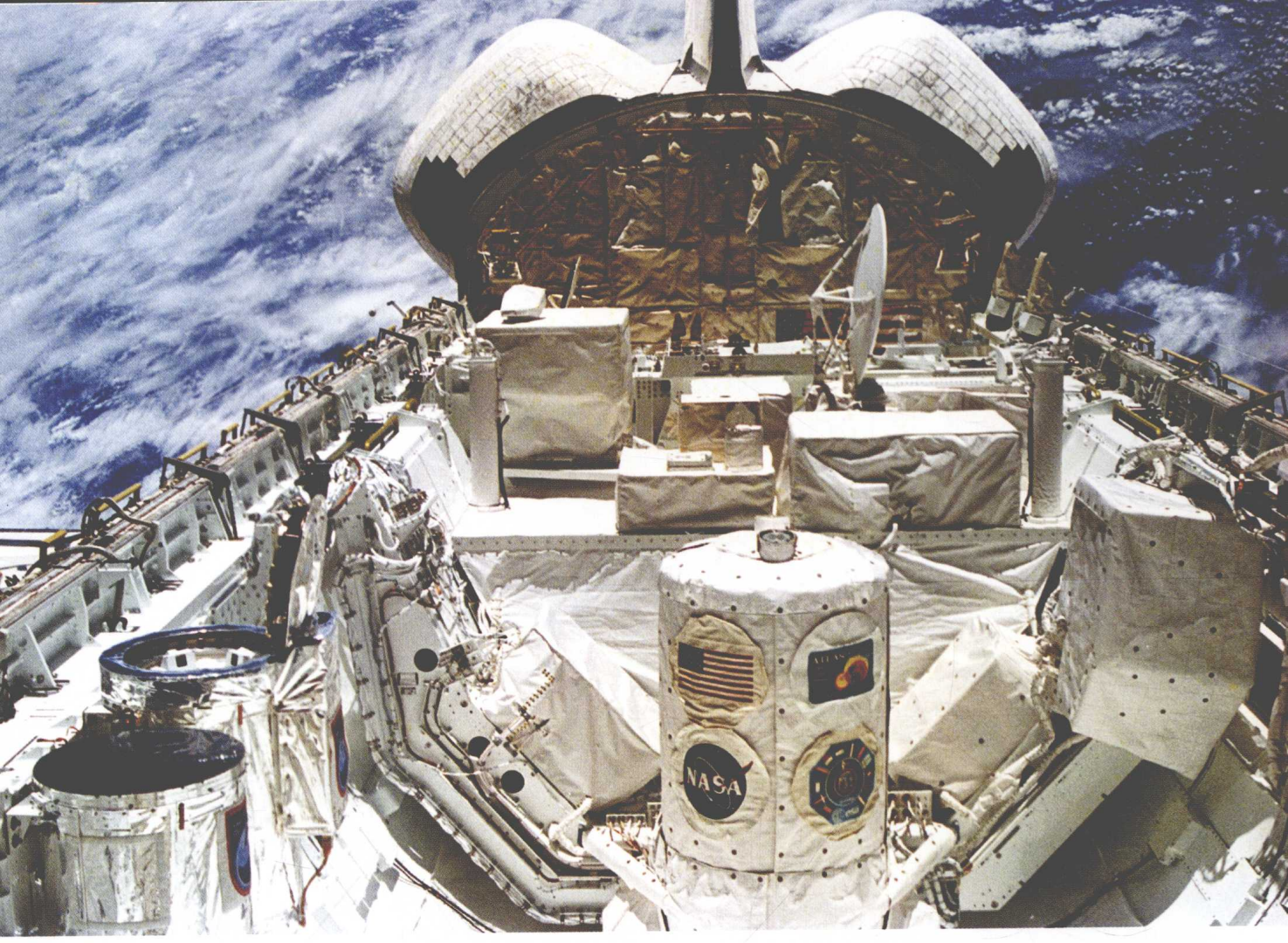
The commercial sector was crucial to the effort to make human spaceflight more economical and routine, and NASA's business plan depended on a growing



Discovery crews completed two of the five servicing missions that extended the life of the Hubble Space Telescope well beyond its planned ten years. In this view from the 1999 servicing mission, astronauts Steven L. Smith and John M. Grunsfeld, working at the end of the long robotic arm, have opened a bay to replace gyroscopes in the pointing and attitude control system. *NASA*

and active customer base for satellite deliveries and also for research projects. NASA cultivated commercial customers with attractive pricing and incentives, including the opportunity for a corporate payload specialist to join the crew. The first commercial payload specialist, Charles D. Walker of McDonnell Douglas, flew on *Discovery* twice and *Atlantis* once to conduct experiments in a potentially lucrative manufacturing process. Saudi Arabia and France placed payload specialists on *Discovery* to witness the deployment of their satellites, as did Mexico on *Atlantis*. Three members of Congress took advantage of this courtesy and persuaded NASA to put them on crews—Senator Jake Garn on *Discovery* in 1985, Representative William "Bill" Nelson on *Columbia* in early 1986, and Senator John Glenn on *Discovery* in 1998.

Commercial payloads occasionally prompted another mission type: servicing. Twice *Discovery* crews combined deployments with retrievals for repairs or returns when satellites failed to reach their required orbits. The crew of *Discovery*'s second mission celebrated the first in-orbit satellite retrieval with a "2 Up, 2 Down" sign when they successfully deployed two satellites and picked up two others to bring home for refurbishing. Another *Discovery* crew brought an idle satellite into the payload bay, installed a new ascent motor, redeployed it, and watched it ignite on its intended path. These servicing episodes demonstrated



Discovery's science missions typically included retrievable research satellites and instruments mounted in the payload bay. This ATLAS 2 suite of instruments for atmospheric and solar physics investigations flew on the STS-56 mission in 1993. *NASA*

important crew skills and built crew experience for future projects, notably servicing the Hubble Space Telescope and assembling a space station.

Policy changes after the *Challenger* accident took commercial satellites off the shuttle and seriously eroded the commercial market for shuttle flights. Commercial experiments continued to fly as secondary payloads, but *Discovery*'s role soon shifted from satellite delivery to other types of missions.

The Department of Defense reserved *Discovery*'s third flight for the first dedicated, classified, national security shuttle mission, about which little is known beyond the names of the first all-military crew and the first U.S. Air Force payload specialist who was not in the NASA astronaut corps. The primary payload was presumed to be an electronic intelligence satellite. Although the shuttle was designed and developed with national security needs in mind, the air force grew reluctant to rely on the shuttle and NASA as the sole launch provider, preferring instead to maintain its own capacity for assured access to space. Even before the *Challenger* accident and subsequent grounding of the fleet, the Department of Defense began to ease away from the shuttle. It completed its backlog of planned national security missions when flights resumed and then abandoned the shuttle except for occasional small, unclassified payloads.

From 1984 through 1992, *Discovery* flew four of the ten Department of Defense missions. The first two of these were strictly classified, but allegedly spy satellites were deployed for the National Reconnaissance Office. The other two missions were publicly linked

to the Strategic Defense Initiative ("Star Wars"), one unclassified and the other partially cloaked in secrecy. Editorial cartoonists mocked the military missions by portraying the shuttle in disguise or as invisible, but the point was to question militarization of space and the place of secrecy in a public space program defined by its open conduct. The issue dissipated as the air force returned to its preferred rockets and the Space Shuttle moved on to almost exclusively civilian tasks.

In 1990 and again in 1997 and 1999, *Discovery* and its crews made history, first by deploying the heralded Hubble Space Telescope and then by returning twice to service, repair, and redeploy it. *Discovery* was not scheduled for the urgent first visit to install corrective optics, but it drew duty for the second and third of five servicing missions. Spacewalking teams updated the telescope with newer technologies and extended its life by repairing or replacing worn components. With skill and finesse, *Discovery* crews demonstrated the value of humans in space for efficient performance of complex tasks. In-orbit servicing benefited the astronomical community by adding years of continued telescope operations and also built the experience base for future large assembly projects such as the International Space Station.

On missions to the Hubble Space Telescope, the orbiter's name seemed especially apt. Namesake of the exploring ships of Henry Hudson and Captain James Cook, *Discovery* furthered the tradition of exploration and discovery through improved observation of the universe.

Discovery's primary occupation in the 1990s, however, was to support science. On ten missions during the decade, this orbiter carried satellites, observatories, or laboratories for scientific research. It also delivered the sun-circling explorer called Ulysses. NASA's science missions had several purposes: to exploit microgravity as a laboratory environment, to understand better the changes in humans and other organisms during long stays in space, to take advantage of the clear viewing

Discovery made the first and last of nine shuttle missions to Russia's Mir space station, seen here during the shuttle's final departure in 1998. *NASA*