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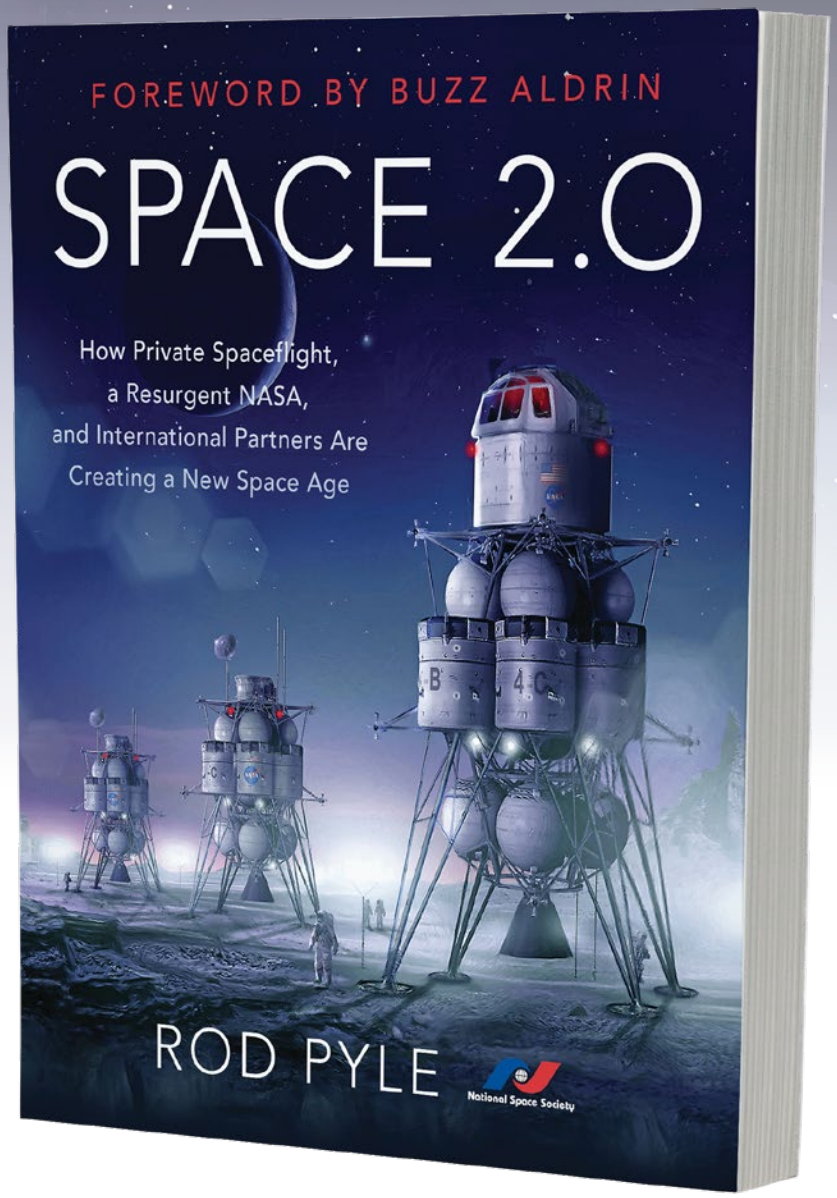

MARKETING AND MEDIA REQUESTS:

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WE'RE ON THE CUSP OF A NEW ERA IN THE GREAT ADVENTURE OF SPACE EXPLORATION.

More than a half-century ago, humanity first hurled objects into space, and almost 50 years ago, astronauts first walked on the moon. Since then, we have explored Earth's orbit with shuttles, capsules, and space stations; sent robots to Mars, Venus, Mercury, Jupiter, Saturn, and Uranus; sampled a comet; sent telescopes into orbit; and charted most of our own planet.

WHAT DOES THE FUTURE HOLD?

In *Space 2.0*, space historian Rod Pyle, in collaboration with the National Space Society, will give you an inside look at the next few decades of spaceflight and long-term plans for exploration, utilization, and settlement.

No longer the exclusive domain of government entities such as NASA and other national agencies, space exploration is rapidly becoming privatized, with entrepreneurial startups building huge rocket boosters, satellites, rocket engines, asteroid probes, prospecting craft, and even commercial lunar cargo landers to open this new frontier. Research into ever more sophisticated propulsion and life support systems will soon enable the journey to Mars and destinations deeper in our solar system. As these technologies continue to move forward, there are virtually no limits to human spaceflight and robotic exploration.

While the world has waited since the Apollo lunar program for the next "giant leap," these critical innovations, most of which are within our grasp with today's technology, will change the way we live, both in space and on Earth. A new space age—and with it, a new age of peace and prosperity on Earth, and settlement beyond our planet—can be ours.

Speaking with key leaders of the latest space programs and innovations, Pyle shares the excitement and promise of this new era of exploration and economic development. From NASA and the Russian space agency Roscosmos, to emerging leaders in the private sector such as SpaceX, Blue Origin, Moon Express, Virgin Galactic, and many others, *Space 2.0* examines the new partnerships that are revolutionizing spaceflight and changing the way we reach for the stars.

ABOUT THE NATIONAL SPACE SOCIETY (NSS)

NSS is an independent nonprofit educational membership organization dedicated to the creation of a spacefaring civilization. NSS is widely acknowledged as the preeminent citizen's voice on space, with over 50 chapters in the United States and around the world. The Society publishes *Ad Astra* magazine, an award-winning periodical chronicling the most important developments in space.

ABOUT THE AUTHOR & BOOK

ROD PYLE is a space historian who has worked with NASA at the Jet Propulsion Laboratory and the Johnson Space Center. He has written nine books on the history and technology of space exploration and science for major publishers in the US, UK and Asia. As a journalist, Rod's work has appeared in Space.com, LiveScience.com, The Huffington Post, *Popular Science*, and many other print and online venues. Rod has also produced documentary programming on spaceflight for The History Channel as well as Discovery Communications. He has written on spaceflight and science for NASA/JPL and Caltech, and authored a guide to executive education for the Johnson Space Center/The Conference Board's *Apollo Leadership Experience*. Rod speaks frequently on spaceflight and executive development, and is a frequent radio guest with regular appearances on WGN/Chicago, KFI/Los Angeles and numerous syndicated radio programs. He worked on the TV series *Star Trek: Deep Space Nine* as a visual effects coordinator for three seasons, and spent a decade at the Griffith Observatory in Los Angeles. Rod is a graduate of Stanford University and the Art Center College of Design in Pasadena, California, and a member of the National Space Society, the Author's Guild, the National Association of Science Writers and the Producer's Guild of America.

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AN EXCERPT FROM CHAPTER 1: ENDING SPACE 1.0

"If you want to build a ship, don't drum up people together to collect wood and don't assign them tasks and work, but rather teach them to long for the endless immensity of the sea."
—Antione de Saint-Exupery, author and pioneering aviator

"When something is important enough, you do it even if the odds are not in your favor."
—Elon Musk, founder of SpaceX

JULY 8, 2011 COULD HAVE BEEN any other summer day on the Florida coast—the sky was a stunning blue, a warm breeze blew across the tidelands, and the green water offshore was glassy. But this was not just another day in the Sunshine State. Before me a was a billboard-sized digital clock, slowly counting down towards zero, and three miles beyond that stood a space shuttle, shimmering in the midday heat. Billows of white vapor spewed from its orange fuel tank as the ultra-cold liquid oxygen boiled-off, as if anxious to be ignited. Atlantis appeared ready to bolt into the heavens.

This morning would host the 135th and final launch of the space shuttle program, an exciting event (as all launches are), but one was swaddled in both hope and wistfulness. The hope hinged on the up-and-coming NASA partnership with commercial space providers SpaceX and Boeing, who were building the presumed replacements for the shuttle's delivery of astronauts to the International Space Station (ISS). The wistfulness was for the end of the first era of human spaceflight, space 1.0, which began with the early Mercury program and culminated in the Space Transportation System, more commonly known as the space shuttle. The shuttle program had been America's premiere space effort for over thirty years. It had returned us to space in 1981 after the six-year post-Apollo lull (the last Apollo spacecraft flew in 1975), conducted countless experiments in orbit, deployed and repaired the Hubble Space Telescope, docked repeatedly with the Soviet Mir space station, and built the International Space Station. While the shuttle never fully realized its intended destiny as a more affordable and reusable means of reaching space than its predecessor—the shuttle was complex, delicate, dangerous, and expensive to refurbish— the fleet served NASA for more than three decades, providing relatively routine access to low Earth orbit. This launch represented the final act of the program.

Atlantis's primary payload that day was the final major part of the ISS, a Europe-supplied component called the Multi-Purpose Logistics Module, that would complete the sprawling orbital complex. Atlantis carried only four astronauts instead of the normal six or seven, due to the fact that there were no more shuttles available for a rescue in case of an in-flight emergency. If there was a problem, the astronauts would have to shelter in the ISS, and four was the maximum number that could be safely accommodated.

As the countdown reached its final seconds, a gush of water erupted at the base of the launch pad to absorb the massive acoustic shock from the rocket engines that would soon pummel the flame trench. A bright flicker emanated from the base of the shuttle, and a tremendous volume of smoke billowed outward as the engines came up to full power. Moments later, at T-minus-zero, the side-mounted solid rocket boosters ignited and Atlantis leapt skyward, departing on its final journey at 11:29 am. A deep rumble washed over us a few seconds later, as the spacecraft climbed slowly skyward, gaining speed and riding a column of smoke into the east.

As the smiling crowd slowly departed the stands, a sense of finality settled over me. Nobody knew for certain when another rocket would depart from Pad 39. America's future in human spaceflight was dependent on new partnerships with private aerospace companies, an arrangement that was in flux. It could be years before U.S. astronauts departed from the Cape again.

As the spectators headed home, Atlantis made its way to the space station. Before docking, it paused about 600 feet away for astronauts already aboard the ISS to give the shuttle's tile-covered underbelly and the leading edges of its wings a thorough inspection. Those tiles, and the reinforced carbon composite shells that made up the front ends of the wings, would be its sole protection from the incandescent heat of reentry it would face in just under two weeks. NASA had learned the hard way that damage to these elements of the Thermal Protection System could result in catastrophe upon reentry, as had occurred eight years earlier with the shuttle Columbia. A piece of foam insulation from the fuel tank had broken free during launch and impacted the leading edge of the left wing, punching through the thin reinforced carbon composite there, dooming Columbia and its crew. The Columbia accident was the second loss of a shuttle since Challenger exploded in 1986, and just one more in a long list of flights in which protective thermal coverings were damaged during launch, imperiling the crew. This fragility was one of a number of factors that led to the termination of the shuttle program.

With that solemn assessment complete, Atlantis docked with the ISS, delivering the station's final major component, and the shuttle's mission continued for its 12-day duration. Atlantis returned for the last time on July 21, 2011, was decommissioned, and now resides in a museum display at the Kennedy Space Center, locked in a permanent orbit around a huge rear-projected image of the Earth.

The end of the shuttle program also created a yawning gap in America's ability to fly humans into space. The Constellation program, initiated by President George W. Bush in 2004, was intended to create a replacement for the shuttle—a cheaper, expendable rocket and capsule, designed along the lines of the Apollo spacecraft of the 1960s. This new program was also supposed to have the capability to return astronauts to the surface of the Moon. But Constellation, continually over-schedule and under-budgeted, was cancelled by President Obama in 2010 after a program review by aerospace experts, so the shuttle program came to an end without a replacement.

Let me repeat that: America was giving up its sole functioning capability to fly astronauts to the space station that we had designed and built, at staggering expense, without a domestic replacement. This stunned much of the spaceflight community, and a lot of people, including a number of Apollo-era astronauts, were quite vocal in their dissent. Neil Armstrong, the first man to walk on the moon; Jim Lovell of Apollo 13 fame; and Gene Cernan, the last man to depart the lunar surface, all strongly condemned the decision. In an open letter to the President, the three former astronauts said, that the decision to cancel the Constellation program was "devastating." The letter continued, "America's only path to low Earth orbit and the International Space Station will now be subject to an agreement with Russia to purchase space on their Soyuz … until we have the capacity to provide transportation for ourselves. The availability of a commercial transport to orbit as envisioned in the

president's proposal cannot be predicted with any certainty, but is likely to take substantially longer and be more expensive than we would hope." Their assessment of the pace of commercial spaceflight's ability to deliver astronauts to orbit turned out to be prophetic. While much progress has been made since that final shuttle launch, many experts suggest that commercial spaceflight partnerships have been consistently underfunded, and the contractors that will be providing astronaut transportation to the ISS—Elon Musk's SpaceX and Boeing—have been running behind schedule. While nobody can say how the Constellation program would have turned out, the U.S. has suffered an eight- to ten-year gap in human spaceflight capability since the end of the shuttle program.

The shuttle's temporary replacement, the Russian Soyuz, was to cost NASA $32 million per seat for each American astronaut that flew to the ISS. That sounds expensive, but was on its surface much cheaper than flying on the shuttle, which cost a minimum of $71 million per person. This represented a large cost savings over the development of the Constellation program… if low Earth orbit was your only destination. But Constellation promised the ability to send missions to the Moon and eventually Mars, so the numbers are difficult to compare. Constellation would also have been capable of delivering much larger, heavier payloads to orbit. In the short term, buying seats on Soyuz seemed like a bargain, but was not. By 2017 that price had risen to $81.7 million, arguably more per passenger than the shuttle, and with far less capability. Not such a bargain anymore.

There are a number of reasons for this discomfort with flying aboard the Soyuz besides the direct per-person launch costs. While the Russian launches were (initially) cheaper, the use of the Soyuz bound American astronauts to Russian flight schedules, which were often erratic. American astronauts would also have to train at Russian space facilities, which represented an added expense. The Soyuz capsules were also much smaller than the shuttle's crew compartment, carrying a maximum of three, as opposed to the shuttle's compliment of seven astronauts. Finally, manned Soyuz flights were unable to carry a meaningful amount of cargo to the station—the U.S. would end up paying for robotic cargo flights to offset what the shuttle was no longer delivering.

There was an additional objection contained in the letter from the three astronauts that went beyond complaints about Russian pricing and the uncertain future of commercial spaceflight, one more philosophical in nature. They continued, "Without the skill and experience that actual spacecraft operation provides, the U.S. is far too likely to be on a long downhill slide to mediocrity. America must decide if it wishes to remain a leader in space. If it does, we should institute a program which will give us the very best chance of achieving that goal."

Their contention was that the U.S., a premiere power in spaceflight, was ceding its ability to get people into space, and perhaps more critically its ability to operate large human spaceflight programs in the future. In response, the Obama administration outlined plans to spend more money to support development of human-rated spacecraft in the private sector, and to salvage parts of the Constellation program—an evolution of Constellation's heavy booster, now dubbed the Space Launch System, and the Orion capsule.

To many observers, this represented a welcome change in priorities. NASA would continue to build—albeit very slowly—their own space capsule and large rocket, which would carry a human crew to rendezvous with an asteroid in the 2020s. They would additionally direct funding to private spaceflight companies such as SpaceX and Boeing to deliver astronauts and supplies to the ISS.

There was one major bug in the ointment, however. The Asteroid Redirect Mission (ARM), as it came to be known, while a valid demonstration of technology and engineering, was not popular. It appeared on the surface to be a program invented more to give Orion/SLS something to do as opposed to a valid science and engineering program. ARM died with the start of the Trump administration, and has since been replaced with a NASA initiative to return to the Moon.

This is where we find ourselves near the end of the second decade of the 21st century. Regardless of the destination planned for Orion/SLS, both vehicles have been consistently behind schedule and over budget. But the Orion/SLS system continues to move forward, and is currently slated for a maiden flight in 2019-2020. The realpolitik of the programs involves a great number of jobs in a few NASA facilities and aerospace contractors in various congressional districts; always important political considerations.

At the same time, NASA funding for private sector efforts has fallen short of its own stated goals every year since 2010. SpaceX, Boeing, and other commercial space providers continue to vie for increased government funding for commercial spaceflight capability. NASA's overarching plan is for the commercial providers to handle getting people and cargo to the International Space Station, while Orion/SLS handles NASA's human exploration plans beyond low Earth orbit.

This scenario may sound a bit bifurcated, with too little money being spent in two overlapping camps, but there are reasons for optimism. In early 2017, the Trump administration reactivated a government oversight group called the National Space Council. This body had existed twice before--once between 1958-1973, then again from 1989-1993. Its mandate is to tackle long-range policies for American goals in space, reporting directly to the executive branch, with the plan then being implemented by NASA and other federal departments. The Council is chaired by the Vice President, and is composed of top space policy makers, cabinet-level government officials, and the NASA administrator. It is advised by a selection of aerospace professionals from companies old and new, as well as a number of military personnel.

The Council has created recommendations for how NASA can best move ahead, both with its own efforts and with continued funding for the private sector. The preferred balance they seek is for the private sector companies to be properly funded do what they can do best—create a set of robust, low-cost spaceflight capabilities to get humans and cargo to orbit, and compete to improve these services for increasingly lower costs.

The two companies currently developing a contracted capability to deliver astronauts to the ISS are Elon Musk's SpaceX and Boeing. SpaceX is building and flying the Falcon 9 rocket, which is currently running regular cargo supply runs to the ISS, and are poised to begin flying astronauts to the station in 2019 or 2020. It has independently developed and flown the Falcon Heavy mega-booster, but this is not, as yet, part of NASA's commercial program.

Boeing and United Launch Alliance have their own contracts with NASA, and a Boeing-built capsule called the Starliner will soon be launching atop ULA's Atlas rockets to also deliver crews to the ISS. These traditional aerospace companies know that they must adapt or die in this new environment, and are working hard to compete with SpaceX.

Other commercial entities are flying cargo to the ISS under contract to NASA. Orbital ATK is providing commercial cargo services to the ISS, and Sierra Nevada Corporation, a company that is experimenting with a mini-shuttle, is preparing to join them on these commercial cargo runs.

For decades, the U.S. and Russia were the only countries flying humans into space, but this is changing. China launched the first crewed flight of its human spaceflight program 2003, and has lofted two small space stations of its own. India is poised to follow with human a spaceflight capability within a decade. Clearly, new international players and the U.S. commercial sector are gaining traction in an area that has been, since 1961, the exclusive domain of the United States and Russia.

These developments are heartening, as they represent a strong shift in favor of more frequent, less expensive, and more diversified access for humans to travel into space. But back in 2011, as I watched the smoky trail of Atlantis dissipate over the Kennedy Space Center, these were still mostly promises in the making. SpaceX would not make their first cargo run to the ISS until 2012, Boeing was just beginning work on the Starliner, and China was striving to deliver the first crew to its tiny Tiangoing-1 orbiting laboratory. These were promising beginnings, but it was, at the time, far from certain how any of these efforts would play out.

As I traveled home from Florida, I reflected upon the circuitous route that U.S. space activities and those of other nations have taken since the 1960s. I thought about how the Apollo spacecraft had been replaced by the shuttle, ending our efforts for human exploration beyond Earth orbit. I reflected on what alternative paths might have been followed, and what the results might have been. I balanced these notions with positive thoughts about the rise of private spaceflight and China's nascent efforts. One thing became increasingly clear: whatever the next few decades hold in store, the results are unlikely to resemble the first space age, and that's a good thing.

Since the late 1970s, many space advocates have pined for another "Kennedy moment," when an American President or foreign leader (probably Russian) would stride to a podium and announce a daring, large-scale government program to accomplish aggressive new goals in space, such as JFK did when he announced the Apollo lunar landing program in 1961. Three presidents have made similar announcements, but none have stuck like the lunar landing challenge did—and little wonder. Kennedy's announcement, which kicked off the space race, was motivated primarily by geopolitics, and was very much a product of its time. It is not a moment likely to be reenacted in the 21st century; the world has moved on from the cold war world of binary superpowers. We are now in a far better position to embark upon a sustainable program of human spaceflight and space development, and toward a permanent, robust human presence off-Earth that will benefit everyone who participates.

WELCOME TO SPACE 2.0.

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