SAMPLE

Cosmic Explorers: The Space Shuttle

Workhorse of Orbit

Aira Astralis

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Introduction

For thirty years, between 1981 and 2011, the United States operated a vehicle that no nation has matched since: a winged spaceship the size of a small airliner, launched like a rocket, flown in orbit like a ship, and landed like a glider, again and again, one hundred thirty-five times. It was called the Space Transportation System by its builders, and everyone else called it the Space Shuttle, and for a generation it was the human space program. The International Space Station exists because of it. The Hubble Space Telescope exists, and survives, because of it. More than three hundred fifty people flew to space on it, including schoolteachers, scientists, and senators, and the phrase going to space meant, for most of a working lifetime, climbing aboard one of five flying machines with names as familiar as ships of the line: Columbia, Challenger, Discovery, Atlantis, Endeavour.

This book is the Shuttle's biography, told for the general reader, and it is a biography of a machine in the fullest sense: the Shuttle had a birth, an education, a prime of life, tragedies, a middle age, and a long, deliberate retirement. It was conceived in an argument about money and designed in a series of political compromises that shaped everything that followed, and the reader who wants to understand any single Shuttle mission needs the design history first, because the machine was from birth a collection of trade-offs, some of them mortal. It was built to make spaceflight routine, and it did, in a way nothing else ever has: for three decades, the launch of a crewed vehicle was a scheduled event, bookable years ahead, with a manifest of payloads and a customer list, and the ordinariness of it was both its greatest achievement and, twice, the seed of its disasters.

The numbers earn a place early, because the scale is easy to forget. Across one hundred thirty-five flights, the fleet logged over thirteen years of combined time in space across missions, carried nearly four million pounds of cargo to orbit, deployed satellites and planetary probes, serviced and repaired the greatest telescope ever built, and assembled, mission by mission, the largest structure humans have placed off the Earth. Two of its five ships were lost, with fourteen astronauts aboard them, and the losses are chapters of this book, told with the seriousness the subject demands, because the Shuttle's story cannot be told honestly without them, and because the investigations that followed each loss changed, permanently, the way the spacefaring nations think about risk.

The Shuttle is also, and this is the reason for a book rather than an article, one of the great engineering stories. The machine itself was a compilation of inventions: the first reusable thermal protection system, a quilt of silicated

tiles that let an aluminum airplane survive re-entry heating; the first crewed solid rocket boosters; the first fly-by-wire spacecraft, controlled entirely by computers; the first main engines tuned so close to their material limits that their combustion chambers ran, deliberately, at pressures and temperatures beyond anything before them. It was a spaceship assembled from a bomber's flight deck, a lighthouse of propellant tanks, and the world's largest firework boosters, and it flew for thirty years, and the reader who follows its design will meet, at every joint, the fingerprints of the budgetary and political arguments that shaped it.

The chapters run in the order of the life. We begin with the bargain: the post-Apollo environment that demanded a reusable spaceship as the price of continuing human spaceflight at all. We follow the design fight, the building of the machine, and the anatomy of the stack. We ride a full mission, from the launch pad to the runway, and walk the early test flights. We survey the working years, the satellites and the laboratories, and then the first loss, the January morning in 1986 when the routine broke, and the long climb back. We fly the repair missions that saved Hubble, and the assembly flights that built the station. We come to the second loss, in 2003, and the changes it forced. We close with the retirement, the numbers, and the legacy, because the Shuttle's story ends with a question that the spacefaring nations are still answering: what should a spaceship be, and who should ride it.

No mathematics is required, and no prior knowledge of spaceflight. Where a number tells the story better than an adjective, the number is given plainly. The reader will finish with an understanding of what the Shuttle was, what it cost, what it did, why it looked the way it did, why it failed the way it failed, and why, a decade and more after its last landing, the machine that was supposed to be the first of a fleet remains the only one of its kind.

Chapter 01: The Bargain: A Spaceship to Keep Spaceflight Cheap

The Shuttle did not begin as a design. It began as a price. To understand why the most complicated flying machine in history took the shape it did, the reader must first understand the situation of the American space program in the years after Apollo, because the Shuttle was not the machine anyone wanted, but the machine the country could afford, and its whole body is the record of that arithmetic.

The Apollo program, the lunar landings, was the most expensive civilian project of its century, consuming at its peak about four percent of the federal budget. It succeeded, completely, and in succeeding it destroyed its own justification: once the moon had been reached, the political will that had paid for it evaporated, and the National Aeronautics and Space Administration faced the 1970s with a shrinking budget and a public that had stopped watching. The agency's leadership, most prominently Administrator Thomas Paine and then James Fletcher, faced a stark fact: no successor program on Apollo's scale would be funded. If human spaceflight was to continue at all, it had to be sold as economical.

The economical case pointed to one idea above all others: reuse. The rockets of the era were, in the blunt phrase of the engineering culture, artillery: each one flew once and was destroyed in the process, and the cost of every launch included the whole cost of the vehicle. Aircraft, by contrast, were refueled, maintained, and flown again for decades, and the economics of aviation were the economics everyone knew. If a spaceship could be built that came home, was serviced, and flew again, the cost per flight, in the argument of the era, would fall dramatically, and human spaceflight would settle into something like an airline: scheduled, ordinary, and cheap. The vision had a name in the early studies, the Space Shuttle, a shuttle being a vehicle that runs a route back and forth, and the name outlived every revision of the vision.

The new spaceship was assigned a cargo before it had a shape. The post-Apollo plan, articulated in a series of studies in 1969, called for a space station in orbit, a lunar base, and a Mars expedition, all serviced by the new shuttle, and the shuttle's design was driven by what it had to carry: station modules, crews, satellites, and propellant. The station's budget died in Congress within two years, the lunar and Mars plans died with it, and the shuttle survived as the only funded element, a truck built to supply a destination that was never approved. Stripped of its purpose, the machine had to become its own justification, and the selling of it to the White House and Congress, in 1971 and

1972, took the form of an economic promise: the Shuttle would fly all of the nation's payloads, crewed and robotic, and by flying them cheaply, it would pay for itself.

The promise set the requirements, and the requirements set the fatal compromises, described in the next chapter. To be economical, the vehicle had to be fully reusable and fly often. To win the payload business of every government agency, it needed a large cargo bay, which fixed its size. To serve the Department of Defense, which signed on as a customer whose support was politically essential, it needed to be capable of flying polar-orbit missions, launching from the west coast into paths that overfly the poles, and polar missions demanded performance margins that shaped the machine's mass and configuration. And to satisfy the budget process, its development cost had to fit under a ceiling that was, by the standards of the vision, brutally low.

The bargain was struck, and the President announced it: in January 1972, Richard Nixon approved the Shuttle's development, speaking of routine access to space the way one speaks of a new highway. The words of the announcement were the vision's high-water mark: an economical space transportation system, taking the place of the expendable rockets, opening space to routine travel. Nothing in the announcement mentioned that the design had been reshaped, in the year before, to fit the money, or that the reshaping would eventually cost two crews, and the story of the reshaping is the story of the next chapter.

The design the bargain killed is worth one paragraph of mourning, because it was the better ship. The engineers' first drawings were of a fully reusable two-stage vehicle, a winged booster that would fly back to a runway and a smaller orbiter riding it, both pieces recovered, both pieces cheap in the arithmetic the bargain demanded. That ship priced out beyond what the budget would pay, and the compromise that survived recovered only the orbiter and the booster casings, throwing away, on every single flight, the largest and most expensive part of the stack. The reader should hold the shape of that original drawing across the rest of the book, because the Shuttle's whole story, its economics and its two catastrophes included, is in large part the story of a fully reusable ship that could not be afforded and the half-reusable one that was built instead.

The reader should also understand what the bargain did to the program's engineering culture, because the effect outlasted the design phase by decades. A machine designed to a political price carries its tensions into operation: every component inherited a requirement that could not be renegotiated without reopening the whole bargain, and the program's

engineers spent thirty years improving a machine whose fundamental configuration was fixed in 1972 by people who could not have known what they were fixing. The tile quilt could be improved but not replaced, the wings could be inspected but not shrunk, the side-mounted stack could be instrumented but not reconfigured, and every safety upgrade fought the same fight, the argument of the redesign against the argument of the schedule, on ground where the original bargain had already conceded so much.

End of free sample. The full book is available at putrabooks.github.io

ABOUT THE AUTHOR

Aira Astralis is a science writer specializing in astronomy and space exploration. Her work spans the full breadth of humanity's relationship with the cosmos -- from the earliest naked-eye observations to the engineering marvels of modern space missions.

Her books are built on a foundation of primary sources: peer-reviewed research, mission archives, and direct engagement with the scientific community. She writes for readers who want to understand not just what we know about the universe, but how we came to know it.

She believes that the most important frontier is not out there but in the gap between what scientists discover and what the public understands. Her books exist to close that gap.