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Emergence of the Orbital Age:
American Spaceflight following the *Columbia* Accident

by

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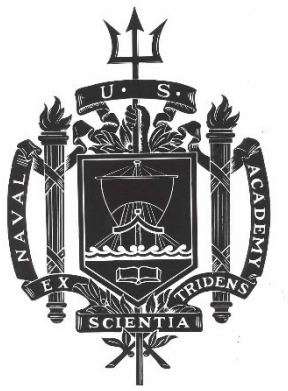

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American human spaceflight long remained the domain of the government and major contractors. The 2003 Columbia accident challenged traditional thoughts and assumptions about the space program, leading to the first commercial cargo program, a planned retirement of the Space Shuttle, and a need to create a new crew vehicle without an expanded budget. The Obama administration used the reality of the 2008 recession and the Columbia accident to bet on commercial providers to return Americans to space.

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EMERGENCE OF THE ORBITAL AGE: AMERICAN SPACEFLIGHT FOLLOWING THE *COLUMBIA* ACCIDENT

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Abstract

The debate over commercial versus public-funded ventures left the United States with two concurrent human spaceflight programs–one focused on commercial development to continue regular operations, and the other on exploration through government ventures. Focusing on the *Columbia* accident as a catalyst, this project charts the history and impact of the *Columbia* Accident Investigation Board, the Constellation program, the Commercial Orbital Transportation Services (COTS) program, and finally, the Commercial Crew program. This investigation finds that the emergence of commercial human spaceflight pivoted on a desire to replace the Space Shuttle, the economic realities of the mid-to-late 2000's, and the placement of key personnel inside the Obama administration coinciding with the technological success of companies like SpaceX, leading to an opportunity for commercial ventures to prove their worth in the human spaceflight sector.

This project focuses first on the challenges faced by the Space Shuttle program that led ultimately to an experimental vehicle that never realized its objectives for hundreds of missions and rapid reusability. The loss of fourteen lives and two orbiters led to the *Columbia* Accident Investigation Board, which published its report nearly a year after the accident. The board found that mismanagement of scheduling, the mixing of precious crew and cargo, and the general mischaracterization of the shuttle as an operational, not experimental, vehicle led to the demise of *Columbia* and *Challenger*. Their report forced an examination of human spaceflight by NASA, Congress, and the President.

President Bush responded in 2005 with the Vision for Space Exploration, setting a return to the Moon as the goal for NASA and commissioning NASA to develop a new program known as Constellation. This new program faced immediate challenges–primarily a lack of Congressional

support for increased budgets and a variety of continuing resolutions that strung out work and froze funding on the program. By the time President Obama came into office, Constellation was years behind schedule.

Concurrently with Constellation, Mike Griffin, then the NASA Administrator, made an investment in commercial cargo transportation through the Commercial Orbital Transportation Services (COTS) program. A development program designed to help companies create cargo capsules, the program was NASA's first investment in private space vehicles. Griffin believed in slowly building up commercial industry, including an option to provide crew to the International Space Station (ISS) within the COTS contracts, but principally planned on the Constellation program to provide access to the ISS.

President Obama and his space policy advisor, Lori Garver, came into office with an objective of fostering commercial space. A committee chaired by Norm Augustine recommended an influx of cash to NASA, and recommended potentially turning ISS crew responsibilities over to commercial providers. The Obama administration embraced this recommendation, capitalizing on an opportunity to turn over routine operations to commercial ventures. Lori Garver led a small group inside NASA that created the Commercial Crew Program and rejected government programs such as Constellation. Debates between Congress, the old guard of NASA, and the Obama administration ultimately resulted in two concurrent programs; Commercial Crew for the ISS, and the Space Launch System for exploration.

Keywords: human spaceflight, commercial crew, public-private partnership

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Introduction

The Orbital Age

Every person alive remembers where they were during major global events: the September 11 attacks, the *Columbia* disaster, the election of Presidents, the beginnings and endings of wars, and for those who were alive, the landing of man on the Moon. These events form a national identity, a collective consciousness of Americans and mankind alike that mark turning points in our history. These turning points often mark the end for the ways of old, and the beginning of innovation and change that continually molds our modern world.

The history of human space exploration is rich with these moments. The launch of Yuri Gagarin in 1961, propelling him as the first human in space, forever changed our perspective of achievement and the realm of possibility. The first spacewalks by Alexei Leonov and Ed White in 1965 proved that humans could survive in the vacuum of space. Exploring the Moon across five Apollo missions brought humankind to an unfamiliar land and an appreciation of our comparatively tiny home. These events marked the Golden Age of Space Exploration, the 'Space Race' as it is colloquially known.

A new era of cooperation in space and early attempts to normalize life in space soon followed the Space Race. Space stations like *Skylab* and *Mir* showed the world the ability of humankind to spend prolonged periods of time in space, while the emergence of a revolutionary launch vehicle, the Space Shuttle, pushed humankind even further. The Age of the Shuttle marked a period of receding financial support for space, yet still achieved milestones such as repairing and retrieving satellites, the construction of a more permanent space station, and even launching deep space probes.

NASA's victory in the Space Race with the Moon landings and the impending financial and fuel crisis of the Seventies forced NASA to deal with fiscal realities. NASA leadership, inexperienced with fighting for Congressional and Presidential support, struggled to push forward programs within government funding levels. The Space Shuttle, the sole surviving component of the Space Transportation System, became the jewel of NASA and rose through a weak budget and inconsistent agreements between NASA and the Air Force. Finally launched in 1981, the Shuttle opened a new age of space flight for America that grounds NASA of today.

The Age of the Shuttle also introduced Americans to space flight tragedies for the first time. While the Apollo I crew perished in a ground fire, the loss of the crew of *Challenger* on STS-51L in February 1986 offered a gut check to a nation which had avoided loss of life during spaceflight since 1961. *Challenger* ended any hope of the Shuttle becoming a vehicle to usher in a new age of space exploration, of normalized operations and expanded commercial markets. But the Shuttle carried on, remaining the face of American spaceflight for over thirty years.

The Freedom Space Station, originally a product of nationalism under the Reagan administration, evolved and survived as the International Space Station, a collaboration between the United States and the former Soviet Union. Life in space became one of cooperation and a future of normal missions and tours in space, breaking records time and time again. The Shuttle reached its peak operational tempo during this era, launching the Hubble Space Telescope, deep space probes, ferrying more Americans than ever before to space, and broadening horizons for space flight to all Americans, not just white fighter pilots.

The disintegration of Space Shuttle *Columbia* in 2003, a mere sixteen minutes from home, forced the nation to confront the human and financial costs of the Shuttle program and human spaceflight. It represented another seven lives lost in a preventable disaster due to neglect

in budget and a can-do attitude common in exploration. The *Columbia* Accident Investigation Board, tasked with informing the President, Congress, and NASA on future steps for the Shuttle and human spaceflight, published its report in late 2003, focusing upon the management of NASA, the viability of the Space Shuttle orbiters, and the dedication of the nation to human spaceflight and its goals within.

The Board's report shaped decisions for the next decade, recommending recertification of the Space Shuttle for continued use, a new emphasis on crew safety within NASA, an overhaul of NASA management practices, separating crew from cargo, and, most importantly, the setting of a national space strategy for human spaceflight and exploration. Different interpretations of the Board's recommendations by successive NASA administrators, Presidents, and the aerospace industry created a rapidly shifting environment in human spaceflight, seen today and continuing to evolve. These different interpretations fueled a willingness to bet on commercial industry, a deep examination and debate of the role of government and NASA within human spaceflight, and opened space to more people than ever before. The *Columbia* accident sparked a revolution in American spaceflight and engineering, challenging the United States to examine its purpose and truly buy-in to human spaceflight and exploration.

The *Columbia* investigation set an end date on the Shuttle program and pushed NASA to develop a new program. The Constellation program reinvigorated NASA toward a future focused on exploration rather than normalization. The Commercial Orbital Transportation Services program kick-started commercial launch contracting services and evolved into the modern Commercial Resupply Services contracts utilized within the International Space Station program. The Obama administration's bet on the Commercial Crew Program pushed commercial providers, particularly SpaceX, into an international spotlight. The strength of the aerospace

industry, its importance to national defense, and Congressional reluctance saved the Orion spacecraft and shifted NASA's role towards deep-space exploration. The question of this age is not whether space launch is possible for commercial entities, but whether it is profitable enough to pursue given the enormous risk involved.

This report focuses on a new era of revitalization: The Orbital Age. The ever-changing commercialization of space begun in 2006 with the Commercial Orbital Transportation Services program marked the rise of commercial interest and a market in space, and the return of NASA to its roots of pushing the boundaries of exploration. The downfall of legacy companies, the rise of innovators in new markets, and the evolution of human spaceflight offers an interesting lens by which to examine the warring ways of new and the days of old.

Chapter 1

Triumphs and Compromises: The Space Shuttle

The Space Transportation System, the envisioned successor to the Apollo Program, planned for a space station in low Earth orbit, a space tug to tow satellites, and eventually Mars exploration, evolved through budget cuts and reality checks within the White House and NASA into its sole surviving component; the Space Shuttle. A revolutionary leap in space technology, the Space Shuttle sought to become the sole national launch vehicle; it held responsibility for crewed missions, deep-space exploration, and commercial, government, and military satellites. Realizing the dream of flying a craft from the surface of the Earth to the heavens and landing to be reused captured the minds of Americans and the world alike, a poetic and idealistic future following the crude, tumbling capsules of the Mercury, Gemini and Apollo missions. The Space Shuttle today remains a remarkable icon of American ingenuity and scientific capability in the public eye, yet among space historians and enthusiasts, the Shuttle's reputation is marred with budget overruns, two disasters, and significant divergence from its stated mission.

The Dream Meets Fiscal Reality

The groundwork for what became the Space Shuttle started in the 1960's as a fully reusable, two-stage spacecraft, a far cry from the crude, expendable, multi-stage rockets and capsules of the Space Race. Created in the fading effects of the Vietnam War, a desire to lessen government expenses following the colossal budget of Apollo era NASA, and other global economic events, the Shuttle evolved from a $9.9 billion dollar fully-reusable behemoth into its now-iconic configuration consisting of an orbiter, an external fuel tank, and two solid rocket

boosters that formed a partially-reusable, one and a half stage launch system with an original estimated price tag of $5.5 billion dollars.[1]

An important theme throughout the Shuttle's conception, development, and lifecycle is a focus upon the economic advantage of the Shuttle over competing ideas and strategies for space launch. Roger Launius, former Chief Historian of NASA, wrote that 'from the outset, the economics of the shuttle outweighed any other features.'[2] Gone were the days of a national goal to place a human on the moon; NASA had to evolve to survive the reality of the 1970s. American victory in the Space Race with the Apollo 11 moon landings detached the space program from questions of national security and the Cold War. The rise of federal budgets under the Johnson administration and drastic budgetary cuts under the Nixon administration affected NASAs budget disproportionately compared to other federal agencies. NASAs budget dropped from an expected $5.25 billion a year in purchasing power beyond the Apollo landings to an approximately constant $3.2 billion dollars (in 1971) without adjustment for yearly inflation.[3]

The Office of Management and Budget (OMB) under Nixon squeezed NASA to develop economically beneficial programs, beyond that of any other government expenditure at the time. OMB, focusing on a need to reduce costs and prove the worth of any launch system, required NASA economic analysis to determine cost savings of any potential system over alternatives through the use of "discounted dollars."[4] In essence, NASA was required to prove that the Shuttle would pay back a 'loan' from the government, the loan being its budget. The 'loan

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[1] T.A. Heppenheimer, *History of the Space Shuttle, Volume Two: Development of the Shuttle, 1972-1981* (Washington: Smithsonian Institution Press, 2002), 3-5.
[2] Roger D. Launius, "Designing the Shuttle: Living Within the Political System," in *Space Shuttle Legacy: How We Did It and What We Learned*, ed. Roger D. Launius, John Krige, and James I. Craig (Virginia: American Institute of Aeronautics and Astronautics, Inc. 2003), 29.
[3] Heppenheimer, *Development of the Shuttle*, 5.
[4] Ibid., 14.

payments' would be the operational savings of the Shuttle over any other vehicles and programs, while the "interest rate," or the "discount" in discounted dollars, was set at ten percent.

Mathematica Inc., an American research company in Princeton, New Jersey, took the lead on these economic analyses. Between 1970 and 1972, Mathematica published two full reports and one interim report covering the Space Shuttle program proposals and the economic statistics associated with each proposal.[5] Each report found the Space Shuttle to be economically viable beyond a certain 'break-even' point of usage.

The initial report focused on the dream of a two-stage, fully-reusable shuttle. This report assessed the development cost of the shuttle to be $12.8 billion, becoming economically feasible with at least five-hundred fourteen flights across a twelve-year period.[6] While viable in terms of the discount dollars, the constraint of NASAs budget forced another two reports seeking a cheaper alternative.

The report published by Mathematica in January of 1972 laid the groundwork for the eventual adoption and approval of the shuttle configuration as it is today. The report found that a shuttle utilizing rocket boosters and an external tank, tasked by both NASA and the Department of Defense (DoD), could return savings of over $13.9 billion discounted dollars across a 624-flight schedule. A less intensive 514-flight schedule, with over 40 flights per year, that represented NASA and commercial launches would return $10.2 billion discounted dollars of savings over other launch systems.[7] NASA and Mathematica proved to the OMB under Nixon that this shuttle configuration was viable and the most logical step forward through a creative use of cost-benefit analysis rarely required for any other federal spending program.

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[5] Heppenheimer, *Development of the Shuttle*, 15.
[6] National Aeronautics and Space Administration, *Economic Analysis of the Space Shuttle System*, by Klaus P. Heiss and Oskar Morgenstern, 1972, 11.
[7] Heppenheimer, *Development of the Shuttle*, 15.

T. A. Heppenheimer argues in *Development of the Space Shuttle: 1972-1981* that cost-benefit analysis rose as OMB's preferred tool for NASA programs following the Apollo program.[8] The moon landings placed the United States far in the lead in space, invalidating the arguments of national pride made during the expensive Apollo program. The Space Shuttle was to become NASA's 'turnpike into space,' saving the federal government money, allowing other expenditures and the development of its replacement in a timely manner.

OMB's usage of the discounted dollar forced NASA to adjust the Space Shuttle orbiter design to fit into an overall program that would not just save money, but technically earn money on the back end as if the federal government existed as a bank. If NASA received $1000 to develop the Shuttle in one year, then they must save the government at least $1221 dollars across two years of usage in order to be seen as viable.

The cost-benefit analysis that molded the Space Shuttle orbiter and program into the system we know today, while the preferred tool of the OMB, became the focus of NASA in the early 1970s as a form of reconciliation with the White House. Thomas Paine served as Nixon's administrator of NASA until mid-1970 and developed a sour relationship between NASA and the White House, with Paine refusing to alter plans for smaller budgets.[9] The new administrator, James Fletcher, worked to repair this relationship and coordinate with OMB on a more realistic project within presidential objectives. Realizing internal and external pressures, Fletcher's NASA molded the Space Shuttle orbiter's design into a vehicle with a total program cost of under $1 billion a year for development.[10] These redesigns, captured in the aforementioned Mathematica reports, ended a months-long impasse on the future of crewed spaceflight between

[8] Heppenheimer, *Development of the Shuttle*, 2-12.
[9] Launius, "Designing the Shuttle," 30.
[10] Ibid.

NASA and the White House: NASA's lack of experience in working within the bureaucracy of the White House and Congress drove this decision. The use of cost-benefit analysis by Mathematica showcased NASAs willingness to work with OMB and work towards common objectives, however, reliance on this analysis provided later critics a massive target once the Shuttle program faced rising costs.

The evolution of the Space Shuttle program from a fully to partially-reusable vehicle followed a primarily economic and political thread. The resulting partially-reusable system depended on the desire of the presidential administration to cut overall budgets and inexperience within NASA in politics within the larger context of the presidency and Congress. While economic and political concerns largely shaped this divergence away from reusability, the military would have a much larger role in evolving the shuttle from the small vehicle envisioned in the early-1960s into the workhorse that launched in 1981.

One Launcher, All Customers

A large piece of the economic analysis performed for NASA by Mathematica hinged on one key metric; high launch cadences. Anticipating over 40 launches per year was not merely a function of NASA inflating numbers to make the Shuttle more profitable; NASA expected that the Shuttle would fulfill *all space launch requirements* during its operations. The Shuttle would become the launch vehicle for all space assets; weather satellites, commercial satellites, spy satellites, astronauts, and even deep-space probes.[11] Retiring other expendable launch vehicles (ELVs) such as the Titan III, the federal government would make its deepest savings by divesting of all other vehicles. A reusable craft with high operational tempo could challenge the lower costs of simpler, expendable vehicles. Realizing this goal of a single, multi-purpose launch

[11] Gordon, *The Space Shuttle Program*, 21-21.

vehicle dramatically modified the shuttle dream from that of a small craft designed for a few crewmembers into a vehicle with a massive cargo bay, meeting requirements primarily set by the Air Force and attractive to commercial and foreign partners.

Concurrent with DoD involvement with the Shuttle, NASA planned internally on offering commercial launch services to global customers. In order to draw customers away from ELVs such as the European Ariane rocket, the Atlas-Centaur already in NASA use, and the Titan 34D that the Air Force also invested in, the operating costs of the Shuttle had to be lowered. The Mathematica reports depended on the assumption of a high launch cadence to drive cost-per-flight downward, giving birth to the idea of a single launch vehicle for all purposes.

The Air Force itself played a major role in space in the late 1960s, launching spy satellites in the CIA's Corona program.[12] Predicting the necessity and role of these satellites to increase, the Air Force invested in larger launch vehicles such as the Titan III. Learning of the shuttle concept, originally designed to carry only twenty-five thousand pounds to orbit, the Air Force demanded the capacity be raised to sixty-five thousand pounds. Desiring polar launches to place spy satellites into orbit, the Air Force funded its own launch site for the Shuttle at Vandenberg Air Force Base. Potential uses involving only a single orbit necessitated a cross-range ability of 1265 miles, resulting in NASAs delta wing design seen on the Shuttle today.[13]

A major issue between NASA and OMB focused on the number of orbiters to be constructed. NASA wanted to build five orbiters, President Jimmy Carter's OMB assessed that building three was economically feasible. The DoD carried the day when it decided that the first two orbiters as designed were overweight, and that a new orbiter with a lighter design and a

[12] Heppenheimer, *Development of the Shuttle*, 79.
[13] Ibid.

backup must be maintained for national security launches; settling the number of orbiters at four.[14]

The DoD's interest in the Space Shuttle solidified in 1978 when President Carter issued NSC-37, a directive laying out space reconnaissance roles and endorsing the primary usage of the Shuttle in such activities. Carter's support continued, eventually saving the program by directing the Air Force to cover a near billion-dollar overrun in 1979. In 1980, Administrator Robert Frosch utilized the DoD connections of the Shuttle to save it from budget cuts that other defense programs also were immune to, but NASA was subject to.[15] The Shuttle, shaped by DoD requirements, demands, and desires, found refuge in its unique role of bringing together defense, civilian, and commercial launches into one central platform.

Competitors

Despite the demonstrated interest in the Shuttle from the DoD, the Air Force continued to further develop a more capable ELV, the Titan 34D. The Titan III had served as the Air Force's primary launch vehicle during the late 1960s and early 1970s, yet the Air Force desired higher performance. The Titan 34D, designed to provide better performance for DoD launches, became the DoD's stopgap between the Titan III and the planned Space Shuttle launches.[16] While the Air Force planned to shift to the Shuttle, the emergence of a new American launch vehicle with the Europeans arrival in the launch services market challenged the notion of the Shuttle as the sole launcher for all customers.

Europe's rising importance in space launch emerged in the 1960s and 1970s. NSAM-338, a memorandum approved by President Lyndon Johnson in 1965, barred Europe from launching

[14] Heppenheimer, *Development of the Shuttle*, 350-360.
[15] Ibid.
[16] Ibid., 83-84.

their own communications satellites, on American launch vehicles, competing with the American-led Intelsat constellation.[17] France and West Germany partnered in an experimental communications system known as Symphonie and requested American launch services in 1968. Administrator Thomas Paine demanded European assurances of purely experimental use, ensuring a lack of competition with Intelsat. Insulted by this demand, France and the rest of Europe took particular interest in developing their own launch vehicles instead of relying upon American services.[18]

Administrator Paine visited Europe in 1969, attempting to garner foreign contributions to the Space Shuttle and its components, also seeking to avoid European competition. At home, the Nixon administration sought to avoid committing to a joint program with the Shuttle, as reneging on the program in the future would incur severe political pains.[19] Internationally, the Europeans were developing their Europa 3 rocket, remaining wary of American cooperation in space launch. Throughout 1972, the White House, State Department, and DoD severely restricted European involvement in the building of the Space Shuttle or any of its prime components.[20] The DoD distrusted foreign suppliers, the White House desired flexibility in budgets unavailable to international programs, and the State Department wished to control the outflow of American research and technology. European involvement soon downgraded from a potential contractor on one of the prime components to the developer of a 'space tug' designed to lift satellites launched on the Shuttle into higher orbits. Further objections by the DoD degraded the European

[17] W.W. Rostow, *National Security Action Memorandum No. 338 (Revised)*, 1967.
[18] Heppenheimer, *Development of the Shuttle*, 46.
[19] Ibid., 49.
[20] Ibid., 50.

contribution further, resulting in what became known as Spacelab, a pressurized module designed to fit in the cargo bay of the Shuttle and carry experiments.[21]

Angered by a lack of cooperation with the Americans, the French evolved Europe's previous Europa family of rockets into a new concept design; today it is known as Ariane. The French led the way in the establishment of a unified European Space Agency (ESA) in 1975, bringing all members behind the Ariane program.[22] Ariane's first launch in 1979 opened an alternate path for commercial launches, staging itself as a challenger to the Shuttle's primacy as *the* launch vehicle of the west.

The idea of the Space Shuttle as the primary launch provider for western launches formed the bedrock of the Mathematica Inc. reports. NASA had yet to manage even double-digit crewed launches in a year, necessitating a reliance on NASAs numerous launches beyond human spaceflight. NASA secured buy-in from the DoD and the ESA in this concept of the Shuttle as a primary provider, yet the DoD and ESA continued to develop their own ELVs in the background. The Shuttle's plans depended on dominance of the market, however, neither the DoD or ESA fully committed to the idea of the Shuttle as *the* multi-purpose launch vehicle for all.

Growing Pains and Tragedy

The first flight of the Space Shuttle, STS-1, in 1981 marked the end of a development cycle with three major delays but only a seventeen-percent overrun on budget. Hopes were high for the program, with the Shuttle reaching operational status merely a year after its fourth mission. NASA seemed poised to accomplish the objectives of high operational tempo and

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[21] Michael R. Gordon, *The Space Shuttle Program: How NASA Lost Its Way* (North Carolina: McFarland & Company, Inc. Publishers, 2008), 20-23.
[22] Heppenheimer, *Development of the Shuttle*, 57-64.

continually decreasing flight costs, although not exactly according to expectations. The Shuttle ramped up from two launches in 1981 in a test phase to nine operational launches in 1985. The Shuttle program began 1986 with high hopes of twelve launches; a mere third of the proposed tempo in the Mathematica reports; off-track, but still a higher tempo than ever before for crewed vehicles.[23]

However, all was not well within the Shuttle program. Budget cuts forced deferrals in spare parts, captured in the Rogers Commission report on the *Challenger* accident. A senior NASA engineer said that "I think we would have been brought to our knees this spring [1986] by this problem [spare parts] if we had kept trying to fly."[24] While outside appearances and projections indicated an elevating flight rate, internally NASA resorted to parts cannibalization, struggled with manpower, and deferred building facilities and infrastructure to support this higher flight rate. Having grown accustomed to budget cuts and deferring parts of programs to later dates during the development of the Shuttle, NASA crumbled under pressure to reach the goal of twenty-four flights in 1990, set in 1985.[25]

The culmination of these struggles came in January 1986 with the explosion of Space Shuttle *Challenger* minutes after launch, forever changing the landscape of the Space Shuttle's purpose. The tragic loss of life in spaceflight, a first for the United States, focused international attention on the Shuttle and its safety. A Presidential Commission investigated the incident and widely criticized cultures of safety, can-do attitudes, and the overall pressure that schedule

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[23] Matthew H. Hersch, "Using the Shuttle: Operations on Orbit," in *Space Shuttle Legacy: How We Did It and What We Learned*, ed. Roger D. Launius, John Krige, and James I. Craig (Virginia: American Institute of Aeronautics and Astronautics, Inc. 2003), 199-200.
[24] Columbia Accident Investigation Board, *Report Volume I*, 175.
[25] Ibid., 165-170.

placed on the Space Shuttle program. The *Challenger* accident and the Commission's report shattered the perception of the Shuttle as the launch vehicle of the future.

A revolutionary step meant to normalize space travel like an airline, instead the Space Shuttle would be reserved for only the most necessary flights and roles. The DoD started shifting their payloads away from the Shuttle in 1983, cementing this decision in the wake of *Challenger* by rarely launching aboard an orbiter after. NASA itself banned the Shuttle from launching any commercial payloads, further restricting the operational tempo of the vehicle and opportunity to cut costs and spread the responsibility for maintenance and costs onto other entities.[26] The *Challenger* disaster ended the idea of a single launcher for all purposes, offering room globally to the Titan III, Atlas, Delta, and Ariane rockets in its wake.

NASA found itself in a rut following the *Challenger* disaster. Costs hovered around $500 million per flight, and the flight rate never again approached double-digits.[27] NASA's original plans for the Shuttle expected lower costs due to flight rate and outside customers, yet *Challenger*'s fallout ended any chance of saving money through customers. NASA's launcher-for-all suddenly ballooned to require roughly double the budget it was expected to receive throughout the early 1990s, severely undercutting any plans for a replacement program following a timeline similar to the Shuttle's.[28] The Shuttle's troubling safety record, inability to grow into a higher flight rate, and increased costs drastically reduced any chance of a viable replacement without a gap in spaceflight capability.

The shift of the Shuttle away from DoD and commercial launches marked the beginning of what Matthew Hersch calls 'the shuttle's most productive years in service.'[29] The bulk of the

[26] Hersch, "Using the Shuttle," 201.
[27] Ibid., 204.
[28] Author's own analysis yet to be published.
[29] Ibid.

Shuttle program occurred after *Challenger* and before *Columbia*, conducting a wide range of scientific missions; government satellite deployments, Spacelab experiments in the cargo bay, satellite capture and repair, deep-space probe deployment, and most famously, the deployment and repair of the Hubble Space Telescope. The Shuttle found its 'groove' in the 1990s, returning to a tempo of between five-to-eight launches per-year, far below the initially conceived goal, yet revolutionary for a crewed program.[30]

The 1990s continued the trends of the 1980s with regards to funding and safety. NASA continued to suffer budget cuts and subsequently underfunded the Shuttle. The early nineties saw a twenty-one percent reduction in costs and nearly seven-thousand personnel losses.[31] NASA began looking into Shuttle replacements, vehicles such as the National Aero-Space Plane, the X-33, X-34, VentureStar, the Delta Clipper, and other fully-reusable vehicles. NASA's continuing obsession with a spaceplane variant drove it down a rabbit hole of challenging technologies, billions of dollars, bold ideas, and no launch vehicles, leaving the Shuttle with no clear replacement by the early 2000s.

The emergence of the Space Station *Freedom* concept during the Reagan Administration, which soon morphed into the International Space Station, offered the Shuttle an opportunity to fulfill one of its original objectives as part of the Space Transportation System; building and servicing a space station. The Shuttle flew thirty-six missions in support of the space station, twenty-seven of which were for assembly, in comparison to the two assembly missions flown by any other vehicle. The Shuttle payload bay determined the requirements of the station and

[30] Hersch, "Using the Shuttle," 201-205.
[31] Gordon, *The Space Shuttle Program*, 200-202.

necessitated its construction approach, piece-by-piece.[32] ISS support missions made up less than thirty percent of the Shuttle's 135 flights, yet the commitment to ISS assembly and its dependence on the Shuttle's design and capabilities saved the Shuttle from cancellation following the *Columbia* disaster.

Legacy of the Shuttle

The history of the Space Shuttle program continues to be controversial. A revolutionary vehicle that captured the nation and the world, realizing a dream of winged flight to space. A symbol of NASA's troubled relationship with safety oversight and sweeping issues under the carpet. An iconic image of American ingenuity and a unique capability never matched by the Soviet Union in an operational setting. Most importantly to this paper, however, is the Shuttle's role as a roadblock in NASA's budget for future plans. The Shuttle, intended to be a low-operating-cost vehicle with a high operational tempo across twelve years, became a goliath that lasted thirty years, incurring more severe operating costs, modernization costs, and maintenance costs than ever predicted. Any hope of developing a viable Shuttle replacement required overcoming the vast challenges of budgetary constraints from the Shuttle itself, before considering any other factors.

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[32] Howard E. McCurdy, 'Constructing a Port in Orbit: The Space Shuttle and Building the Space Station," in *Space Shuttle Legacy: How We Did It and What We Learned*, ed. Roger D. Launius, John Krige, and James I. Carig (Virginia: American Institute of Aeronautics and Astronautics, Inc. 2003), 260.

Chapter 2

The *Columbia* Accident Investigation Board

On February 1, 2003, Space Shuttle *Columbia* disintegrated over the southeastern United States due to a failure of the Thermal Protection System that shielded the Shuttle during the extreme heat of reentering Earth's atmosphere from orbit.[1] The failure itself, rooted at a physical level by the striking of foam from the external fuel tank against the left wing of the Shuttle, became a topic of national debate and interest; the Shuttle had once again resulted in lives lost, and America needed answers. The Administrator of NASA at the time, Sean O'Keefe, ordered the creation of a board to investigate the accident, its physical, programmatic, and systemic roots, and to issue recommendations to be taken by NASA, Congress, and the President to decide space policy of the future.

CAIB Recommendations

The *Columbia* Accident Investigation Board (CAIB) consisted of thirteen members; astronauts, generals, admirals, and academics in technical fields.[2] Tasked with determining the cause of the accident and recommending changes for future safety, the Board examined the direct physical cause of the accident, the Space Shuttle program history as a whole, national space strategy (or rather the lack thereof), and systemic contributors to the accident. CAIB offered twenty-nine written recommendations, fifteen of which were deemed as 'return-to-flight', necessary to restart Shuttle operations and finish construction of the International Space Station (ISS).[3] These recommendations challenged NASA's organization, technical management, and safety culture, while also informally challenging national policy and

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[1] Columbia Accident Investigation Board, *Report Volume I*, 49.
[2] Jennifer Troxell, "Columbia Accident Investigation Board (CAIB) Synopsis," NASA History Office.
[3] CAIB, *Volume I,* 225.

decisionmakers. Testimony of board members before Congress regarding their report laid out four main lines of effort that helped define the Orbital Age that followed: prioritize safety of crew over all else with a particular focus on schedule management, separate crew and cargo in spaceflight, construct a true national space policy, and recertify the Shuttle for flight to use beyond 2010.

The CAIB report and testimony set the stage for the "Orbital Age." The major recommendations to center crew safety in human spaceflight programs and construct national space policy offered straightforward avenues of success, while charges to recertify the Shuttle and separate crew from cargo left NASA, Congress, and Presidential administrations to debate and figure out pathways forward. The debate on these future plans and the emergence of a new aerospace industry shaped and molded the Orbital Age that followed.

Safety of Crew First

The degradation of a safety-centered culture at NASA became a primary concern of the CAIB during their inquiries. Three of the twenty-nine recommendations, including the longest recommendation, center around the safety culture and organization of NASA as a whole.[4]

CAIB identified their most "perplexing question" to be "How could NASA have missed the signals the foam was sending?"[5] Human Space Flight safety is challenging and complex, but CAIB noted a discernable lack of concern about debris strikes and persistent unexplained occurrences in Shuttle flights. NASA managers became comfortable with assuming current safety based on prior successes and avoidance of disaster–in essence they became complacent–rather than closely analyzing data and testing all systems. NASA, once heralded for their

[4] CAIB, *Volume I,* 184.
[5] Ibid.

methodology of rigorous testing during the Apollo program, normalized writing off occurrences as insignificant if the flight returned safely; a safe return indicated safety, not luck.

Foam strikes on the Space Shuttle occurred before *Columbia*. NASA recorded a total of thirteen different incidents of foam debris or damage to the orbiter's Thermal Protection System. STS-112 suffered a strike and returned to Earth safely a mere three months before *Columbia*. STS-113 launched after, assessing the foam strike in STS-112 to not be a risk by merely "restating earlier assessment of foam loss."[6] No testing occurred between these missions, nor was the foam strike from STS-112 even mentioned in STS-107's final Flight Readiness Review. NASA managers viewed these strikes as a normal occurrence, not requiring further analysis for safety as the flight record itself *proved* safety. The distinct lack of identifying a prior issue as a future safety concern showcased how easily NASA's safety program could be bypassed, offering a route to compromise flight certification. Issues became 'rolled up' in reports, data never recorded, and solutions never developed.

Organizational structure enabled this culture of rug-sweeping, driven by a weak safety enterprise and conflicts of interest between managers and safety officers. Safety programs, a function intended to overrule managers and adhere to standards, remained subordinate to engineers and decisionmakers and relegated to recommendations, not directives. Each subordinate NASA center maintained its own safety program.[7] However, key officials often held multiple 'hats' between engineering, management, and safety, leading to weak checks and balances. Safety programs lacked independence and maintained too much familiarity with the program they were assigned to oversee, hindering proper safety and data gathering practices.

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[6] CAIB, *Volume I,* 128.
[7] Ibid., 184.

CAIBs recommendations included developing an independent Technical Engineering Authority responsible for requirements and flight waivers, affording NASA Headquarters direct control of the entire safety apparatus for the Space Shuttle, and reporting to Congress on their efforts towards these recommendations. CAIB charged NASA with centering safety in their culture and funding it appropriately, rather than subordinating it to those individuals it was designed to protect.[8]

Management and Schedule Guarantee Safety

All industries maintain internal and external schedules–deadlines they expect to meet that workers labor to accomplish in time. NASA maintains schedules for entire programs such as the Space Shuttle, often overlapping and interdependent on other programs, such as the International Space Station. Interdependence between the ISS and the Space Shuttle, due to international pressure and the prestige of the station, became a large factor in a pressure to launch *Columbia* and maintain a tight Shuttle schedule.

NASA was no stranger to aggressive schedules. This was evident in the rapid evolutions and steps made between Alan Shepard's first moments in space in 1961 to the first steps of a man on the moon in 1969. NASA operates with difficult goals, national attention, and congressional and executive scrutiny, often forcing aggressive timetables and objectives upon engineers and managers. However, NASA proved itself time and time again. The opinion of the CAIB made a case for the extreme pressure to maintain Shuttle and ISS goals with the Shuttle missions surrounding the launch of *Columbia*.

An average cadence of thirty-six launches per year was the dream of the Shuttle program. NASA committed itself to ten launches in less than sixteen months from 2002 to February 2004,

[8] CAIB, *Volume I,* 225.

surpassing that maximum earlier cadence seen before the *Challenger* disaster.[9] While managers of the Shuttle program felt that this cadence and pressure to launch on time was not significant, the labor workforce of the Shuttle disagreed. Workers in both the ISS and Shuttle programs spoke of particular focus on holding the Shuttle program to schedule, despite feedback regarding the unreasonableness of this feat.

The critical source of this schedule pressure focused on one particular date–February 19, 2004–the launch of STS-120 for the planned completion of the core American contribution to the International Space Station.[10] The entanglement of the Shuttle and ISS, alongside the desire to maintain schedule on the international stage, urged managers to find space in the schedule to stay on track. NASA even distributed a screensaver to managers with a countdown to STS-120, further stressing the importance of the deadline to senior management. [11]

The launch cadence alone did not produce all the pressure; the complexity of ISS and Space Shuttle missions contributed as well. Management of Shuttle launches became interdependent on ISS assembly order, Russian launch schedules, and other government payload requirements. Shuttle and ISS traded mass on flights of all types of payloads, including astronauts.[12]

The four-orbiter fleet became strained by the necessity of the flight schedule, with *Columbia* retaining no capability to go to the ISS. As a result, the other three orbiters needed to pick up the slack. *Discovery* entered its maintenance period, leaving two orbiters to fly five missions to the ISS in 2003. Modification of *Columbia* for ISS flights solved the Shuttle Program

[9] CAIB, *Volume I*, 131.
[10] Ibid.
[11] Ibid., 132-133.
[12] Ibid., 134.

manager's schedule issues, introducing planned modifications following STS-107.[13] *Columbia*'s on-time launch of STS-107 became a critical goal so it could fly to the ISS just eight months later and enable the U.S. core completion of the ISS.

The pressure to maintain all Shuttle flights on their schedules also likely influenced manager decision-making. A foam strike on STS-112, normally classified as an In-Flight Anomaly requiring data to be collected before the next flight, instead was classified as an "action," and quickly written off as not significant for STS-113, the next Shuttle mission. Senior management even began hiring a third shift of workers in a bid to maintain margin in the schedule and launch STS-120 on time.[14] Numerous employees expressed their concerns to CAIB after the accident, however, CAIB noted no incidents of concern communicated up to senior management, an issue attributed to NASA's legendary 'can-do' attitude that rewards creative solutions and hard-working individuals.

The pressure of schedule even became evident in NASA's handling of the *Columbia* foam strike. Shuttle managers, aware of the foam strike on *Columbia*, planned to take photos of the left-wing strike once *Columbia* returned to Earth to make decisions for the next flight, STS-114. The Shuttle Program managers "concern about *Columbia*'s foam strike were not about the threat it might pose to the vehicle in orbit, but about the threat it might pose to the schedule."[15] Concerns over cargo and schedule subordinated crew safety.

CAIB ultimately made one recommendation to NASA regarding schedules: to maintain a schedule that takes account of actual allocated resources, to constantly evaluate deadlines, and to better understand the risk that deadlines and schedule place upon decision-makers.[16]

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[13] CAIB, *Volume I,* 134.
[14] Ibid.
[15] Ibid., 139.
[16] Ibid., 225.

Separate Crew and Cargo

Interestingly, the most well-known recommendation of the CAIB, to separate crew and cargo in future spacecraft, appears only once in the 248-page report as an informal 'observation.' Mentioned in passing as a factor in designing a crew escape system, alongside replacing the Shuttle, the report pays little attention to directly addressing the complex issue of tying cargo to dangerous crewed flights. The majority of the reasoning behind this conclusion can be found above; tying important cargo launches to human launches forces neglect of safety without careful oversight.

The importance of completing the core American segment of the International Space Station forced a dangerous and rapid schedule on Shuttle Program managers. Admiral Gehman, chairman of the CAIB, captured it best when he stated before Congress: "We specified… that whatever it is that we replace the Shuttle with that the concept of operations should be to separate the crew from the cargo, because as long as you keep crew and cargo together, you have to sub optimize human safety. And that–therein is the dilemma."[17] Admiral Gehman advocated utilizing alternate systems to supply the ISS, restating the board's recommendation to separate crew from cargo and utilize *expendable launch vehicles* when possible.

The vagueness of this recommendation and the lack of detail in the formal report and in testimony presented NASA with a confusing situation. Understanding the need to separate crew and cargo, CAIB left NASA managers and engineers stumped by the definition of 'separation.' Separation could mean separate launch vehicles, separate capsules, or multi-purpose capsules configured for only crew or cargo at once. The importance placed upon the point of separation,

[17] *The Columbia Accident Investigation Board Report*: *Hearing Before the Committee on Science,* 108th Congress. (2003) 47-48.

combined with the distinct lack of detail behind the recommendation, left NASA to work out the answer largely by itself, opening room for debate and discourse.

Construct a True National Space Policy

The distinct absence of a national policy regarding goals of the Space Shuttle program, plans to replace or evolve the Shuttle, and overarching goals of human spaceflight and exploration were a major focus of the CAIB report. While not specifically entailed in any of the primary recommendations, Admiral Gehman testified that the intent of the CAIB was for their report to be "the basis for an important public policy debate that needs to follow. We must establish the Nation's vision for human space flight…from these decisions will flow the debate on how urgent it is to replace the Shuttle…let the debate begin."[18]

The Executive Summary of the CAIB report details the base level reasons for the accident: the shedding of foam, the compromises of the Shuttle design, schedule pressure, and a weak and low-priority safety culture, but ultimately traces many of these issues to the absence of national guidance. The guidance afforded in national space policy documents enables proper decision-making, vests authority clearly in different offices, and offers requirements and objectives for equipment to be evaluated against. The Shuttle Program, lacking any overarching national policy, allowed the development of informal chains of command, undocumented norms, and divergence from normal operating procedures that enabled issues to escape the eyes of managers focused on schedule and other program objectives.[19] Cold War politics moved beyond the Space Race after the Moon landings, resulting in the deflated budgets NASA received throughout the Shuttle era, and more importantly, a drought of national policy and guidance.

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[18] *The Columbia Accident Investigation Board Report*: *Hearing Before the Committee on Science,* 108th Congress. (2003) 42.
[19] CAIB, *Volume I,* 6.

The CAIB report recommended establishing a national policy, hinting throughout the report that various organizational and cultural issues stem from the lack of committed national goals, allowing different managers to determine importance of objectives and enabling cracks within a larger system.[20]

Recertify the Shuttle to use beyond 2010

The CAIB report and testimony, focused on returning the Shuttle to flight, acknowledged the inherent danger of the Shuttle as a crew launch vehicle and defined immediate changes required to fly the Shuttle again in the near future, which was primarily intended to finish the International Space Station. CAIB included a requirement to recertify the Shuttle through NASA's human rating requirements for usage beyond 2010. The CAIB essentially prescribed a 'no later than' date for the Shuttle program without significant inspection and examinations to prove the safety of the flight hardware.

Recertification for use beyond 2010 itself was not unreasonable; The report mentioned possible operation of the Shuttle until 2020.[21] Confusion, however, arose in the CAIB's formal recommendations and their written report. On one hand, CAIB prescribed recertifying Shuttle for use beyond 2010, on the other hand, they wrote that "it is in the nation's interest to replace the Shuttle as soon as possible as the primary means for transporting humans to and from Earth orbit."[22] CAIB presented interesting yet conflicting conclusions: The Shuttle would be safe for flight, if managed properly, through 2010, yet the United States needed to replace it as soon as possible.

[20] CAIB, *Volume I*, 225.
[21] Ibid., 111, 116, 205, 209, 223.
[22] Ibid., 210.

CAIB's report contained conflicting recommendations. Why recertify the Shuttle if we should retire and replace it as soon as possible? The CAIB report indirectly suggested a Shuttle retirement date, pressuring NASA either to recertify the Shuttle and likely discover major issues requiring repairs, or move on from the Shuttle and begin a new era of human spaceflight.

Chapter 3

The Griffin Years

The remainder of 2003 saw NASA recovering from the *Columbia* accident, striving to return the Space Shuttle to flight safely. Following the CAIB report, President Bush and Sean O'Keefe, administrator of NASA, turned their attention to one of the main recommendations of the *Columbia* Accident Investigation Board report: a national space policy. the Bush administration published the *Vision for Space Exploration* (VSE) in February 2004 to focus NASA on a post-Shuttle world.[1] NASA was to pivot its focus from the ISS, opening the door for cost-saving ventures.

The VSE captured the major recommendations of the CAIB report, accepting NASA's failings wholeheartedly and becoming the first public commitment to the Space Shuttle's retirement near the end of the decade. It focused on a return to space *exploration* rather than routine operations aboard the ISS and in low-Earth orbit. The VSE called for, among other things, retirement of the Space Shuttle in 2010 upon completion of the ISS, the focus of research at ISS on exploration, the return of humans to the Moon as early as 2015 but no later than 2020, development of a new crew exploration vehicle by 2014, and separation of crew from cargo in both future exploration and operations aboard the ISS.[2]

O'Keefe formed the Exploration Systems Directorate (ESD) and appointed Admiral Craig Steidle as its Associate Administrator. Steidle inherited responsibility for developing the new hardware and architecture for accomplishing the exploration goals of the VSE, principally the development of a new Crew Exploration Vehicle (CEV) and the launch architecture for successful

[1] National Aeronautics and Space Administration, T*he Vision for Space Exploration*, February 2004, 1.
[2] Ibid., 5-7.

missions to the Moon.[3] A retired naval officer, Steidle had experience managing technical programs for the Pentagon and took a unique approach to his new position. He formed 13 working committees to oversee work and coordinated a fly-off between two competing vehicle designs for crew exploration. This fly-off would pitch two competing contractors against each other while they developed their crew capsules, and allow NASA to select a winner after two years of evaluation and testing.[4] Steidle's program depended upon a minimum of eight launches in order to support a single crew mission to the Moon.

O'Keefe retired as NASA administrator in February 2005. President Bush appointed Michael Griffin as his successor. An experienced engineer and manager, Griffin had served as an associate administrator under Dan Goldin in the early 1990s. Griffin had served as the head of In-Q-Tel, a venture capital firm that chiefly works for the CIA to provide seed funding to emerging capabilities in the intelligence community.[5]

Upon his Senate confirmation in April 2005, Griffin altered course from O'Keefe and Steidle's plan. Hoping to eliminate the planned crew launch gap of four years following the Space Shuttle's retirement in 2010, Griffin altered the current plan for a fly-off in 2008 and picked a new contractor to begin development of the CEV.[6] Griffin also commissioned a new study, the Exploration Systems Architecture Study (ESAS), which brought teams from across NASA to assess various ideas for an architecture to return the US to the Moon. An architecture lays out in deep detail all systems and moving parts required to execute an eventual lunar mission. The

[3] Henry Lambright, "Launching a New Mission: Michael Griffin and NASA's Return to the Moon," *IMB Center for The Business of Government*, May 5, 2009, 11.
[4] Ibid., 11.
[5] Ibid., 9.
[6] Ibid., 12.

principal question lay between a Shuttle-derived launch vehicle or utilizing Evolved Expendable Launch Vehicles (EELVs) from the Department of Defense's space launch program.[7]

Released in November 2005, ESAS recommended a different approach from Steidle: a new Crew Launch Vehicle (CLV) and Cargo Launch Vehicle (CaLV) be developed for usage in a "1.5 launch" architecture.[8] The launch of the CaLV carried the cargo and lunar lander required for a Moon mission, while the "half launch" on the smaller CLV carried the crew onboard a CEV to rendezvous with the other launch. Crew and cargo maintained separate launch vehicles, and safety margins were a key factor in decisions between various vehicles.

The CEV would mimic the system used in Apollo with separate modules for crew and the various support system, but upgraded to house six astronauts and be capable of spending six months at the ISS.[9] The CEV would be built in a phased manner, with emerging technologies and capabilities as the vehicle went through test flights and flights to the ISS as the replacement crew vehicle following the Space Shuttle's retirement.

The CLV, a two-stage rocket, utilized segments from the Space Shuttle's solid rocket motors with a liquid-fueled stage above a Space Shuttle Main Engine found on the Shuttle orbiter. The ESAS study concluded this option as the best due to its margin of safety, likelihood to launch in 2011, and its use of existing human and organization resources and expertise.[10] Altering the DoD's EELVs to be human rated presented cost challenges while also not raising safety margins to a level near the new CLV. William Gerstenmaier, NASA's Associate Administrator in charge

[7] Exploration Systems Architecture Study, *Final Report*, National Aeronautics and Space Administration, November 2005, 40.
[8] Ibid., 46.
[9] Ibid., 28.
[10] Ibid., 40-41.

of the ISS and Space Shuttle operations, credited the CLV decision with the speed of bringing solid rocket motors online to shorten the launch gap.[11]

The CaLV component of the study investigated EELV-derived architectures, side-mount Shuttle-derived architectures (in which a cargo vehicle strapped to the external tank, much like the Space Shuttle), and a Shuttle-derived heavy-lift rocket. All the EELVs were found to need new upper-stages in order to launch lunar missions, while side-mounts were found to not be capable of lunar missions without a minimum of three launches. ESAS recommended a Shuttle-derived heavy-lift rocket, leveraging an extended core stage (based on the Shuttle's external tank), four Space Shuttle Main Engines, and extended Shuttle Solid Rocket Motors in order to accomplish a lunar mission with one launch each of the CLV and CaLV.[12]

Griffin accepted all the recommendations, implementing the Constellation Program with the Orion Crew Exploration Vehicle, the Ares I Crew Launch Vehicle, and Ares V Cargo Launch Vehicle, with various other pieces of equipment such as the lunar lander and various research endeavors. The immediate priorities were Orion and Ares I, with lunar lander and Ares V development beginning only once work neared completion on Orion and Ares I.[13] Work would be completed sequentially and in accordance with resources provided.

Challenges struck Constellation before it became a program of record. Because of costs related to the wars in Iraq and Afghanistan, the Office of Management and Budget (OMB) worked with President Bush to cut his deficit in half and reduce spending. NASA fell victim to cuts. The budget raises called for in the VSE soon disappeared as political and fiscal realities set in. By late fall of 2005, Griffin and his staff realized that they were short nearly $5 billion dollars to finish

[11] Interview with Mr. William Gerstenmaier, conducted on January 20, 2023.
[12] Exploration Systems Architecture Study, *Final Report*, 46.
[13] Lambright, "Launching a New Mission," 14.

the Space Shuttle program and complete the ISS's construction.[14] Griffin turned towards flat-lining the space science budget at NASA in an effort to secure funding for the Space Shuttle, placing Griffin and OMB on a collision course.

A seven-month battle between Griffin and the OMB ensued. This culminated in a December 2005 meeting at the White House between the President, Vice President, the OMB Director, Griffin, and other officials.[15] The meeting focused upon the commitment to finishing the ISS and Space Shuttle programs and the proposal to flat-line the science budget at NASA in order to fly-out the Space Shuttle and accelerate Orion and Ares I to reduce the launch gap. OMB pushed to cancel the Space Shuttle program early and allow the ISS program to end concurrently.

Griffin considered the meeting a slight victory. President Bush committed to flying the Space Shuttle out to 2010 to finish the ISS, to raise NASA's budget so that science could continue with its planned funding, and to provide more money for the Space Shuttle program. This December 2005 meeting, however, ended any chance of Orion and Ares I launching before 2014, as the budget increase for NASA was not enough to cover the Space Shuttle shortfall, forcing Griffin to reprogram Constellation to fund the Space Shuttle with an additional $3 billion dollars through its completion.[16]

Foundations of Commercial Space

Beyond the attention of the public and media, NASA began to investigate turning over certain responsibilities for the space program to commercial providers. Funding levels for NASA left little room to supply the ISS. NASA had begun purchasing commercial launch services in 1990. It formalized the process by creating a contract office called the Launch Services Program

[14] Lambright, "Launching a New Mission," 15.
[15] Ibid., 16.
[16] Ibid., 16.

(LSP) in 1998, with a focus on providing services for NASA science missions and probes such as the *Opportunity* rover.[17] NASA now sought to expand commercial service beyond science missions to support the human spaceflight program.

President Bush's Vision for Space Exploration directed NASA to "pursue commercial opportunities for providing transportation and other services supporting the International Space Station and exploration missions beyond low Earth orbit."[18] A program of the Marshall Space Flight Center, Alternate Access to Station (AAS), awarded seed funding to a variety of companies interested in space exploration. AAS offered companies time and funding to develop concepts for launching cargo to the ISS.[19]

In February 2004 one of these companies, Kistler Aerospace, was awarded $227 million dollars to develop their reusable K-1 launch vehicle to deliver cargo to the ISS.[20] SpaceX protested the award due to the lack of competition for the contract. NASA and Kistler countered by claiming that AAS itself served as the competition. SpaceX's complaint, sustained by the Government Accountability Office, led to the cancellation of the contract and forced NASA back to the drawing board.[21]

Early 2005 saw the establishment of the ISS Commercial Cargo Services (ICCS) program, this time located at the Kennedy Space Center, the primary NASA launch site. OMB allocated $140 million dollars to this program to deliver launch services to the ISS. ICCS, located alongside the LSP for space science, sought to deliver similar capabilities for the ISS.[22]

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[17] Rebecca Hackler, "Commercial Orbital Transportation Services: A New Era in Spaceflight," *National Aeronautics and Space Administration*, May 2014, 12.
[18] NASA, *The Vision for Space Exploration*, 3.
[19] Hackler, "Commercial Orbital," 7.
[20] Lori Garver, *Escaping Gravity: My Quest to Transform NASA and Launch a New Space Age* (Diversion Books, 2022,) 87.
[21] Ibid.
[22] Hackler, "Commercial Orbital," 9-10.

When Michael Griffin became NASA administrator, he began investigating the problem of resupplying the ISS without the Space Shuttle. Founded in his experiences leading the In-Q-Tel venture capital firm, Griffin decided to try a seed funding partnership with private industry to supply cargo to the ISS. The new program took the name Commercial Orbital Transportation Services (COTS) and absorbed the old ICCS team at the Kennedy Space Center.[23] COTS would provide $500 million dollars, split between two providers, across a five-year period to develop and test fly cargo vehicles from each provider. A critical aspect of the COTS program lay in its location. COTS fell under the jurisdiction of the Johnson Space Center, the center with principal responsibility for crewed spaceflight. COTS focused on cargo resupply, but included a clause for crewed flight. Griffin placed COTS with Johnson in hopes that acceptance of cargo would eventually lead to acceptance of commercial crew.[24]

The National Aeronautics and Space Act of 1958 which established NASA had laid out its authority to conduct "other transactions" to accomplish its mission. This "other transaction authority", known as a Space Act Agreement (SAA), permits NASA to form unique partnerships to develop capabilities outside of normal federal acquisition laws and regulations.[25] Federal acquisition rules often preclude smaller or developing companies, as they normally lack the funding and resources to implement all the staff and paperwork required for federal contracting, and have an absence of history that works against them when competing within normal contracting rules.

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[23] Hackler, "Commercial Orbital," 16-17.
[24] Howard McCurdy, "NASA, Industry, and the Commercial Crew Development Program: The Politics of Partnership," in *NASA Spaceflight: A History of Innovation*, edited by Roger D. Launius and Howard E. McCurdy. (Switzerland: Palgrave Macmillan, 2018,) 355.
[25] Ibid., 355.

The COTS program utilized SAAs to select two companies from a list of competitors, and provided funding to develop a cargo launch system for the ISS. Requirements were basic, with NASA defining its annual mass needs to ISS, the number of flights they might require per year, and four different development tracks: COTS-A for external, unpressurized cargo; COTS-B for internal, pressurized cargo; COTS-C for returning pressurized cargo; and COTS-D for crewed spaceflight. The COTS contracts provided fixed-price payments at defined milestones to the companies selected, and contained clauses of termination if companies failed to reach their milestones. As an SAA program, COTS focused on developing systems to launch cargo to the ISS, while another follow-on program would follow standard federal contracting rules to award actual flights to ISS.[26]

NASA consulted a venture capitalist, Alan Marty, from Silicon Valley for advice on developing the program, showcasing NASA's desire to innovate beyond standard contracting methods.[27] NASA released an Announcement for Proposals for COTS in January 2006. Companies had to present 65-90-page proposals for their cargo capsules and plans for launch. This allowed companies creative freedom, the ability to propose changes to intellectual property rights, and fixed-price milestones to accommodate their needs. Companies were expected to cover 80-90 percent of the total development costs with NASA's funding to cover the remaining capital.[28]

NASA received 21 proposals in the first round in March 2006, ranging from legacy giants such as Boeing to startups such as PanAero Inc. NASA focused on three companies: SpaceX, Rocketplane Kistler (RpK, a merger of the aforementioned Kistler Aerospace), and SpaceDev. NASA ultimately selected two: RpK and SpaceX. SpaceX received $278 million to aid in their

[26] Hackler, "Commercial Orbital," 22.
[27] Alan Marty "Commercial Crew & Cargo Program Office," by Rebecca Hackler, January 18, 2013.
[28] Hackler, "Commercial Orbital," 12.

development of the Dragon cargo capsule and Falcon 9 launch vehicles, while RpK received $207 million for their K-1 launch vehicle.[29] NASA received legal challenges to the program and contracts, but ultimately, NASA proceeded with their new SAA procurement method. The Government Accountability Office recognized NASA's "other contract authority" and permitted NASA to structure their agreements as they saw fit.[30]

While SpaceX met its deadlines through the early years of the COTS program, RpK struggled to raise the required capital. The company lagged behind 30 days in their initial financing round, a $40 million goal, and then failed to reach a total of $500 million goal in May 2007.[31] RpK's CEO, Randy Brinkley, blamed NASA's inability to commit to a follow-on contract, where NASA would use the services they helped develop, in a timely manner as the critical issue behind its financing struggles.[32]

The eventual follow-on program for COTS, Commercial Resupply Services (CRS), released a Request for Information in July 2007, and indicated a guaranteed total of only three missions.[33] RpK subsequently lost funding and confidence from its investors, due to a perceived lack of profit from these missions. When the Request for Proposals formally opened the CRS competition months later, there were a total of 8-12 flights available to those awarded the contracts. RpK's CEO further stated that "we had been defaulted by NASA," pinpointing the struggle NASA and private companies attempted to navigate with risk and private financing of programs.[34] RpK's failure became a case study in the concept of "anchor tenancy" in commercial spaceflight, where

[29] Hackler, "Commercial Orbital," 30.
[30] Ibid., 31.
[31] Ibid., 61.
[32] Randolph Brinkley, "Commercial Crew & Cargo Program Office," by Rebecca Hackley, May 1, 2013.
[33] Ibid.
[34] Ibid.

the government guarantees use of services during the development process to aid companies in raising private capital.

NASA recognized the need for follow-on contracts to stabilize development operations with anchor tenancy. William Gerstenmaier, then Associate Administrator for Human Exploration and Operations responsible for the ISS and the Space Shuttle, realized the need for guaranteed cargo following the final Space Shuttle flight for ISS completion. Gerstenmaier urged Griffin and other Associate Administrators to move the CRS contracts forward.[35] They were awarded in December of 2008.

NASA ultimately terminated RpK's contract due to their funding issues and redirected funding through a second competition round. NASA selected Orbital Sciences Corporation with their Cygnus capsule and Antares Rocket.[36] SpaceX and Orbital both proceeded with development of their respective spacecraft and launch vehicles, ultimately carrying out various test flights. Governments and corporations alike learned lessons from these cooperative agreements, learning how to best assess and weigh financial and technical risks. These companies and NASA took these lessons and subsequently applied them to the Commercial Crew Program.

The emergence of commercial involvement in human spaceflight hinged on this initial willingness to trust cargo to commercial providers. CAIB's recommendation to split cargo and crew influenced the design of Constellation, while the push to return to exploration left routine missions to the ISS as lower priority. These factors relegated cargo to the commercial sector. Gerstenmaier's recognition of the impending gap between cargo capability to the station and the arrival of Griffin with his experience in venture capital allowed COTS to develop as an idea and

[35] Interview with Mr. William Gerstenmaier, conducted on January 20, 2023.
[36] Hackler, "Commercial Orbital," 33.

concepts such as anchor tenancy through CRS to speed along development of COTS. NASA had finally opened the door to the commercialization of space.

Chapter 4

The Obama Administration

2008 marked a tumultuous time: the stock market crashed, the housing market imploded, the global economy painfully rippled across American society, and war still raged in Iraq and Afghanistan. The election of Barack Obama marked a turning point for many Americans, most famously captured in his own "Hope and Change" campaign ads. While many Americans continued their daily struggle and focused on their jobs and families, a new group of spaceflight pioneers set the stage for a dramatic showdown between the Presidency and Congress, and between the innovation and creativity of NewSpace and the "Old Guard" of NASA and aerospace. A split in NASA leadership, different understanding of NASA's role in the budget process, and balance between Presidential and Congressional power ultimately resulted in a split between commercial and government programs.

Congress in 2007 and 2008, emboldened by a Democrat victory in both chambers, challenged President Bush and the war in Iraq, among other initiatives. While the Constellation program, set to replace the Space Shuttle and return the US to the moon, remained out of the spotlight of Congressional criticism, it became a victim of continuing resolutions in Congress. There were eight different continuing resolutions in 2007 and 2008, each only maintaining appropriations at the level approved in the previous fiscal year, while simultaneously blocking new work from starting.[1] Each resolution restricted NASAs ability to continue timely work on Constellation, delaying the program.

The agency's own "Lessons Learned" report concerning Constellation emphasized the overly optimistic assumptions of the program, and recommended planning for a continuing

[1] Congressional Research Service, *Duration of Continuing Resolutions in Recent Years,* January 19, 2012.

resolution in each fiscal year's first quarter.[2] Griffin shifted milestones for Constellation in order to adjust to fiscal realities. But because Constellation became more responsible for legacy Space Shuttle equipment and infrastructure each year as the Space Shuttle began to be phased out, Constellation fell into a vicious cycle in which each successive schedule adjustment saved less funding than the last.[3] The plan for Constellation to reuse ground hardware and the associated yearly costs to maintain this hardware further ate into the budget for Ares I and Orion.

Constellation also became subject to budget cuts and was sacrificed to maintain the ISS and Space Shuttle programs. A difference of over $2.5 billion dollars in the first three years of the program delayed the launch of Orion and Ares I from 2012 to 2015.[4] The program planned for adequate budget reserves, but the extent of budget restrictions in the early years forced Griffin and NASA to decide between safe and timely operation of the Space Shuttle or development for Constellation.

This turmoil ultimately came under intense scrutiny from the incoming Obama administration, with Lori Garver as the transition team leader for NASA. A non-engineer and space policy expert, Garver had followed a career of advocacy to transition team leader and ultimately Deputy Administrator of NASA.[5] Weaving in and out of NASA jobs, Garver followed a long path of encouraging commercial growth in routine space operations. She coordinated a Russian Soyuz capsule ride for herself in the early 2000s, and continuously pushed for commercialization of spaceflight.[6]

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[2] Jennifer L. Rhatigan, *Constellation Program Lessons Learned: Executive Summary*, National Aeronautics and Space Administration, May 20, 2011, 12.
[3] Ibid., 6.
[4] Ibid., 12-13.
[5] Lori Garver, *Escaping Gravity: My Quest to Transform NASA and Launch a New Space Age* (Diversion Books, 2022).
[6] Ibid., 71.

Michael Griffin and Lori Garver clashed during the transition period. Garver stated that NASA employees and managers actively avoided discussing Constellation with the Obama transition team, while Griffin felt insulted that her team was "looking under the hood" of the Constellation program, his "pet project."[7] Griffin avoided regular meetings with Garver during the transition period and briefings presented to Garver were devoid of information surrounding budget, timelines, and status of Constellation hardware development.[8]

The Obama administration chose a new administrator to succeed Griffin. Steve Isakowitz, a senior engineer and executive with a wide breadth of experience in government positions, became the initial nominee in February 2009. Senator Bill Nelson of Florida, famous for his own flight aboard the Space Shuttle before the *Challenger* disaster, opposed Isakowitz. Garver, speaking in her autobiography, identified Nelson's reasons for opposition as "nebulous." Nelson torpedoed Isakowitz assuming the position, stating that he had his own candidate in mind.[9] The trend of Democrats placing roadblocks in the way of the Obama administration in space would continue in the future.

The administration continued searching for a candidate. Garver next focused on gauging the interest of Sally Ride, the first American woman in space, but she refused.[10] The Obama administration stumbled through candidates, delaying the appointment process, leading to the establishment of the Review of US Human Space Flight Plans Committee instead to kickstart the process of changing NASA's current plans.[11] Nicknamed the "Augustine committee" for its chair, Norman Augustine, former Lockheed CEO and chair of a previous space policy committee, the

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[7] Garver, *Escaping Gravity,* 81.
[8] Ibid., 81.
[9] Ibid., 6.
[10] Ibid., 8.
[11] Ibid., 9.

committee provided Garver and the administration a mechanism to criticize Constellation and open the door for new ideas in Congress. The committee was charged with reviewing current American plans for human spaceflight and potential alternatives.

President Obama in late May 2009 nominated Charles Bolden, an African-American graduate of the Naval Academy and veteran of four Space Shuttle flights, who had flown to space with Senator Nelson but had been out of touch with space policy since returning to the Marine Corps in 1994.[12]

Bolden and Garver represented different experiences and approaches towards space exploration. Bolden knew the traditional method of NASA programs and planning, representing the "Old Guard" of NASA and aerospace giants, such as Boeing and Lockheed Martin, within the Obama administration.[13] Garver represented a new approach to the role, a self-proclaimed "space pirate" who strove to innovate and push NASA towards commercialization in order to carry out the wishes of the Obama administration as she understood them during her time leading the NASA transition.[14] Their differences soon drove a split in NASA thinking, a split that persisted into NASA future programs.

NASA and the Budget Process

The Augustine Committee published its report in September 2009. It sharply criticized the current trajectory of crewed space flight. The committee found that Constellation's goal of a 2015 launch was unrealistic; it was more likely to occur in 2017.[15] Five options were laid out by the Augustine committee:

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[12] Garver, *Escaping Gravity,* 9.
[13] Interview with Maj Gen (ret.) Charles Bolden, conducted on September 20, 2022.
[14] Garver, *Escaping Gravity*, 209.
[15] Review of U.S. Human Spaceflight Plans Committee, *Seeking A Human Spaceflight Program Worthy of a Great Nation*, October 2009, 5.

Option 1: Continue current programs (Constellation) with current budget.

Option 2: Modify current programs and add a commercial crew program.

Option 3: Continue current programs with an additional $3-5 billion dollars.

Option 4: Modify current programs with a Moon-First plan, with expanded budget and possible Shuttle extension.

Option 5: End current programs in favor of commercial crew for low-Earth orbit, and continue deep exploration with a new heavy-lift program.

The only options viewed as viable for a minimal launch gap and continued exploration were options 3, 4, and 5. Thus, the Augustine report heavily emphasized commercial crews and pushed for increased funding for NASA.[16]

White House staff met with NASA and OMB officials in October 2009 and laid out the President's preferences and options for NASA and OMB.[17] Every option indicated the need to start a commercial crew program, while terminating the Ares I CLV. Bolden made no objections to these plans at the meeting, and also made no objections during a meeting in November 2021 with the Director of OMB. Yet NASA's 2011 budget submitted to OMB contained none of these new directives, instead continuing Constellation on its current trajectory. The President met with Bolden in December 2009, but Bolden highlighted a new nuclear rocket program instead of discussing options for Constellation and Commercial Crew.[18]

Bolden viewed his role as a mediator, not as the executor of presidential wishes. Bolden himself recognized in an interview that he was not a "commercial ideologue," and that he was "on the outside looking in," with regards to the Obama administration.[19] Relationships were strained

[16] Review of U.S., *Seeking A Human*, 6.
[17] Garver, *Escaping Gravity*, 97.
[18] Ibid., 99.
[19] Interview with Maj Gen (ret.) Charles Bolden, conducted on September 20, 2022.

between Bolden and White House staff at this time. Bolden did not wish to place human spaceflight entirely in the hands of commercial providers, instead wanting the government to maintain a stake in development of vehicles for exploration. OMB briefed the President's budget plan, which proposed a full cancellation of the Constellation program, to Bolden in late January 2010. Bolden felt "like he'd be kicked in the gut," and has since repeatedly insisted that the cancellation of Constellation was "shoved down Congress' throat."[20] [21]

The January 2010 budget proposal contained a $19 billion request for 2011, an additional $6 billion across the next five years, the cancellation of Constellation in order to fund an additional Space Shuttle flight and extension of ISS operations to 2020, and the creation of the Commercial Crew Program (CCP).[22] NASA would not develop any new launch or crew vehicles under this proposal. With early warning of the budget proposal, Bolden reached out to White House staff and begged for a chance to restructure Constellation instead of terminating it.[23]

Bolden and Garver continued to duel over their interpretations of the president's wishes and their role in implementing these wishes. Bolden, a retired general, approached his role as administrator with an understanding of the military chain of command. Bolden believed that the trust placed in him as administrator allowed him to make decisions without the President's direct input; if the president disagreed, he would "negate" Bolden's orders and issue a change.[24]

Bolden viewed his role as that of a mediator between the wishes of the committees overseeing NASA in Congress and the White House. He understood the anger soon to arise in Congress and struggled to keep NASA in the "rocket business," hoping to convince the White

[20] Garver, *Escaping Gravity*, 101.
[21] Interview with Maj Gen (ret.) Charles Bolden, conducted on September 20, 2022.
[22] Kenneth Chang, "Billions for NASA, With a Push to Find New Ways Into Space," *The New York Times*, February 1, 2010.
[23] Michael Coats, "Johnson Space Center Oral History Project," by Jennfier Ross-Nazzal, August 5, 2015.
[24] Interview with Maj Gen (ret.) Charles Bolden, conducted on September 20, 2022.

House of NASA's need to return to development of systems, rather than existing purely as an operational entity for spaceflight. NASA had not developed its own crew vehicle since 1981 with the Space Shuttle, and Bolden recognized the need for a heavy-lift vehicle to launch missions to the Moon and Mars; these lacked any immediate commercial viability, necessitating NASA involvement to reach these destinations.[25]

Conversely, Garver viewed her role as Deputy Administrator and former transition team leader as strictly following presidential directives: The Office of Science and Technology made it clear that the president wanted a commercial crew program and needed to cancel Constellation to fund both human and robotic exploration. Garver's identity as a "commercial ideologue" and former advisor to the president led her to interpret presidential guidance strictly: NASA's role was to implement presidential wishes, not advocate for its own interests.[26] Garver and Bolden frequently clashed over their ideas of the president's wishes, and their understanding of command by negation.

Both policymakers brought their individual experiences to the table. The implementation of the President's intent instead permeated Bolden's thinking; his role as administrator was to convert the President's objectives into a realistic plan. Bolden recognized the severe costs of terminating Constellation and sought to alleviate Congressional concerns about loss of jobs and other challenges in their districts if Constellation ended.[27] Garver focused upon her own desires to commercialize space in an effort to make space a sustainable endeavor; commercial crew needed to be established to start this process, and that meant a termination of Constellation to fund ISS completion, another Shuttle flight, and the CCP.[28] Bolden saw himself as an equal representative

[25] Interview with Maj Gen (ret.) Charles Bolden, conducted on September 20, 2022.
[26] Garver, *Escaping Gravity*, 107.
[27] Interview with Maj Gen (ret.) Charles Bolden, conducted on September 20, 2022.
[28] Garver, *Escaping Gravity*, 102-107.

of both Congress and the President, as they both agreed to appoint him to his position of administrator.[29]

A History of Rebellion and Dissent

The Augustine committee's and Obama administration's criticism of the Constellation program was not new. Earlier, a rebel group within NASA called DIRECT (referring to a direct transition between the Space Shuttle and their proposal), a grass-roots group of various NASA engineers and spaceflight enthusiasts proposed an alternative to the Ares family of rockets of the Constellation program, called Jupiter.[30] It called for a scalable system that developed shuttle components directly into launch vehicles and maintained the Orion CEV from the Constellation program for crewed launches. The key attraction of DIRECT's proposal was that it could fly in 2013, two to four years ahead of the Ares I.

DIRECT's timeline relied on greater usage of Space Shuttle components, taking a Shuttle external tank and adding SSMEs to it, stacking the Orion CEV on top, and strapping solid rocket motors to the side. The size of the launch vehicles would evolve over time, eventually stretching to a heavy-lift system similar to the Ares V proposal.

Detractors of Ares, many within the rebel DIRECT team, pointed out various conflicts behind the Ares I launch vehicle. The rocket closely matched a technical paper that Griffin himself authored and published for the Planetary Society. Scott Horowitz, the chief engineer for Constellation, became associated with the Ares I rocket, whose nickname became the "Scotty Rocket."[31] In a more damaging claim, detractors pointed out that Horowitz, a former executive at ATK Thiokol, had proposed a similar rocket while working there. The conflict of interest? ATK

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[29] Garver, *Escaping Gravity*, 141.
[30] David Noland, "NASA & Its Discontents: Frustrated Engineers Battle with NASA over the Future of Spaceflight," *Popular Mechanics*, February 2009.
[31] Garver, *Escaping Gravity*, 109.

Thiokol was the prime contractor for the Ares I first stage, as it was the sole manufacturer in the United States of large solid rocket motors.[32]

These claims of corruption, combined with a culture of pressure to support Ares I through various engineering problems, drove the DIRECT team to propose very few modifications to existing launch infrastructure for early launches, as the system fit within the Space Shuttle footprint.[33] Jupiter offered double the mass to the ISS over Ares I. Jupiter received some recognition in January 2009, when leaders of the team met with the Obama transition team for NASA and proposed their concepts to replace the Constellation program.[34] While their proposals did not end up in the transition team plan as a recommended option, the proposal remained in their minds.

A January 2010 article in *Popular Mechanics* revealed that Bolden ordered a meeting between the DIRECT team with the co-heads of the Constellation program, Doug Cooke and William Gerstenmaier.[35] This meeting between the groups occurred likely after Bolden learned of the 2011 budget proposal and the intent to terminate Constellation. DIRECT's lead advocate, Ross Tierney, stated that the two men seemed receptive to the idea.[36] The idea of a DIRECT-like proposal for a continued, direct transition from the Space Shuttle to a follow-on lunar vehicle found itself firmly planted in the minds of NASA engineers.

Bolden's role as mediator between the forces of Constellation contractors and Congressional supporters and the White House solidified. Contact between the DIRECT team and

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[32] Garver, *Escaping Gravity*, 109.
[33] David Noland, "NASA & Its Discontents: Frustrated Engineers Battle with NASA over the Future of Spaceflight," *Popular Mechanics*, February 2009.
[34] Joe Pappalardo, "NASA Renegades Pitch Obama Team New Post-Shuttle Plan," *Popular Mechanics*, January 9, 2009.
[35] David Noland, "Rebel Engineers Sit With NASA to Chart Future of Manned Space," *Popular Mechanics*, January 29, 2010.
[36] Ibid.

senior NASA leadership, in the midst of the new budget proposing an end to Constellation and government programs entirely, showcased Bolden's desire to maintain a NASA stake in developing vehicles. A new idea of evolvable launch vehicles, extending up to heavy-lift rockets, emerged in the minds of Constellation supporters.

The Process Becomes the Focus

Bolden's formal announcement of NASA's 2011 budget proposal in February 2010 led to widespread backlash within NASA–particularly the Constellation program managers–and the various Congressional committees responsible for NASA.[37] Committee members from the various states where NASA jobs and contracts were located, such as Florida, Alabama, and Texas, felt any decision to drastically change contracts threatened their districts' interests and their own reelection prospects.

Bolden struggled to sell the new budget to Congress, leading Congress and other NASA leaders to discern that the budget was not really his; Congressional support for the budget diminished as a consequence. Media and critics soon focused on Garver as the likely 'culprit' for this unpopular budget, leading many to believe that the President and the NASA Administrator had been outmaneuvered by the Deputy Administrator of NASA.[38] Bolden insisted in a 2022 interview that the commercial approach for NASA was not an idea or concept within NASA. Bolden intimated that the Obama transition team essentially planted people inside NASA to run programs such as Commercial Crew. Bolden alluded to the difficulties created for him by the new Deputy Administrator, Lori Garver.[39]

[37] Garver, *Escaping Gravity*, 10.
[38] Ibid., 9.
[39] Interview with Maj Gen (ret.) Charles Bolden, conducted on September 20, 2022.

The stage for conflict was fully set in March 2010 when *Space News* reported on a new, alternative budget plan being developed by the Johnson Space Center under the orders of Administrator Bolden.[40] This so-called "Plan B" called for a development of a heavy-lift launch vehicle and represented compromise between the President's desire to cancel Constellation and continuance of the program. An email tying Bolden to the idea set in stone the divide between the "old guard" of NASA supporting the Constellation program and the "space pirates" led by Garver, who had President Obama's support for her plans to commercialize space during her time as the transition team leader.

Compromise and Harsh Winters

Full-blown conflict erupted between the various Congressional committees overseeing NASA and the Presidency. Apollo-era astronauts testified in Congress in complete opposition of the President's budget.[41] Democratic and Republican politicians alike criticized the proposal and expressed concern for their districts. Bolden testified for multiple hours on the Hill, fielding various difficult questions, most memorably a question regarding the effect of canceling the use of solid rocket motors and the effect on military space and nuclear endeavors that canceling Constellation would have.[42]

Bolden's position within the Obama administration deteriorated as a result. Knowing about issues in the Ares I program, such as immense oscillations due to the solid rocket motor that would require major redesigns yet remained hidden from Congressional criticism, Bolden pleaded with the White House to allow him to work on an alternative to the outright cancellation of Constellation, Plan-B.[43] Bolden wanted a continued NASA stake in developing and launching

[40] Amy Klamper, "Johnson Space Center Prepares 'Plan B' with Bolden's Permission," *Space News*, March 4, 2010.
[41] Garver, *Escaping Gravity*, 12.
[42] Interview with Maj Gen (ret.) Charles Bolden, conducted on September 20, 2022.
[43] Interview with Maj Gen (ret.) Charles Bolden, conducted on September 20, 2022.

rockets, a return to the first few decades of NASA with Apollo and the Shuttle program, and navigated between the President and Congress in an attempt to achieve this goal.

In April 2010, amid heavy backlash to the budget proposal, President Obama finally showed firm presidential support for the new NASA plan to end Constellation. Speaking at Kennedy Space Center in Florida, the President laid out a revised version of the budget in an attempt to alleviate concerns.[44] The new plan had a surprise, however: the Orion CEV would be simplified and retained to serve as a Crew Rescue Vehicle (CRV). This attempt to compromise with contractors and the Constellation program was unknown to Bolden. Instead, it was initiated by Garver and White House staff.[45]

Negotiations between the administration, NASA, and Congress continued throughout 2010. Bolden's Plan B team and concept eventually emerged at the forefront of the negotiations. Ultimately, Congress passed the NASA Authorization Act of 2010, creating the CCP and directing NASA to design a heavy-lift rocket to initially launch 70 megatons (MT), up to 130 MT, to lunar orbit, by 2016 with just under $12 billion in budget.[46] The most important requirement, however, directed NASA to use Constellation contracts "to the greatest extent possible." Congress forced NASA into an awkward legal corner, with many concerned about possibly terminating Constellation projects as prohibitively expensive.[47] Instead, the bill tried to coerce NASA into accepting a design that largely continued Constellation work.

Legal debates regarding the existing contracts clause soon ensued. Alliant Techsystems (ATK), at the time the only major creator of large solid rocket motors, pushed the Congressional delegation from their state, Utah, to ensure solid rockets would be part of the new heavy-lift rocket.

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[44] Garver, *Escaping Gravity*, 109.
[45] Interview with Maj Gen (ret.) Charles Bolden, conducted on September 20, 2022.
[46] Garver, *Escaping Gravity*, 117.
[47] Ibid., 118.

The delegation met with Bolden and Garver and chastised them for considering any other option aside from solid rockets, asking Bolden and Garver to pledge to "follow the law and use solid rocket motors."[48]

The administration met with Congressional leaders in September 2011 to finalize the design of the newly-named heavy-lift rocket, the Space Launch System (SLS), following a 90-day study and subpoenas from Congress being sent to Bolden and Garver.[49] The next day, the Senate held a press conference announcing the new SLS plan. The SLS retained a remarkable similarity to the earlier Ares V CaLV from Constellation, with many contracts modified from Constellation to support SLS, including the Orion Multi-Purpose Crew Vehicle (MPCV, renamed from CEV), and the Ares V central tank and upper stage contracts with slight modifications.[50]

The battle between Constellation and the Obama administration, certainly not over, passed into a new phase. With the CCP written into law, SLS and Orion survived from the Constellation program. NASA and Congress had decided to split human spaceflight priorities: hereafter, government and legacy aerospace giants would handle deep exploration while commercial providers took over low-Earth orbit and more routine operations in deep space. Challenges to commercial programs, however, continued into the future.

Budget Problems

Conflict between NASA and Congressional appropriators continued well beyond the September 2011 compromise between government and commercial space. The first round of the Commercial Crew Development Program (CCDev1), started with $50 million from the 2009

[48] Garver, *Escaping Gravity*, 119.
[49] Ibid., 122.
[50] Ibid., 123.

stimulus bill, kicked off the CCP.[51] 31 competitors submitted proposals, with five winners selected in February 2010; Sierra Nevada, Boeing, Blue Origin, Paragon, and the United Launch Alliance.

The initial rounds of CCP would follow the COTS template; milestone payments under Space Act Agreements (SAAs) and continued rounds of competition, with flights being awarded in a final round, combining the functions of COTS and CRS into one program, building in a guarantee of flights under traditional federal contracts to each competitor once their systems were committed to by NASA.[52]

During the budgetary battles occurring in mid-2010, President Obama's speech at the Kennedy Space Center in April 2010, with an interest in compromising by continuing the Orion CEV to rescue ISS crew, started CCDev1 off with controversy. The companies participating in the contracts raised concerns they would compete against the so-called "Orion-lite" and lose money. The eventual September 2011 compromise alleviated these concerns as Orion removed the ISS as a possible destination.[53]

Round 2 of the CCDev program began in October 2010, seeking to develop and mature technologies for the selected companies to utilize in their full-size vehicles. Following an agreement in Congress to fund the government in April 2011, NASA received $289 million for CCDev2, and shortly thereafter selected four companies; Sierra Nevada, Blue Origin, SpaceX, and Boeing. NASA started planning for the third round of the CCP, requesting over $3 billion for SLS/Orion and $850 million for CCP.[54] The September 2011 compromise, while guaranteeing the future of Commercial Crew and SLS/Orion, did not commit Congress nor NASA and the President

[51] Howard McCurdy, "NASA, Industry, and the Commercial Crew Development Program: The Politics of Partnership," in *NASA Spaceflight: A History of Innovation*, edited by Roger D. Launius and Howard E. McCurdy. (Switzerland: Palgrave Macmillan, 2018,) 363.
[52] Ibid., 364.
[53] Ibid., 363.
[54] McCurdy, "NASA," 368.

to funding levels in the 2010 Authorization Act. Congress appropriated $406 million to CCP, less than half of the requested funds.

NASA debated when it was legally required to switch from SAAs to federal contracting rules, with many within NASA believing the third round of CCP to be the appropriate time in order to define requirements for the entire crew architectures. Bolden met with his Deputy and Associate Administrators in December 2011; Gerstenmaier pushed for federal contracts for this round with one victor to speed development and shorten the launch gap to ISS, while Garver pushed for another round of SAAs in order to select at least two competitors and ensure competition.[55] Bolden sided with Garver and NASA announced the third round of CCP, called Commercial Crew Integrated Capability (CCiCap).[56]

While the competition for CCiCap continued throughout 2012, Bolden and Garver attempted to convince Congress to fully fund CCP. The COTS program, whose success or failure found itself intrinsically linked to CCP, launched its first full test flight with cargo delivery to the ISS by SpaceX. SpaceX's success provided enough political support to NASA for Congress to increase their funding for 2013, providing $489 billion of NASAs $830 million request, up from $409 million in 2012.[57] NASA announced two and half winners for CCiCap: Boeing's CST-100 Starliner and SpaceX's Crew Dragon each received about $400 million across a nearly two-year period, while Sierra Nevada's Dream Chaser received just about $210 million across the same period.[58]

The struggle for a better budget continued into 2013, with NASA fighting for funds to continue to commence the final round of the development program, called Commercial Crew

[55] Garver, *Escaping Gravity*, 185.
[56] McCurdy, "NASA," 368.
[57] Ibid., 371.
[58] McCurdy, "NASA," 371.

Transportation Capability (CCtCap). Following Orbital's test flights, the COTS program officially ended and transitioned fully to CRS in September 2013.[59] Bolstered by the success of both companies, NASA and the administration secured $696 million for COTS in fiscal year 2014, still short of the full request, but the largest amount thus far.[60]

NASA closed out the competitive Commercial Crew rounds in September 2014, selecting Boeing's CST-100 Starliner and SpaceX's Crew Dragon and associated launch vehicles, with each program receiving $4.2 billion and $2.6 billion in guaranteed contracts, respectively. CCP continued along, however, still lacked full funding and continued to get delayed from the initial launch date goals of 2017.[61]

Winning Hearts and Minds

The launch of the first COTS test flight to the ISS by SpaceX in May 2012 marked a new period in the history of Commercial Crew.[62] Commercial industry proved that it was capable of flying to ISS, constructing their own launch vehicles, and creating a pressurized capsule for cargo, indicative of a likely evolution to crewed variants. While success within the COTS program first solidified the CCP program and turned the tide of Congressional approval, failure in spaceflight would firmly place low-Earth orbit operations to the ISS within the hands of commercial providers.

Upon the completion of the COTS program, flights to the ISS for resupply fell under the Commercial Resupply Services (CRS) program, situated within the ISS program. Regular flights from both Orbital and SpaceX continued from 2013 onward. CRS continued without issue until October 2014, when the Antares rocket carrying Orbital's Cygnus capsule failed and resulted in

[59] Hackler, "Commercial Orbital," 75.
[60] McCurdy, "NASA," 372.
[61] Ibid., 372.
[62] Dave Klinger, "SpaceX Dragon berths with International Space Station," *Ars Technica,* May 25, 2012.

loss of cargo.[63] Orbital paused launches in the interim, shifting their launches to United Launch Alliance (ULA) Atlas V's until they could fix their Antares launch vehicle.

Four cargo launch vehicles remained to resupply ISS: SpaceX's Dragon, Russia's Progress, the Japanese H-II Transfer Vehicle (HTV), and the European Automated Transfer Vehicle (ATV).[64] Six months after the Orbital loss, the Russians suffered a communication issue with a Progress capsule that resulted in loss of mission. Now cargo transport to the ISS depended upon three capsules, down from five.[65]

NASA and SpaceX moved their schedule forward to cover the loss of Orbital capability, proceeding for seven months until SpaceX suffered a failure in their Falcon 9 rocket during launch in June 2015. Two failures in seven months halted the CRS program and all resupply for the ISS temporarily moved abroad, to the European ATV and the Japanese HTV, two capsules.[66]

Counterintuitively, the failures of CRS helped Administrator Bolden argue for more Commercial Crew funds. Bolden focused on the need to cooperatively develop two new crew capsules and have separate launch vehicles for each, as the redundancy helped ensure that the United States could launch its astronauts if any of the four subsystems, capsules or launch vehicles, failed.[67] NASA and the administration, pressing the need for multiple providers, felt vindicated by these failures and convinced Congress that two providers was necessary. The resulting mediation between Congress and the administration provided NASA's full budget request for the first time

[63] Jason Rhian, "With Loss of SpaceX Dragon- NASA Now Dependent on Russia, Japan for Access to ISS," *Spaceflight Insider*, June 28, 2015.
[64] Ibid.
[65] Ibid.
[66] Ibid.
[67] Interview with Maj Gen (ret.) Charles Bolden, conducted on September 20, 2022.

in late 2015; over $1.2 billion.[68] Congress finally supported NASA's plan fully, with roadblocks becoming technical, rather than financial.

The mediation between Bolden, Congressional committees overseeing NASA, and the Obama administration created an opportunity for commercial providers to thrive. The establishment of CCP in the backdrop of the SLS program offered commercial providers time to prove themselves while lacking full funding, and permitted the COTS program and CRS flights to not only confirm the capabilities of commercial providers, but demonstrate the need for two providers.

[68] McCurdy, "NASA," 372.

Conclusion

Emergence Based on Trust

A term created by Sierra Space, a rising star in the realm of human spaceflight, the *Orbital Age* hinged on the impending commercialization of space and a developing economy in low-Earth orbit and beyond. The commercialization of space can be dated to the Commercial Space Act of 1984, and traced through small hops from commercial payloads to commercial launches of NASA exploration probes throughout the 1990s. The emergence of the *Orbital Age* during the mid-to-late 2000s marked an evolution in the history of human spaceflight.

Throughout the short history of space exploration, the government always took the risk of overseeing construction of spacecraft related to human exploration, whether they carried cargo or crew. The Russian Soyuz, American Saturn, and the Space Shuttle: each program collected the might of industrial power and the ability to take risks for the government to expand human knowledge of space. The Bush and Obama administrations forced NASA to abandon small hops in favor of a massive leap in trust and confidence in commercial providers to provide services for human spaceflight. America's willingness to turn over "more routine" human spaceflight missions to commercial providers showcased that even space travel had been normalized in our society.

The willingness of the Bush and Obama administrations to hedge bets on commercial providers for cargo and then crew transportation to low-Earth orbit hinged on a convergence of problems faced by NASA for the past few decades. The development, life, and tragedies of the Space Shuttle program presented a vehicle that backed NASA into a corner. The dependence on the Shuttle to construct the ISS, itself a contributing factor to the *Columbia* accident, drove a need to maintain the Shuttle until ISS completion. The Space Shuttle budget itself placed a major

roadblock for any replacement. A desire to safely develop a replacement through the Constellation program resulted in a delayed program with larger budget shortfalls every year. NASA recognized the need for commercial services to cover the gap in cargo capability to the ISS, while the Obama administration and its NASA transition team, led by Lori Garver, saw a commercial crew initiative as the solution for the challenging budget situation.

The *Columbia* disaster challenged American thinking about human spaceflight and prompted a change in direction and purpose. The loss of more astronauts aboard the Space Shuttle pushed NASA to recertify and replace it, and concerns of prioritizing crew safety forced NASA to separate cargo and crew. The CAIB report set a preliminary sunset date of 2010 for the Space Shuttle and charged the President and NASA to develop a national space policy for the future of human spaceflight.

The sunset of the Space Shuttle program in the early 2010s marked the end of a legendary space exploration program. The Shuttle launched one-hundred and thirty-five times, bringing numerous satellites and probes to space, and principally assembling the International Space Station (ISS). The program pressed through the early *Challenger* disaster for a long career of routine spaceflight, enabling a new era of human exploration that normalized life in space.

During the Bush administration, NASA refocused itself toward exploration through the Constellation program and made the first strides in commercial space with the COTS program. Political realities of the late Bush administration constricted NASA's budget and immediately delayed Constellation, while COTS demonstrated the viability of Space Act Agreements and the potential for commercial space.

Controversy surrounding the Constellation program, in particular the Ares I rocket, led to a rebel group of NASA engineers called DIRECT. The DIRECT team advocated for a more

direct transition from the Space Shuttle to its replacement, and introduced the idea of an evolvable heavy-lift launch vehicle. Their proposals found their way to the highest levels of government and resembled later plans for the SLS.

The transition period to the Obama administration marked a challenging time for NASA. Lori Garver led the Obama transition team for NASA and worked on the 2009 stimulus bill to provide funding for CCP. A delay in nominating an administrator led to the establishment of the Augustine committee and provided political cover for the Obama administration to change course from the Bush administration. The nomination of Charles Bolden to be NASA administrator set the stage for a dramatic showdown between the "Old Guard" of NASA and the "commercial ideologues" led by Garver.

The split in NASA leadership placed two concepts at the forefront of Congressional consideration: a heavy-lift vehicle for exploration and a commercial-provided crew capability to low-Earth orbit. Mandates to continue Constellation contracts and the concerns of Congressional committees in charge of NASA led to the SLS, a heavy-lift rocket very similar to the DIRECT proposal that utilized many Constellation contracts.

The emergence of commercial space depended upon the trust and confidence placed in commercial providers for routine operations. Griffin's early bet on commercial cargo laid the foundation for NASA deputy administrator Garver and the Obama administration to double down on commercial services. The relatively low level of funding provided to COTS allowed commercial providers time to prove themselves, while the reality of the Space Shuttle pushed policymakers to support CCP as the CRS flights proved the need for multiple providers.

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Appendix

Oral History Interview with Maj Gen (ret.) Charles Bolden

20 September 2022

Conducted by MIDN Landon Clouse

MIDN LANDON CLOUSE: Just to provide some background, with my project I'm looking at, kind of just a broad history of NASA trying to replace the Space Shuttle. So, like going back to the 'Shuttle B', 'Shuttle C' concepts through the National Aero-Space Plane, VentureStar, all the different programs throughout the life of the Shuttle that were intended to replace the Shuttle, but ultimately Commercial Crew ends up being the one to do it. Particularly, your time as the transition period canceling Constellation moving into Commercial Crew is what I wanted to focus on sir.

MAJ GEN CHARLES BOLDEN: That'll work.

CLOUSE: You came into NASA at kind of an awkward period, the Augustine Committee was looking at the Constellation program and assessing options for you. It was a weird time where the program had been underfunded for a while, you didn't really know what the next steps were going to be, so when they [Augustine Committee] released their report, were you kind of on the same wavelength with what the Augustine Committee was proposing or some of the options they gave? Eventually you ended up going with basically Option 5B, were you on that wavelength when you were interviewed for Administrator and came into the job?

BOLDEN: Well when I was interviewed, when I had my meeting with President Obama, there was no, to my knowledge, and that's important to understand, I was not aware that there was an Augustine report underway when I interviewed with him. I interviewed with him in the April/May time frame in his first term and I think the Augustine Committee may have been

charted, but I don't know if they had already started their work, they may have but I really don't remember to be quite honest.

When I was announced as the nominee, I knew that there was some work underway but I had not had an opportunity to either talk to them. I did not know what the scope of their study was or anything, so while some people say I should not have been surprised by the result, I was surprised by parts of it because I had not been involved at all. I had not interviewed with them, I had not talked with them. I knew Norm Augustine very well, so I wasn't worried he was going to do anything radical, but I still didn't know exactly where they were coming from. In principle, I agreed that Constellation was probably not where we should be, but that we should find another program that would get us to deep space. Getting back to the Moon was not something in my mind at that time, it was going straight to Mars, so I was one of the 'Mars-guys.' I knew that Shuttle was not that vehicle and that we needed to retire Shuttle at some time. In fact, I had felt we needed to phase Shuttle out a long time ago, but I had not really thought about commercial that way that we have it today, but I thought that we needed to phase it out in order to put more money into exploration and deep space human space flight. So, I was sort of on the same wavelength but not on the same wavelength in every aspect because I didn't know what they were doing.

CLOUSE: So, as you've talked about in, and I remember growing up and seeing the news about the cancellation of Constellation, I've been into space for a long time, that was a big leap of faith in commercial industry to jump from the initial COTS contract, where they were okay let's maybe try this little bit, to pretty much full faith with them in Commercial Crew Development. How did you approach that from the timeline of the Augustine Report was put out and they had

their five different options and some of them talked a little bit about maybe it's time for commercial crew options? What made you take that leap of faith in commercial industry?
BOLDEN: I didn't. I didn't take the leap of faith initially, and that is what had me on the outs with some folk in the old Executive office building. I was not a commercial, I use the term 'commercial ideologue.' There were some who believed just give all the money to the commercial sector, you know, give it all to Elon and SpaceX and sit back and watch. In fact, NASA's first budget under President Obama, the one that I had to roll out, had NASA essentially, in human space flight, relegated to trying to develop LOX RP or a LOX kerosene engine to replace the Russian RD-180, so that was going to be NASA's task, and they were going to assign all the other responsibilities for developing human space flight to the commercial sector, and I was not in favor of that at all. So, I was on the outside looking in.

The other thing I was not in favor of was, and this was terminology, this was using the term cancel when we talked about the Constellation Program. I felt that the term the Office of Management and Budget coined and put into the budget, was that we were going to terminate Constellation. Terminate has a very significant contractual meaning and what it brings with it is incredible costs because you've now got to pay contractors a lot of money for stuff they didn't do. You know, you've got to pay them for things they were going to do because you terminated the contract, you didn't convert it, you didn't transition, and my plea with the President and people around him was that instead of terminating Constellation, we come up with a plan to transition from Constellation to another, more efficient, more affordable human deep-space program. That's where we, I think, ended up but it was a long way to get there. We never got away from using the term termination, so we did terminate Constellation and it did in fact end up with NASA having to pay relatively significant costs to companies like Boeing and Lockheed for

terminating the contract, just cutting it off and moving on with something else. Those were some of the early things, it took me a while to get to know people in SpaceX and Orbital, which then became Orbital ATK and is now Northrop Grumman, to get to know some of the upstarts and people coming in and to find ways to trust them and get them to trust us. We put in place a two-year program of evaluating all of the requirements and standards, so engineering requirements, human rating standards, all that kind of stuff, we brought everybody to the table for about a two-year period of time and said 'okay, let's come up with some acceptable standards and requirements for everybody for human space flight. When we finished, we had what we thought were some pretty good rules in place. You know, the issue with NASA standards and NASA regulations was many of them were holdovers from the Apollo days, they addressed systems that no longer existed. They addressed ways of operating that we no longer followed and so we wanted to move into the twenty-first century and the commercial sector helped us to do that.

CLOUSE: This kind of stems off from you saying you were kind of on the outside with commercial and not really an 'ideologue' as you called it. Were the Associate Administrators more onboard with commercial? Where was this commercial aspect within NASA coming from exactly?

BOLDEN: Well the commercial approach was not being pushed within NASA, the commercial approach was being pushed from the outside, by people who were on the Obama transition team, and people mainly on the outside. What they had done is they had brought over some people and put them in place in NASA that I think they intended to take over and run the programs and make them happen. So, NASA took kind of a bum rap in being opposed to commercial spaceflight, you know you said I came to NASA, I came back after an absence because I was at NASA for fourteen years as an astronaut and although I was still an active-duty Marine detailed

to NASA, my heritage was still NASA. I understood the way that we thought, I didn't exactly understand the way that people in the Executive branch in the Executive Office of the White House thought, and that was where I had to come along. I had to move more toward where folk advising the President were, and there were a couple of things where my understanding of what the President wanted to do was a little different from what other people understood the President wanted to do. So there was frequently conflict and tension between my understanding of what the President wanted to do and other people's understanding, and at times it got to the point that I had to remind people that we may have differences of opinion, it really doesn't matter in the long run because I'm the Administrator and you are not. That discussion actually took place sometime, you as a military person can understand, you understand the concept of unity of command. There were no 'co-Administrator's,' I was the Administrator, I was answerable to the President, and so that caused a little tension for the first couple of years, where people would actually come back and say 'but the President wants to do this,' and I said 'no but that's not what the President told me. So we're going to do it this way unless I get direction otherwise.' I actually had a morning coffee with a guy that ran the President's cabinet, the Cabinet Secretary, he invited me over for a cup of coffee and told me he got word that I felt unloved. I said 'well, kind of,' and he asked me 'why? What was the problem?' I said 'well, you know, nobody ever calls me, nobody's ever telling me that I'm screwing up and stuff like that and I don't know. I'm hearing that I'm not doing what the President wants.' He said 'Let me tell you something. If the President was unhappy with what you were doing, you'd know it.' He said 'you keep doing what you're doing, let us take care of everything else, but we call cabinet secretaries and agency heads because we don't like what they're doing, not because they're doing a good job. Unless we call you and tell you to stop, you just keep doing what you're doing.' So that really helped me out,

and then I got some additional help that came in after my second year. Brought in a new Chief of Staff, eventually I got a new Deputy at the end of the first term who was significantly different than the first deputy, and things began to come along pretty well.

CLOUSE: Commercial Crew was never really easy, especially with Congress.

BOLDEN: No, because we didn't…it wasn't easy, Midshipman Clouse, because we didn't approach it the right way, we didn't approach that significant part of NASA's budget as a partnership with Congress, we were going to stuff it down their throats. OMB is notorious for doing that, they will put things in the President's budget knowing they're not going to float because they know Congress is going to come to the rescue and change it, either plus them up or kill them, and the President doesn't have to get accused of doing it. They took money out of Human Space Flight and put them into places like Earth Science in massive amounts and they knew that wasn't going to float. They knew that Congress was going to roundly reject that, and they did, over and over. I thought it was a case of us not working to see if we could develop a partnership between the President and the Congress, to try to find a way to establish some liaison the way we used to do back in the old days, when 'Tip' O'Neill used to go over and sit down with Ronald Reagan and they'd have a whiskey or whatever it was, and Democrats and Republicans went to restaurants on the Hill, they'd fight all day in Congress and go out for dinner together. They don't do that anymore, they don't even talk to each other anymore. A lot of that really got its start during the Obama administration because of the animosity that built up between Congress and the Executive Branch.

CLOUSE: What made it easier going to Congress with Commercial Crew, because obviously the start of the approach, I've read through a lot of the congressional testimony and they're very angry, especially Congresswoman Giffords in particular was a vehement critic of canceling

Constellation and diving into Commercial Crew. What made it easier as time went on to deal with Congress and to get them onboard with Commercial Crew asides from SpaceX finally, in 2011 I believe, having their first successful flight for cargo, what other aspects made it easier to go to Congress and request money for Commercial Crew?

BOLDEN: I think it was persistence on the part of the President and his key people, one was the Secretary of the Treasury, sorry he became the Secretary of the Treasury, the head of OMB, Jack Liu, he and the President's Legislative Affairs Advisor, a young guy who had served in both the Democrats and Republicans in the House and Senate, he was admired and respected and anytime he went over to the Hill and I was able to go with him, people would sit and listen. It took a couple years but over time we built up a sense of trust between the President and the Congress, and once they saw the success of Commercial Cargo, I think they decided that it was okay to take a risk. The other thing was the fact that once we terminated Shuttle, we retired Shuttle in July of 2011, and we had no alternative, I think they started to see 'okay, if we're going to bring human space flight back to the US as an origin point, we've got to come up with an alternative and that right now looks like Commercial Crew.' So, we were able to continually go with them. One of the keys was Bill Gerstenmaier, who was the head of, at the time, we called it 'HEO', it was the Human Exploration Operations Mission Directorate, HEO-MD. It had been OSMD, I think it was Office of Space Flight or something like that. We had actually combined two directorates into one, the one that was looking at exploration programs, the future program like Moon and Mars, and human space flight, like the Space Station and flying with the Russian's. We combined them into one under Bill Gerstenmaier, and Bill was very, very highly respected on the Hill, so it was just his going-in and making commitments to Congress about funding and about execution and stuff like that, and so they trusted him, they trusted the President's

Legislative Affairs Advisor, and over time Jack Liu from OMB began to make adjustments and the like so we were able to gain their confidence enough to get the Authorization Act of 2010, which put SLS, Orion, and deep-space exploration in concrete as a matter of law, and also said we're going to commit to commercial capability to get our crews to space. It put a little bit more money into Aeronautics, shored our support of Earth Science, and the like, so that was the key, that authorization bill.

CLOUSE: Yes sir.

BOLDEN: And that, Midshipman Clouse, that bill came about because Jack Liu, and I am going through old age here and my mind is failing me on the name. Rob, the legislative affairs guy, he was a young black guy, the one that I was saying was highly respected on the Hill. Rob, Jack Liu, and I went over and had a meeting with then-Senator Bill Nelson, and Senator Kay Bailey Hutchinson, who were the Chairman and ranking member of the Senate Authorization Committee, they wrote the Authorization bill and we had Senator Mikulski and the senator from Alabama, who agreed on all this, and then we had members of the House who agreed, and we were able to get the authorization bill and that was followed by the appropriations bill that put some funds toward Commercial Crew; not anywhere close to what we needed or what we asked for, but it was the first tranche of money in 2011, and I want to say it was $500 million.

CLOUSE: That sounds about right sir.

BOLDEN: It may have been $400 or something like that. We had asked for a billion, they gave half, and we said 'okay, that's a start.' We gradually worked up from there, and it was not until 2015 that we actually got the very first full funding for Commercial Crew. By then we were already four years behind, if not more, but then things were okay.

CLOUSE: We haven't mentioned him too much, but your predecessor, Mike Griffin, he started COTS initially, and he testified before Congress a couple of times talking about how it was just 'seed funding' to try and spur commercial interest into space. Specifically, when he discussed the Augustine Report, the initial congressional hearing in 2009 that presented the report to Congress, he even mentioned how a commercial market for space didn't exist and he opposed the usage of NASA funds to support commercial crew development. How did you reconcile the fact that the original creator of a commercial program in NASA initially opposed that evolution of Commercial Crew?

BOLDEN: Well, I was not aware of that to be quite honest. When I came in, I had stepped away from NASA when I left the Astronaut Office and gone back 'whole hog' to the Marine Corps, as you may know. When I retired from the Marine Corps in 2003, I had six years of doing almost nothing except speeches to help NASA, but not really involved in the politics or anything. When I became the NASA Administrator, I kept in my weekly senior staff meetings, I kept asking 'how did we get to the point that we were willing to fund commercial cargo but we didn't put any money down for commercial crew? Somebody help me understand this.' It's really important, if I'm going to be successful here, that I understand what happened. Finally, one of my chief advisors said 'well, you really want to know?' and I said 'sure.' He said 'well, Mike Griffin told us to forget about it, it wasn't going to happen, never going to happen and I'm not putting any money into commercial crew.' I said 'okay, here's a news brief; It is going to happen, we are going to put money down toward it, so let's start thinking that way, let's start thinking positively.' That's when the whole of the agency, with some exceptions, decided 'okay this is the way we should go and we're going to go there.' They started trying to find ways to make it happen.

CLOUSE: What do you think was Congress' biggest reason for backlash against the 'termination' of Constellation and the rise of Commercial Crew, besides just kind of shoving it down their throats, as you said with OMB, what else do you think were their major concerns? From what I can tell, the biggest thing is most of the committee that you have to testify before is obviously from Texas and Florida, and Alabama, that obviously has a big impact. Do you think it was more the structure of industry and loss of workplace jobs in those districts that concerned that committee more or…?

BOLDEN: Without a doubt. Anybody who thinks that is not a major factor just doesn't understand politics, Congress, and business. Another reason that we did not want to terminate the program was because it gave a horrible feeling of finality in the congressional districts. When you say you're going to terminate something, the average man and woman on the street says 'hey my job is going away, what am I going to do?' Whereas we wanted to transition from one program to the next, which meant we're going to keep doing what we're doing right now, try to find a way to smoothly convert from a program that has two vehicles to one that has one. We're going to try to keep the workforce in place as much as we can and help them with job transitions, if they need to learn new skills, we're going to make that part of the process. We looked at it, in what I would consider holistically, and it took a while for members of Congress to understand that we're going to go through some pretty bleak times, as we did at the Cape. In Florida, the aerospace community was devastated, we lost I want to say the day after we landed *Atlantis* after its' last flight in July of 2011, we handed out six thousand pink slips to what was then called the United Space Alliance, USA employees, and they were on the streets. It wasn't that they were waiting for another idea to come up, they were on the streets looking for jobs. My fear was that we were never going to get them back. We knew that they would find jobs and then a bright light

came when Embraer from Brazil decided that they wanted to come into the Florida marketplace and they wanted to use facilities in central Florida to build Embraer airplanes, commercial airplanes. So, they built a big factory there and started building their airplanes and many of the commercial commuter airplanes you fly on today are Embraer airplanes. That was a boom to the aerospace industry in central Florida, and people started flocking to Embraer. For us, that was a godsend because it meant we were going to have our employees go back to work, we were not going to have everyone in breadlines, but still that was a gradual return. Following Embraer, a lot more companies started to migrate to central Florida, you got Collins Aerospace, you got a lot of other companies, and that all helped to begin to build the workforce back up, but when we decided what we were going to do, we still had some work to do to try to find people who would come back to the NASA contractor workforce because they felt 'okay, we don't want them to do that again, we don't want them to pull the rug out from under us another time.' So we had to relearn to the respect of the workforce in central Florida. We didn't have quite the loss of people in Texas, because most of the people in Texas were still focused, still in Mission Control, still running the International Space Station, so they had work. The Shuttle people were out of work, but many of them transitioned over to station, so Texas wasn't hit nearly as hard as Florida was. Florida was a Shuttle workforce. Texas was a workforce mainly focused on the International Space Station and making that successful. Plus, they had transitioned people from Shuttle to Commercial Cargo, the Commercial Cargo headquarters was at the Johnson Space Center initially. We kept it there, but when we brought up Commercial Crew, we said 'okay look, we're going to take the headquarters for Commercial Crew and we're going to put that at the Kennedy Space Center, where the focal point of their work is.' That's the way it is today. Commercial Crew headquarters is at the Kennedy Space Center, Commercial Cargo, which really no longer

exists, it's just a part of the International Space Station program is still resident in Houston. Those were compromises that we made, minor reorganizations that we made in order to bring people along. Congressmen began to see that 'okay, I'm not having these massive layoffs,' and where we did we're beginning to bring people back, and they began to support us again, the way they had done. But again, I cannot overstate the critical importance of the success of Commercial Cargo. That showed people that this process of public-private partnership could in fact, and was in fact working and working very well.

The other thing that helped us, believe it or not, was the loss of three vehicles. You would not think so, but early on in the program, I want to say 2013, Orbital had a launch vehicle explode right off the pad carrying cargo to the International Space Station, lost the mission because the cargo module ended up on the beach, but they were down for more than a year. What saved them was the fact that they had built their cargo module to be able to be flown on a variety of launch vehicles, not just the Antares that was their launch vehicle. So they flew a number of flights with ULA, United Launch Alliance, on the Atlas V and other vehicles. Right after that, SpaceX lost a vehicle, it wasn't on launch but it was as soon as the Dragon capsule separated, it sort of lost control and it went into a useless orbit, so we lost that mission. That was within months. And then we said, well we've still got the Russian Progress, and I think it was a month later, we lost a Russian Progress the same way. So, in boom, boom, boom, one, two, three, we lost our three principle cargo vehicles and that kind of was a downer, but we found that the Japanese with their module and the European's with the European Transfer Module, they were all ready to go. In the interim, we used those two vehicles to get huge supplies to the International Space Station. That helped us to convince Congress of the critical importance of redundancy, of having more than one provider, because they were really pressing us from the

very beginning to go with a single provider for Commercial Crew, and we kept explaining 'you know, if we do it now, you're telling us to put all our eggs in one basket, and that basket is SpaceX, a company that's never done this before. We'd like to have at least one more provider.' And over time, Boeing and their board decided that they would accept the risk, and they knew it was a risk because, just like Mike Griffin had said, there was no demonstrated market for commercial crew at the time. We had proven that there is a robust market for commercial cargo, everybody wants to get stuff to space, not everybody wants to get people to space.

CLOUSE: So you would say that the loss of those three craft, because I remember that I read testimony yesterday where you were talking to Congress, I believe it was in 2010 that this one was, and you made a specific argument that you would prefer two commercial craft over one government craft, with either having a Russian backup. You said something along those lines. What you're trying to say is that the loss of those three craft helped that argument, of like 'hey I need two commercial providers, that's better than me having just the one.' I guess at that time you were arguing more for one to two commercial providers, but that also helped strengthen the argument that the government cannot be the only one developing a craft.

BOLDEN: It did, yeah. There were a number of other things going on also. A subtle thing that probably nobody will cover, and I'm not even sure whether you were going to talk about it. When the President went down to the Kennedy Space Center and gave what I consider a major space policy address, I want to say it was April of 2011 or 2012.

CLOUSE: I think it was 2010. It's April 15th, 2010, it was right before the Review of the Human Space Flight Plan, which happened in like May, I think.

BOLDEN: All these things run together, but the President made a number of, that's why I say it was a major space policy address, he said 'We're going to Mars, we're going to go back to low-

Earth orbit from American soil and we're going to do it with our commercial partners, we're going to use the Orion Crew Module and we're going to make it a Crew Rescue Vehicle.' We all about fainted when he said that, because that is not what we were going to do, and I'm not sure who had written this but speech, or advised him, but that was definitely not what we were going to do. That almost torpedoed Commercial Crew, because the promise that we had made to the commercial sector was that Orion would not compete, we would not have a government vehicle to compete with their commercial crew vehicles. Congress kept pushing us to make Orion capable of going to the International Space Station, and we kept pushing back saying 'we cannot do that, we will not do that, because we do not want to find ourselves competing with the private sector, they'll back out and go away, and we'll be stuck with Orion trying to do that and it's not built for that.' We eventually won that argument, or convinced them that having two commercial providers was much better than trying to have two commercial providers or one commercial provider and a government vehicle doing the same thing. That was not going to work. So, it took us a while to convince them, but we finally got there.

CLOUSE: Part of the end of Constellation and evolving it into now SLS, was it intended when you first came into office, was that kind of what you saw happening? Because when you first proposed the Human Space Flight Plan in 2010, it just said that 'we're going to do a study and have a design of a vehicle by 2015.' It pretty much makes no mention of utilizing components from the Shuttle or from Ares, how did that come into being in less than a year basically, going from 'hey we're going to study something and have it by 2015,' to less than a year later, all of the sudden SLS is authorized entirely and it's reusing legacy components.

BOLDEN: Well, because we went to the drawing board, but we brought up with us years of former studies, what are called Design Reference Missions, DRMs, in your reading you probably

read something about DRMs. We studied, and I'll get this number grossly wrong, but could have studied a hundred DRMs for deep space human space flight. We looked at using the Atlas V, we looked at using the Delta IV, the Delta IV Heavy, we looked at commercial vehicles, we looked at combinations of vehicles, every single mission set we looked at required multiple launches, multiple vehicles to get one crew to orbit. We said that's unacceptable. We cannot, the chances of success with multiple launches required to get one crew into a trans-lunar injection or an injection to Mars, that's unacceptable. Because we know that that risk is too high, we kept looking for a single vehicle that could get us where we wanted to go. It didn't take very long to realize that we were already working on an upgraded Solid Rocket Booster for Shuttle, that was already in the works. We were already looking at an upgraded main engine, not the engine itself, but we were looking at a second-generation main engine controller, that was just going to make Shuttle off the page, not for deep space but for low-Earth orbit. We just wanted to be able to get more cargo to low-Earth orbit, that's why the Advanced Solid Rocket Motor and the upgraded Shuttle Main Engine Controller, those were two things. So, we were already far along in the development of those components, and as we started designing, we said 'you know, if we use the SSME, the RS-25, four of them instead of three, and we use the solid rocket boosters, we do a number of things. We give ourselves the lift capability, we preserve the solid fuel industry in America,' Most people don't think about it, that piece itself was critically important. We were going to, you mentioned you may have looked at my hearings, if you saw one of them where I got dropped on my head, and it was early on, was the question 'did you talk to the Secretary of Defense about what the NASA budget was going to do when you rolled it out in February of 2010, or did you just pull it out of your ass that everybody is going to be happy because you're closing down the solid fuel industry?' Because Shuttle and the Solid Rocket Boosters use more

solid rocket propellant than every other program combined in the US inventory. Essentially what we were going to do was either drive the costs off the page for the Department of Defense, or cause the industry to collapse and they would have no source of… So you talk about any solid propelled motor, a Polaris, or one off an airplane, they were going away because they weren't going to have the SRB or the solid fuel industry to support them. I had not, I had not been involved in the initial talks, I was not involved with the Augustine Commission, I thought that all that stuff had been done. I thought that surely, most certainly when they're talking about terminating a program and closing down Shuttle, most certainly they had done this liaison with other branches of the government; that had not been done. I got, I mean I got hammered for it.

CLOUSE: I think I remember reading that specific question actually, where you got asked that. I think your response was something like you were not going to speak for Secretary Gates and the Congressman just went after you right after that question.

BOLDEN: Well and he was absolutely right. That was a critical decision, and Secretary Gates was a critical player, he should have had a say in what we were about to do. I doubt that Secretary Gates even knew what we were doing.

CLOUSE: So looking back at that, it sounds like the initial plan rolled out in 2010 by the President was that heavy-lift decision in 2015, and pretty much it was not getting forced into a corner or pushed by Congress for a specific plan, it was more that you guys went back through the plans realized within less than a year that we actually have a pretty good idea of what we could do and we can go ahead and move forward?

BOLDEN: Yeah, we did. The other thing that people didn't understand was, because we couldn't talk about it, we were not just looking for a vehicle to carry humans to Mars, we were looking for a heavy-lift vehicle that would be able to help the science community do a lot. Like there was

a mission that was starting to take shape, people were starting to get interested in a mission to Europa, one of the moons of Jupiter. What we needed was a vehicle that could us there far quicker than the Atlas V. The Atlas V, it's a heavy lift vehicle, but it's a twelve-year mission to Jupiter. When we started looking at what turned out to be SLS, SLS could get you to Jupiter in about eight years, four years quicker, because SLS had the lift capability to do direct flight to Jupiter, to distant planets, whereas everything else had to use gravity assist; going around a moon, Earth, other planets. This was a serendipitous discovery as we went along looking at the power and the lift capability, we said 'wow.' But we could not go to the science community, we needed to get them on our side. We could not run the risk of engaging the science community because we felt that as soon as we go in and say 'hey, we've got just the right launch vehicle for the Europa mission, or just the right vehicle for these other missions you want to fly,' because they were going to, their mind was going to go immediately 'ah, those human space flight guys are trying to get us to pay for their vehicle and we are not paying a dime toward the development of a new heavy-lift launch vehicle.' So we did not even waste our time going to them, we let it seep out, the capabilities of SLS. Over time, the science community became a big supporter, but it was only when we said 'look, we're not going to ask you to take money from the science budget to fund a heavy-lift launch vehicle, we're going to take care of that out of the human space flight budget,' and we did.

CLOUSE: So kind of moving back a little bit towards the Augustine Report; the only real conclusion that report had was that the space industry needed more money, that was pretty much the only true conclusion they gave in that report. The extra $3 billion a year was kind of the conclusion they came to, that if you wanted a viable exploration program, Congress needed to build up to $3 billion more a year for NASA in the coming years. But, that didn't happen, that

didn't even come close to happening. Why do you think that it didn't fall out that way? Was it primarily the stock market crash and the way the economy just took a dump, or was it more kind of a change in presidential priorities, did you to the President and be like 'hey, we can do this cheaper with commercial,' and they asked you to execute that? I'm struggling to follow how this report that seemed to be received really well by Congress of 'hey we've been underfunding this, we need to fund it more,' and the very next year they go back to underfunding it again.

BOLDEN: Well I mean, if you remember, we weren't saying Commercial Crew and Cargo were going to allow us to take care of the need for the extra $3 billion dollars. The Augustine Committee said 'if you want to do a commercial crew program, commercial crew and cargo, and a deep-space exploration program, NASA needs to be plused up by $3 billion dollars. They said you need a billion just to bring about the commercial crew business, and that's not in there. You need some more for development of a heavy-lift launch vehicle, that's not in there, but Congress didn't buy it, and neither did the White House or OMB. So again, we had to go back to the drawing board and try to figure out how we were going to convince Congress and OMB to plus NASA's budget up over time. If you look at where they are today, they're in pretty good shape, but that took a change of, that took eight years of the Obama administration and a change in administration actually, to get us to where we are today. But the important point was, the Obama administration made incremental increases in NASA's budget, it did increase gently year by year, but never got the big influx, and I think you're right, part of it was the stock market and the housing market industry collapse, you know the recession of 2008. That was something that no administration ever anticipates, and the Obama administration definitely didn't. They didn't anticipate HCA, the massive healthcare program, and that being the number one priority for the administration, that meant that if there were any money hanging around, that was going to HCA,

so NASA found itself battling with other programs within the administration for funds. It was not until they got comfortable that HCA was pretty well cemented in place, they knew they'd have to continue to fight it in Congress every year, but the major funding had been done and they started turning to NASA and putting some money back in.

CLOUSE: Another part of the Augustine Committee, especially in the testimony, by Admiral Dwyer, the Aerospace Safety Advisory Panel, they talked about how Constellation was a safe program, and that it was a working program, it was just underfunded for the first four years of its existence, but nothing was inherently wrong with the design or the idea of the program. Specifically, the Admiral said that any alternative to Constellation would need to be proven safer, proven better than Constellation itself. With that kind of testimony coming from some of the other perspectives outside of the committee, what still led you to go towards Commercial Crew over Constellation? Was it the reality of 'I know I'm not getting $3 billion more,' and that program is more and I think we can do Commercial Crew with less? What exactly led you down that path of everyone saying it's a safe program that's going well and just needs more money, what led you to just break from it?

BOLDEN: I wouldn't say I broke from it. I always believed what the engineers told me, and one thing was they felt it was unnecessary to have two vehicles. When the Columbia Accident Investigation Board came out, Admiral Damon and that committee said that 'NASA should not launch crew with cargo.' We didn't agree with that conclusion, we vehemently disagreed with that conclusion. My predecessor, Mike Griffin, and even his predecessor, Sean O'Keefe, had both accepted that. Sean O'Keefe was the administrator and he said 'we're going to accept all the recommendations of the Columbia Accident Investigation Board, to include going to a system that has two vehicles as opposed to one.' Mike Griffin didn't fight it, being an engineer himself,

he became the chief designer of the Constellation program. So that was his program, he was personally attached to it. I was not wed to it at all because I knew we were having, contrary to what people said, we had engineering problems with the Ares-I and Orion; there was a problem with harmonics. The vibration in the crew module and the vibration rate, if you will, of the two vehicles was different. We could not get Boeing and Lockheed to come to an agreement that there might be a problem with both vehicles and they may need to think about redesigning each to get to a satisfactory vehicle that wouldn't shake the crew to the point of not being able to function when they got to orbit. That's how bad the vibration was modeled to be. So it was easy for me to go away from Ares-I and Orion to something that was going to be better. So I was never one who believed that we needed two separate vehicles. What the Columbia Accident Investigation Board intended, I think, but didn't state very clearly, was that you should never put a crew on top of the fuel tank the way we did with Shuttle. That was a bad configuration. But they said never put the crew together with cargo and that didn't have anything to do with the accident. It wasn't because we had cargo in the payload bay of the Shuttle, it was because we had a bad design with the external tank and the way we were unable to keep the foam from peeling off the external tank.

CLOUSE: Moving on from Constellation, these are kind of more broad questions. The whole idea of my research project, the whole initial question I had when I was devising the project was 'the gap.' What created the gap between the Shuttle and follow on programs? What do you think is the largest reason for the gap between the Shuttle and follow on programs? Whether it's something super close like Constellation, going all the way back to the start of the Shuttle.

BOLDEN: Failure to fund the program. There was one reason and one reason only that we took until 2020 to fly the first flight, it was because we didn't fund it until 2015. So that's four years

behind the President's request and that's five years behind the President's request. So it shouldn't be surprising that it took us those five years to catch up. That's what put us with the first flight of the Crew Dragon with a crew to where it was. That was funding, period. I mean industry did all they could, particularly SpaceX. SpaceX put a lot of their own money into the Crew Dragon, and in fact Boeing made the commitment to Commercial Crew prior to us getting the funding that we knew we needed for it. And they knew it was going to be risky for them. The aerospace industry had a lot more faith in Congress and the administration than other people did. They felt the money would come.

CLOUSE: This more of a general, my own interest type question; a lot in my generation that are space fans, those that grew up watching all the SpaceX launches primarily the fast few years, a lot of people have come to call the SLS a 'jobs program,' I'm sure you've heard that term before. How do you feel about that characterization as a jobs program and not a space program?

BOLDEN: I'm fine with the characterization as long as you understand that it is an exploration program that provides incredible jobs for talented people around the country. You can't expect that the nation is going to support any national program, any government program, that doesn't put people to work. I doubt very seriously that the federal government, that the American public, would turn to a company like SpaceX, that had relatively few employees when they started out, now as they grow, they're getting more and more employees, they will probably never reach the size of a Boeing or a Lockheed or something like that. Jobs are a critically important part of any program that the government puts in place. Show me a program that doesn't brag about the number of people that it employs or the number of places that it touches. That's a part of a government program, people who don't want the government to provide goods and services, they're okay. I had no qualms whatsoever about people criticizing it because it created jobs,

that's what the administration promised. Every administration promises that they're going to put people to work. Show me an administration that says we're going to get rid of jobs and I'll show you an administration that never materializes, that never gets elected. It's easy for people on the outside to say what the President is going to do or what the President should do, but it's the President who has to make the decision, 'okay am I going to put people out of work? I don't think so.' I'm going to do my best to make sure that I can justify every single job that we're paying for.

CLOUSE: You just touched on it a little bit there with the working with partners and devising a plan and moving forward, one of the things that saved the International Space Station in its early days, and it almost failed in Congress, was working with the Russians and making it an international station and sharing the cost and launching and this that and the other. Did that have an effect when devising SLS and is Artemis after your time, I cannot recall now?

BOLDEN: Yes, Artemis is, I refused to give a name to the heavy-lift launch vehicle and Orion. Everybody kept harping on me to name it and I said 'I'm not naming it, because we have a habit of killing programs after we give them names. So we're just going to continue to call it the Space Launch System and Orion.' I'll let a subsequent administrator come up with a name for it, but I'm not naming it because I'm not giving it a target, putting a target on its back that Congress or the White House or somebody else can come along and shoot at. It was Administrator Bridenstine, who was my successor, the Artemis name came up during his time.

CLOUSE: That was going to be my question, why you didn't name the programs.

BOLDEN: Nope, I wasn't going to, I refused to do it.

CLOUSE: A habit of killing named programs, okay.

BOLDEN: Yeah, I wasn't going to do it. We had enough to battle with other than defending a name.

The remainder of the interview was spent discussing personal topics and recommendations for future contact and other sources of information. These were kept to handwritten notes at the request of Maj Gen (ret.) Bolden and are not scribed here.