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The Lunar Gateway, Moon vs. Mars, and the Political Governance of Space Activities

A debate over whether a return to the Moon was a wise stepping stone to a Mars mission or a distraction from it persistently divided the American space exploration community in the half-century following the 1969 Apollo Moon landing. After the second crash of a Space Shuttle in 2003, President George W. Bush put forth an ambitious Vision for Space Exploration with a "Moon, Mars, and Beyond" strategy to be implemented through a massive program called Constellation, described by NASA Administrator Mike Griffin as "Apollo on steroids."[1] In 2010, less than a decade later, President Barack Obama (Bush's successor) rejected that approach, emphasizing that a return to the Moon was not an advance on past accomplishments. Obama favored a direct mission to Mars. Together, the Bush-Obama pairing illustrated the volatility in the long-term strategy for space that had plagued NASA over the past half-century.

In 2018, again less than a decade later, President Donald J. Trump (Obama's successor) directed NASA to return its attention to the Moon, announcing the Artemis program to land humans on the lunar surface by 2024. A critical element of Artemis was the Lunar Gateway, a proposed space station in lunar orbit. The Gateway would be NASA's next major project supporting human space activity since the completion of the International Space Station (ISS). Moreover, as its name suggested, Gateway marked NASA's return to ambitions for deep-space exploration, using the Moon as a first step to Mars and beyond.

With the 2020 election of Joe Biden to the U.S. Presidency, Trump's Artemis program would surely come under increased scrutiny. Would Biden follow the lead of President Obama, for whom he had served as Vice President, and scutter the Moon-to-Mars plan of his predecessor? Or was the Gateway a project around which consensus would gather, uniting the space sector's diverse actors?

President Bush's *Constellation* program and a focus on Moon-to-Mars

Bush's program took a phased approach to reaching Mars, NASA's long-time "horizon goal." First, NASA would ground the shuttle by 2011 and complete the ISS by 2016, freeing up resources for other efforts. It would then return humans to the lunar surface by 2020, all in preparation for robotic precursor missions to Mars in the mid-to-late 2020s.

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In 2005, NASA proposed the ambitious Constellation Program (CxP) to fulfill the President's vision; specifically, to provide near-term access to the ISS and build long-term capabilities to access the Moon and Mars. Constellation included the development of four new pieces of hardware: a rocket to replace the shuttle (Ares I), a crew vehicle (Orion), a heavy-lift rocket to transport cargo and crew to the Moon and deep space (Ares V), and a Moon lander (Altair) (see **Exhibit 1** for illustrations of these vehicles).

Adopting a "pay-as-you-go" strategy, President Bush explained that the overall budget required for CxP would be significant but distributed, "I will call upon Congress to increase NASA's budget by roughly a billion dollars, spread out over the next five years…it's only a beginning. Future funding decisions will be guided by the progress we make in achieving our goals."[2] In FY 2005, NASA's budget request was $16.2 billion, a 5.2% increase over 2004.[3] (See **Exhibit 2** for the proposed FY 2005 budget).

Congress was skeptical of the program at first, as NASA had long faced criticism for its inability to meet cost, schedule, and performance goals. One study examining NASA missions from 1992 to 2007 found average cost growth during that time period was 26.9%, while schedules generally slipped by 21.5%.[4] Particularly salient to Congress was its experience with NASA's most recent large-scale, multi-year exploration project: the ISS. Congress warned that the "poor management and lack of independent oversight" of the ISS, "which resulted in major cost overruns," did not bode well for NASA's ability to manage a program like CxP.[5]

NASA's Office of the Inspector General (OIG) issued a report in 2012 that identified a number of internal factors behind the agency's apparent performance problems. Technical complexity of NASA projects made it difficult to meet cost and schedule goals, and the OIG recommended that "projects shouldn't proceed to implementation unless requirements are well-defined and stable and the available resources – mature technologies, schedule and funding – are set." Another issue identified by the report – deemed "Hubble Psychology" – was a belief at the agency that projects that failed to meet cost and schedule goals would still receive additional funding, relying on the fact that "scientific and technological success would overshadow any budgetary and schedule problems."[6] This phenomenon was named for the Hubble Space Telescope, which was over $3 billion more expensive and launched seven years later than initial projections. Once in orbit and functioning successfully, however, Hubble's achievements and unprecedented imagery eclipsed those setbacks.

NASA's defenders, on the other hand, blamed Congressional miserliness for the agency's failings. To them, the key problem was that insufficient and unreliable funding forced NASA to proceed inefficiently with its projects, delaying and increasing the eventual cost of achieving its objectives. All NASA could do in response was try to secure enough funding to keep its programs alive: a form of "incremental politics" that left the agency unable to repeat the successes of the Apollo era, when funding had been generous and sustained.[7]

Congress agreed to fund the CxP program – though at less than requested – and called for an independent oversight committee to monitor the design, technology readiness, and cost estimates.[8] Congress allocated $15.1 billion to the agency overall, with the exploration budget receiving almost $150 million less than requested. In the accompanying report the committee indicated it was "supportive of President Bush's proposal for space exploration, while continuing to give priority to NASA's science and aeronautics programs."[9]

Some argued that the funding provided by Congress and the President was inefficiently small. An article by astronomer Jeffrey Bell in *Space Daily* argued that under Bush's "go-as-you-pay" funding, "we restrict our ambitions to the level of funding that is actually available. If money runs short, we stretch out the program into later fiscal years and trade-off lower cost/year for more time to project completion." Bell went on to write that "NASA [was] being expected to carry out John Kennedy's space

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program with Bill Clinton's space budget."[10] NASA Administrator Sean O'Keefe bluntly acknowledged that—if the funding levels were insufficient—NASA would allow schedules to slip rather than attempt to secure an increased budget.[11]

FY 2007—when NASA returned to Congress to advocate for increased funding for CxP—was a critical year for the program. Despite two years of work, NASA had not made significant progress in achieving key milestones for Orion and Ares (see **Exhibit 3** for the Constellation Program budget profile). Administrator Griffin believed the agency did not have enough resources to service all the programs with which it was tasked. Congressional concern that NASA was becoming a "single mission agency" (favoring exploration) only grew after an internal briefing chart (see **Exhibit 4**) laid out the NASA programs that would face cutbacks in order to sustain ambitious exploration objectives in the coming years. Without clear results from CxP, Congress wasn't ready to commit greater resources to the program, resulting in $577 million less for NASA exploration systems in FY 2007. According to Administrator Griffin, that decision "jeopardized [NASA's] ability to manage an effective transition from the shuttle to Orion."[12]

As anticipated, the 2007 funding cut only compounded existing issues: cost overruns associated with the development of the Ares vehicle averaged 25%, with an average of one-to-three-year schedule delays. From 2010 to 2014, NASA projected CxP would cost $28.7 billion, representing a cost increase of 140% over the program's first five years. Doug Cooke, former head of NASA's exploration division, when reflecting on the issues with the program remarked, "I don't know who to blame, but all I know is that our budgets weren't there."[13] In a 'Lessons Learned from Constellation' report issued by NASA, report authors noted, "few technical issues arose that could not be solved in relatively short order; rather, the most difficult and most persistent challenges involved cost, schedule, and organization." [14]

President Obama, the end of *Constellation*, and the rise of direct-to-Mars

When President Obama came to office in 2009, he initiated the "Review of United States Human Space Flight Plans Committee," also known as the *Augustine Commission,* to assess the feasibility of achieving the objectives set out by the previous administration. The results were discouraging. Citing a lack of clarity regarding specific milestones as well as a mismatch between the required and allocated resources, the report expressed little confidence that any aspect of the CxP – from the replacement for the shuttle by 2012 to the proposed 2020 Moon landing – would be ready within the next two decades. In 2011, Obama issued a moratorium on the program, zeroing out *Constellation* in NASA's budget request.[15]

Congress was not receptive to Obama's decision. It saw a replacement for the shuttle as a top priority in terms of national security and prestige. Congressman Pete Olson commented that the new policy was, "a crippling blow to America's human spaceflight program. It has taken over 50 years to build and develop America's ascension to its rightful place as the dominant player in human spaceflight. That dominance is apparently no longer desired."[16]

NASA opposed Obama's decision, as well. CxP had become a large-scale program spanning multiple NASA centers and contractors, and cancellation meant that years of work would be lost. Doug Cooke, NASA's Associate Administrator for Space Exploration, said of the decision, "it is difficult for those of us who have worked on it for a number of years and made sacrifices in order to make it successful." Eager to make use of the work (and contracts) that had been underway for years, he noted NASA's intention to "look at everything that's been developed, both in terms of studies and designs and hardware, to see where it might be used in the future."[17]

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Even the NASA Administrator at the time, Charlie Bolden, was reticent to support the cancellation of Constellation. Before President Obama's announcement, he advised the White House to facilitate a "transition" of the program, rather than a full cancellation. He later reflected that "politics played a major role [in the cancellation]." Bolden believed the White House "chose their words very carefully to make it look like NASA had done an abysmal job in constructing the program and managing it."[18]

After cancelling CxP, President Obama announced his own, sharply different vision for NASA at the John F. Kennedy Space Center in Florida. He directed NASA to invest in private spaceflight contracts to secure near-term access to the ISS, an idea with roots in the Commercial Orbital Transportation Services (COTS) begun under Bush in 2005. A move toward a commercial replacement for the shuttle would free up in-house resources for developing a new heavy-lift vehicle to be used for deep-space missions. In particular, rather than return to the Moon—about which Obama noted "we've been there before"—Mars was chosen as the 2030 destination. A newly proposed "Asteroid Redirect Mission" provided an intermediary destination in 2020, with the objectives to collect a boulder, ferry it to a proving ground, and have astronauts investigate the site. Senator Nelson explained, "the plan combines the science of mining an asteroid, along with developing ways to deflect one, along with providing a place to develop ways we can go to Mars."[19]

Obama thereby took a stand on a long-standing debate within the space community: direct-to-Mars vs. Moon-to-Mars.

That debate was not about whether Mars was the eventual goal, as both sides agreed that its scientific and exploration potential was vastly greater than the Moon's. From a scientific perspective, Mars's carbon dioxide atmosphere and possible subsurface water gave astrobiologists hope of identifying signs of either past life or microbial life on the surface. In contrast, while the Moon would provide a valuable astronomical outpost, it was thought to have been formed after splitting from Earth, reducing its appeal to planetary scientists and biologists. For exploration, while Mars would present major challenges for life-support, it offered a more welcoming environment for crewed missions than the Moon, whose largely desolate surface was covered with a thin layer of jagged, fine rocks and no atmosphere. Furthermore, a Martian day would be similar to the Earth's, while a lunar day would be 28 Earth days. Temperature fluctuations on Mars would also be relatively moderate when compared with the lunar surface, where the temperature difference between the lunar night and day would be almost 300 degrees Celsius. Space enthusiasts who saw exploration leading to settlement and the establishment of a space-based economy thus focused their sights on Mars rather than the Moon, as well.

Debate over the path to Mars continued, however, because some argued that the Moon was invaluable as a waystation and proving ground on the way to Mars. Only a three-day journey, as opposed to the six-month Martian mission, a lunar mission was significantly less resource-intensive and allowed for experimentation at lower risk. Due to the orbital alignment, Mars missions would only be possible every two years, whereas lunar missions could occur at any point, and the communication delay between Earth and Mars would be anywhere from 3-24 minutes, posing serious threats to future astronauts in liaising with mission control.[20] A lunar mission scenario was also internationally more appealing: the European Space Agency, China, and Russia had all expressed interest in Moon landings.

On the other side of the debate were those who argued that the Moon was a distraction. Robert Zubrin, director of the Mars Society and advocate for a "Mars Direct" mission architecture, warned that a sustainable lunar base or orbiting station could threaten future Mars missions, creating yet another cost sink for NASA. In his view, a direct Mars launch would be more efficient as opposed to building orbital platforms – either in Earth or lunar orbit – with the ultimate goal of reaching Mars .[21]

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Once on Mars, methane/oxygen propellant could be mined from the surface, supporting surface operations.

In a 2011 opinion piece published in the Wall Street Journal, Zubrin made the case that a direct-to-Mars mission would be possible due to the advances made by SpaceX in developing the Falcon Heavy launch vehicle. He outlined a mission architecture consisting of three launches: one to deliver an uncrewed rocket stage to Mars orbit (to serve as fuel for an Earth-return mission); a second launch for the ascent vehicle, power systems, and reactor to break down carbon dioxide in the atmosphere into oxygen; and a third crewed mission that would be equipped with enough supplies for two astronauts to undertake exploration for 18 months.[22] In his view, if the technology existed to reach and operate on Mars, then that should be the priority for NASA, rather than pursuing complex and costly waypoint architectures.

The NASA Space Authorization Act of 2010, passed on October 11, 2010, reflected a compromise between the Obama administration and its skeptics in Congress and NASA. In particular, it supported continuing commercialization of Low-Earth Orbit and reaffirmed Obama's Asteroid Redirect Mission ARM), but it also endorsed the new shuttle-derived Space Launch System (SLS) to replace Ares I and Ares V and the continued development of a multi-purpose crew vehicle based on the Orion capsule.

The Authorization Act directed NASA to utilize existing workers and assets (mostly holdovers from CxP) in developing the new hardware. Jeff Bingham, a Senate staffer, noted that this was crucial in the face of "pressure [from] the current workforce, and horror stories about people's life savings being sucked up because they no longer have a job, and no prospects of getting one because you're basically doing away with an industry." [23] (See **Exhibit 5** for a diagram of the distribution of work assignments for the Constellation Program across NASA centers). Design constraints for the new SLS were almost identical to the Ares V. The "new" crew vehicle repurposed much of the Orion Crew Vehicle, a decision which the White House noted, "saved critical high-tech contract jobs in Colorado, Texas, and Florida."[24]

In sum, the non-commercial elements of the program which emerged from the Authorization Act largely resembled CxP, albeit under a different name and with different exploration destinations and timelines. Later, Lori Garver would express her frustration that the mission architecture would continue to prioritize the Space Launch System, a "holdover from Constellation, which the Obama administration tried to cancel."[25]

Not surprisingly, this revised space strategy became bogged down with many of the same challenges as had CxP. The Act had set an initial operational date for the SLS of December 31, 2016, but in 2014 that date slipped to November 2018, and it would keep slipping. By December 2019, the agency had spent $14.8 billion developing the initial capability for SLS-1, with costs projected to grow to more than $17 billion – a 60% increase from the Agency's original $10.2 billion projection in 2014. Critics blamed the 2010 Act for including guidance that became "notorious for…dictating design elements right down to payload capabilities."[26]

Meanwhile, the ARM failed to garner support in Congress and was never funded. Congressional Representative Frank Wolf summarized a National Research Council committee report which found "there was no support within NASA or from our international partners for the administration's proposed asteroid mission."[27]

One aspect of the ARM, however, was supported by those who advocated for the Moon as a proving ground: the development of a habitation facility powered by Solar Electric Propulsion (SEP) capable of sustaining and transporting astronauts on long-duration missions in deep space. Oklahoma House

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member Jim Bridenstine pressed NASA to accelerate the habitat program, claiming "deep space habitats are vital to developing the space economy…We now know that water is abundant on the Moon and throughout the solar system. Correspondingly, propellent is available. Once these resources are exploited and stored on orbit the cost of the space enterprise will decrease immensely."[28]

A prominent aspect of the Obama space policy was its continued encouragement of the commercial space sector, the rapid rise of which had surprised nearly everyone in the space community. In the negotiations to cancel Constellation, the Obama administration hoped to free up resources to continue the COTS program's progress toward commercial resupply of cargo and crew to the ISS through contracts with companies such as SpaceX and Orbital ATK.[29] In the Act, support for commercial activity and the more conventional aspects of the program came bundled together.

The push for commercial activity was controversial, as awarding contracts to companies that hadn't yet reached orbit was seen by some as an unwise gamble. In a joint statement made by astronauts Neil Armstrong, Gene Cernan, and Jim Lovell, the trio called Obama's program into question stating, "the availability of a commercial transport to orbit as envisioned by the President's proposal cannot be predicted with any certainty, but is likely to take substantially longer and be more expensive that we would hope."[30]

Nevertheless, despite significant opposition, COTS retained support and continued to drive progress. The Commercial Resupply Services (CRS) contracts, first signed in 2008, awarded $1.6 billion to SpaceX for twelve cargo Dragon and $1.9 billion to Orbital Sciences for eight Cygnus flights to provide resupply missions to the ISS. The first operational resupply mission was flown by SpaceX in 2012.[31] NASA began investing in the development of private crewed flight capabilities in 2010 with the Commercial Crew Development (CCDev) contracts.[32] Emerging from the development and integration phases successfully, Boeing and SpaceX were chosen to fly astronauts to the ISS in 2014, with hopes of an initial flight as early as 2015. (After significant launch delays, SpaceX successfully launched two astronauts to the ISS in June of 2020, marking the first launch from American soil of astronauts in 11 years.[33])

Casey Dreier, director of space policy at the nonprofit Planetary Society, would later say that the legacy of President Obama's administration was, "fully embracing the potential of commercial launch capabilities…and fighting for it against a lot of opposition from Congress."[34]

President Trump, the Lunar Gateway, and the *Artemis* Program

When President Trump came to office in 2017, he moved quickly to shift the country's space strategy. His NASA transition team continued to embrace the long-standing Mars horizon goal, but it called for a return to President Bush's Moon-to-Mars program, and Trump immediately terminated the ARM. A key figure in that transition was Robert Lightfoot, NASA's Acting Administrator while Representative Jim Bridenstine, Trump's nominee for the position, awaited confirmation. With an unusually long tenure, Lightfoot used his year-long stint to push for a new interim (i.e., pre-Mars) objective for the SLS: a new space station in cislunar orbit called the Lunar Gateway.

The Lunar Gateway

Building on the successful model of securing international partners for building the ISS, Lightfoot aimed to amass commitment from other nations for the Gateway. As a counterbalance to President Trump's "America First" rhetoric, Lightfoot maintained a narrative abroad that "America First" did not mean "America alone", and the Gateway would be a clear way to continue important multilateral

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relationships.[35] By late September of 2018, Russia announced its commitment to build the space station with America in lunar orbit.[36] Canada and Japan would soon voice their support as well.

Working through the Multilateral Coordination Board, which was responsible for the management of the ISS, these countries identified five essential objectives of the new Lunar Gateway[37]:

1. Support human and robotic access to the lunar surface to build experience needed to address challenges associated with human missions to Mars.
2. Serve as a platform for important scientific discovery in a deep space environment and on the lunar surface.
3. Use the unique orbit of the platform to provide visibility of both Earth and the Moon's surface, helping with communications relay purposes.
4. Stimulate the development of advanced technologies, expanding the emerging space economy, and leveraging societal benefits of space exploration for citizens on Earth.
5. Enabling other international and commercial entities to participate in human exploration and research and technology development.

NASA expected to spend $3.8 billion on the construction of Gateway between FY 2015 and 2025.[38] It anticipated using SLS boosters launched once every two years to deliver four modules to build the station in lunar orbit. In contrast, the decade over which the ISS was built required 30 missions and cost $150 billion.[39] NASA would also rely on partnerships with international collaborators from the ISS to join in developing key modules (see **Exhibit 7** for the various proposed modules of the Lunar Gateway). The International Habitat Module was to be built in partnership with the European and Japanese Space Agencies, with the European Space Agency additionally providing the 'Esprit' component for communications and refueling.[40] The Canadian Space Agency was to provide another robotic arm for the Gateway, with the Russians providing an Airlock module. Russian involvement in the Gateway, however, was uncertain. Dmitry Rogozin, director general of the Russian Space Agency, Roscosmos, remarked at a space conference in 2020 that "the lunar Gateway in its current form is too U.S.-centric, so to speak [and] Russia is likely to refrain from participating in it on a large scale."[41] Rogozin had also indicated the Russians would be exiting the ISS by 2025, with plans to launch its own station in low-Earth orbit that same year.[42] The announcement of a partnership between the Russian and Chinese to co-develop a base on lunar surface only further complicated matters.[43]

The Artemis Program

The Lunar Gateway would soon be folded into a broader program called *Artemis*. Artemis would be a critical component of NASA's new "Three Domain" (low-Earth Orbit, Moon, and Mars) Exploration Strategy, which aimed to transition the ISS to commercial operations and free up resources for a crewed return to the Moon. Once on the lunar surface, the goal would be to establish a sustainable presence (deemed the Artemis Base Camp) to prepare for future Mars missions. The surface infrastructure for the Artemis Base Camp would be comprised of a Lunar Terrain Vehicle (LTV), a Habitable Mobility Platform (HMP), and a Foundation Surface Habitat (FSH). The choice of architecture was critical to simulate operational requirements for human missions to Mars.[44] Alex MacDonald, Chief Economist of NASA, would call this approach the "minimum viable presence", aiming to "establish a presence that [could] be sustained budgetarily, under multiple out-year scenarios, with a target of at least one short-stay mission a year" (see **Exhibit 6** for the Artemis plan).[45]

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In launching Artemis, President Trump announced that NASA would be responsible for landing the "next man and first woman" on the lunar surface by 2028.[46]

NASA projected that *Artemis* would cost $35 billion. The FY 2021 budget proposal requested a $2.5 billion increase to NASA's budget, bringing the total request to $25.2 billion. Deemed "one of [the] strongest budgets in NASA history", Jim Bridenstine pointed to the budget proposal as a clear sign of the president's support for NASA. Gateway's proposed funding, as a part of Artemis, was $793.3 million.[47]

Hardware already under development, such as the SLS and the Orion crewed vehicle, would be a critical part of the proposed mission architecture, but NASA also prioritized commercial participation in Artemis through public-private partnerships. In April 2020, NASA awarded nearly $1 billion in contracts to three commercial companies—Blue Origin, Dynetics, and SpaceX—to develop human landing systems solutions that would utilize Gateway to reach the lunar surface. In addition, NASA began awarding Commercial Lunar Payload Services (CLPS) contracts—with a value of up to $2.6 billion—to 14 companies to provide crew and cardo landing services for early missions.[48]

The emphasis on commercial participation extended to Gateway itself. In 2020, NASA announced the Gateway Logistics Services (GLS) contract, selecting SpaceX as the first U.S. commercial provider to deliver cargo, experiments, and other supplies to the Gateway. As fixed-price contracts, NASA guaranteed two missions per logistics services provider with a maximum total value of $7 billion across all contracts depending on need.[49] Similar to the Cargo Resupply Services missions to the ISS, NASA planned for multiple supply missions to the Gateway, offering a clear way to partner with the commercial launch industry.

While these contracts were welcomed by NASA and the commercial space industry, Congress was less thrilled by the prospect to outsource lander development to industry. Chairwoman of the House Science, Space and Technology Committee Eddie Bernice Johnson issued a statement regarding the contract awards,

> "I am troubled that NASA has decided to ignore congressional intent and instead press forward with Human Landing System awards to try to meet an arbitrary 2024 lunar landing deadline…the multi-year delays and difficulties experienced by the companies of NASA's taxpayer-funded Commercial Crew program - a program with the far less ambitious goal of just getting NASA astronauts back to low Earth orbit—make clear to me that we should not be trying to privatize America's Moon-Mars program, especially when at the end of the day American taxpayers—not the private companies—are going to wind up paying the lion's share of the costs. I want our Nation to pursue the inspiring goals of returning to the Moon and then heading to Mars, but we need to do it sensibly and safely while we also protect the interests of the tax paying public."[50]

The House budget appropriation reflected these concerns. The House Appropriations Committee funding bill for FY 2021 included just $22.63 billion in allocations for NASA, $3 billion less than the proposed amount. The HLS program received the biggest cuts. While the president's budget requested $3.4 billion for the program, the House Appropriations Committee allocated just $1.56 billion.[51]

In 2021, SpaceX was chosen as the sole awardee of the HLS contract, beating out Dynetics and Blue Origin for its lander proposal featuring Starship, a new fully-reusable super heavy-lift launch vehicle still under development.[52] Although NASA intended to select two providers, in hopes of fostering competition, the agency was restricted due to the budget allocated by Congress. According to Kathy Lueders, NASA's Director of Human Spaceflight, none of the three proposals were within the HLS

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budget, leading NASA to choose SpaceX, which was," both very highly rated from a technical and management perspective and that also had, by a wide margin, the lowest initially-proposed price."[53]

Gateway as the safe bet?

More affordable than landing on the lunar surface, not reliant on commercial service providers, and potentially useful for future Mars exploration ambitions, the Gateway seemed to be the most secure aspect of the Artemis architecture, at least in the eyes of Congress.[54]

Yet, the proposed station was subject to significant criticism from elsewhere. Some feared that the Gateway would simply move NASA from low-Earth orbit to lunar orbit, without going much further. Robert Zubrin argued that NASA was "building the lunar orbit Gateway because we don't have a heavy Mars lander"[55] and that Gateway represented a larger problem within the agency:

> "The real problem with the lunar-orbit Gateway isn't that it's useless or it will cost lots of money, or that it will continue to cost lots of money for decades, taking money away from things we really want to do. The real problem is the form of thinking it represents. That instead of money to do things, we need to do things to spend money."[56]

Other skeptics argued that the development of a Lunar Gateway was premature. Former NASA Administrator Michael Griffin bluntly called the proposed plan to build Gateway before a surface mission "stupid". He went on to say that the Gateway would be "useful when, but not before, they're manufacturing [rocket] propellant on the Moon and shipping it up to a depot in lunar orbit."[57]

NASA Administrator Jim Bridenstine countered this point, arguing that an architecture like Gateway would be crucial to achieve NASA's ultimate goal of reaching Mars. He stated in 2019, "we are not building the International Space Station around the Moon… we do not want to get bogged down, with all of our resources going to the Moon."[58] Unlike the ISS, the Gateway would be a pared down, narrowly scoped space station. For longer-duration missions, the Gateway could serve as an important waypoint for refueling. For missions to the Moon, landers could dock for access to the lunar surface, while spacecraft embarking to destinations beyond the Moon could utilize the Gateway as a critical port, refueling after the fuel-intensive escape from low-Earth orbit.

Still, whether the station should have been chosen as NASA's "next step" was a larger question. As former NASA Administrator Sean O'Keefe said of the Gateway, "it's not a goal and ambition in and of itself. It's another means to an end. It's just the next big step, and it's a good one."[59]

Minimum Viable Gateway

As NASA was beginning to gear up for a 2028 Moon landing, the Trump Administration announced a new directive: the Artemis mission would be advanced by four years to 2024. To accommodate the accelerated timeline, NASA would launch just two of the proposed five modules: the Power and Propulsion Element (PPE) and the Habitation and Logistics Outpost Project (HALO). NASA Deputy Administrator Bill Gerstenmaier said of the decision to initially scale back Gateway, "Gateway was focused towards a little bit of a larger capability, more than we need just for the landing. This focused Gateway back to just the initial components that are needed to land on the Moon."[60]

The proposed reduction in scale came in the face of continued proposals to cancel the station altogether. Canceling Gateway posed its own issues: the Orion Crew Vehicle and lunar landers were designed to rely on the Gateway for landing on the lunar surface, much like the Apollo program utilized the Command and Service Module (CSM), which remained in orbit, in conjunction with the

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Apollo Lunar Module (ALM), which landed on the surface. With Gateway orbiting in a near-rectilinear halo orbit, Orion could ferry astronauts from the SLS to the human landing system. Changing the propulsion system of Orion to enable it to reach a lower lunar orbit without the aid of Gateway was proposed to add billions of dollars in development and threaten the 2024 landing date.[61] Faced with this choice, the decision was solidified to move forward with Gateway, albeit in a scaled back formulation.

In addition to scaling down Gateway to initially include only the PPE and HALO, NASA had to accelerate the acquisition and development of the modules to meet the 2024 deadline while staying within the allocated budget (see **Exhibit 8** for details). In a report released in November 2020, the NASA OIG examined the impact of the evolving Gateway design requirements and shifting timelines on the development schedule for the PPE and HALO modules. In particular, the report scrutinized NASA's acquisition strategy and utilization of contracts that were particularly ill-suited to a program that was continuing to change. First selected in May 2019, NASA awarded Maxar Technologies a fixed-price contract to develop the PPE module. The selection of a fixed-price contract – generally utilized when requirements and specifications were firm – represented, according to space policy expert Marcia Smith, a signal of "NASA transitioning to a commercial procurement strategy for its human exploration program."[62]

Firm-fixed-price contracts had been remarkably successful in the case of the Commercial Crew and Commercial Cargo contracts utilized to support resupply missions to the International Space Station. The NASA OIG, however, was concerned that the acquisition method was not as well-suited to a program such as the Gateway, where timelines and requirements were still shifting. With the new accelerated timeline and other changes in the mission architecture – including a decision to co-manifest the PPE and HALO in a single launch as opposed to two separate missions in an attempt to save costs – the contract value for the PPE had already increased by $78.5 million by 2020, four years ahead of the anticipated launch date.[63]

For the HALO module, NASA did not put the contract out for competition, and instead awarded Northrup Grumman a sole-source fixed-price contract based on its previous work for the agency developing a habitation module. Final contract costs were not agreed beyond a 7-month design phase. The OIG concluded that these decisions to "move forward with developments before requirements [were] firm [and changing] key mission parameters…even after the contracts were awarded" was unwise, and would likely lead to additional cost increases and schedule delays in the future. By 2020, the two initial modules already comprised 40% of the overall Gateway budget (see **Exhibit 9** for the Lunar Gateway proposed budget), and the report questioned whether it would be operational for the 2024 launch date.[64]

President Biden's turn

In late 2020, as the Biden Administration planned its space policy, it would have to decide whether to retain, modify, or cancel the Trump Administration's *Artemis* plan. Artemis remained a program in name only, and it risked facing the same fate as had Constellation and the Asteroid Return Mission when a new administration took power. The choice of achieving a 2024 landing, which many feared was unreasonable, was seen as particularly vulnerable.[65] It was also possible that holdovers from Constellation, which became part of the Artemis program mission architecture, could come to an end. Charlie Bolden, a long-time proponent of the SLS who had often been skeptical of NASA's increasing reliance on commercial providers, would predict in September 2020 that, "SLS will go away…It could go away during a Biden administration or a next Trump administration… because at some point

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commercial entities are going to catch up. They are really going to build a heavy lift launch vehicle sort of like SLS that they will be able to fly for a much cheaper price than NASA can do SLS. That's just the way it works."[66]

Although Artemis' future remained uncertain, NASA had successfully established a broad base of support for the program over the last four years, generating interest and commitments from international partners as well as the private space industry. In October 2021, seven countries (Australia, Canada, Italy, Japan, Luxembourg, United Arab Emirates, and the United Kingdom) joined the U.S. in signing the Artemis Accords, a set of principles to guide space exploration cooperation among nations participating in the Artemis program, solidifying international support for a Moon return mission.[67] According to NASA Administrator Bridenstine, "Artemis [would] be the broadest and most diverse international human space exploration program in history."[68] Commercial players also became an integral part of the Artemis program. Many of the companies jumpstarted by the CLPS programs under the Obama Administration would become potential service providers for Artemis through GLS, HLS, and CLPS (see **Exhibit 9** for a summary of the contracts awarded for the Artemis Program). Artemis could serve as an opportunity to further mature the industry in the near-term.

Would President Biden see the cost of Artemis as justified, or would he usher in another sharp turn in space strategy, as had his two predecessors?

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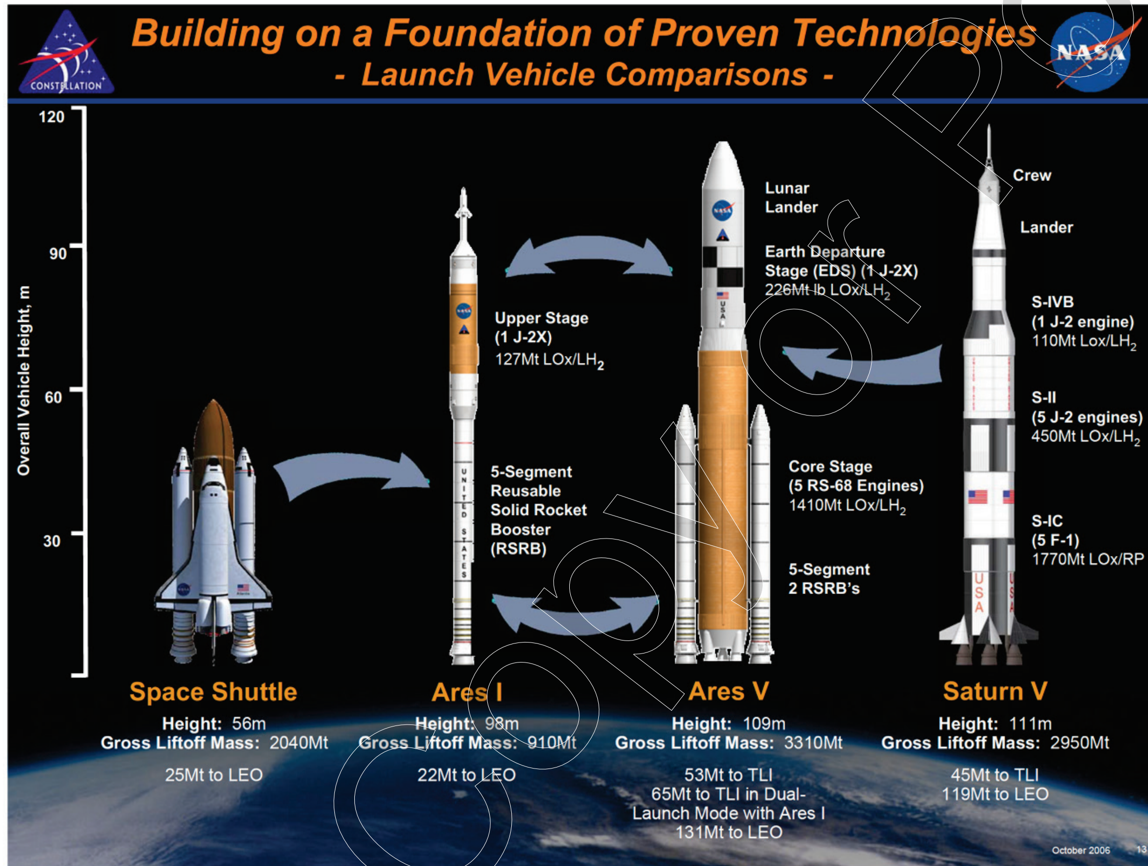
Exhibit 1 Comparison of Launch Vehicles Designed by NASA



Source: https://www.nasa.gov/pdf/163092main_constellation_program_overview.pdf

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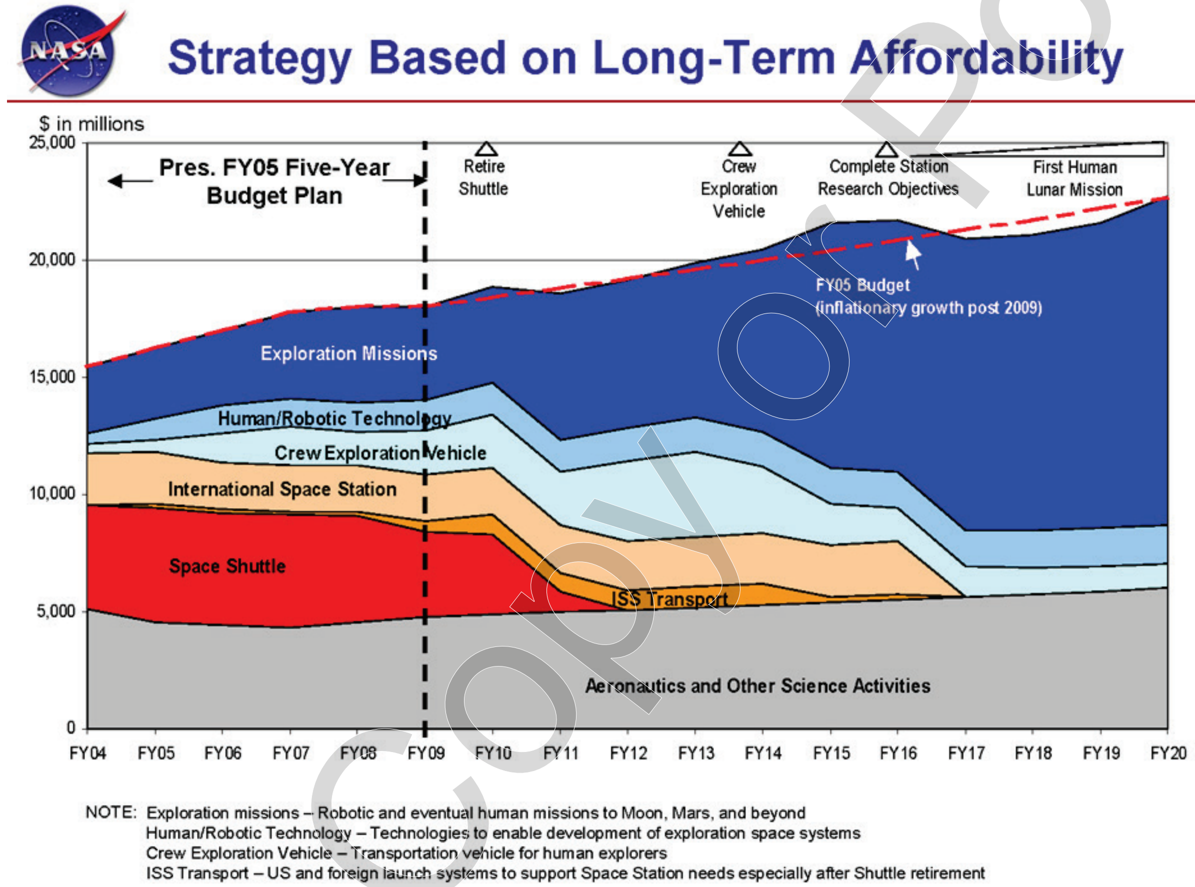
Exhibit 2 Constellation Program Budget Estimates



Source: NASA. "Budget Trends for Exploration Vision," January 14, 2004. https://www.nasa.gov/pdf/54873main_budget_chart_14jan04.pdf.

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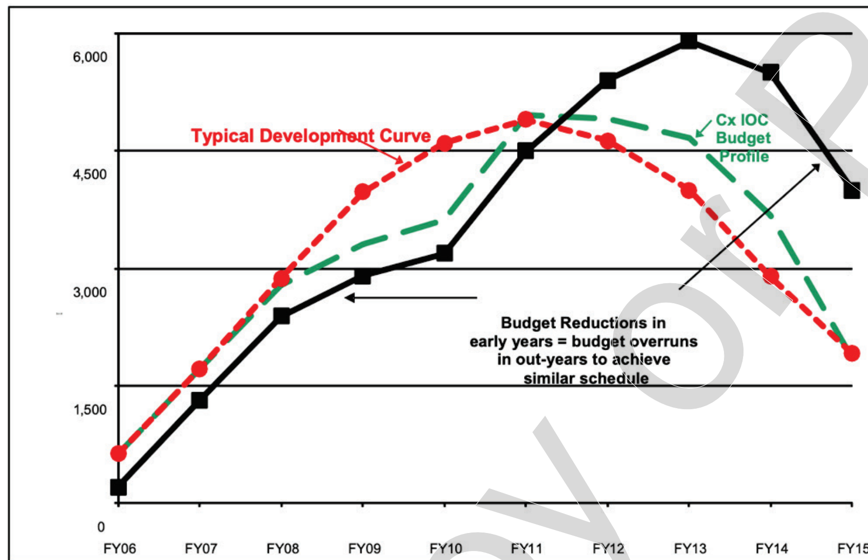
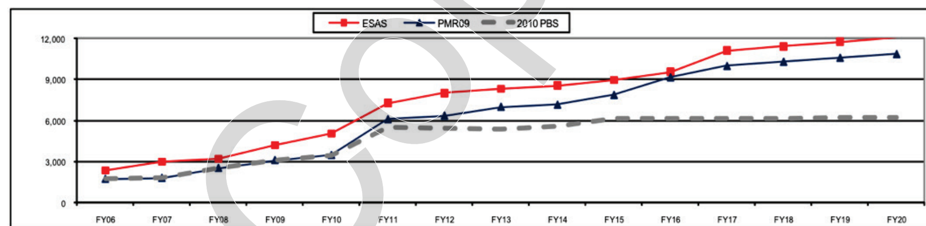
Exhibit 3 Constellation Budget Profiles Before and After Budget Reductions





RY$ In M	FY06	FY07	FY08	FY09	FY10	FY11	FY12	FY13	FY14	FY15	FY16	FY17	FY18	FY19	FY20	Total
ESAS	2,333	2,976	3,195	4,202	5,034	7,273	7,994	8,324	8,558	8,948	9,547	11,107	11,422	11,744	12,073	114730
PMR09	1707	1779	2514	3085	3454	6085	6346	6991	7145	7856	9145	9983	10294	10582	10854	97820
2010 PBS	1707	1779	2514	3085	3454	5524	5444	5376	5570	6153	6161	6170	6178	6186	6195	71496
PMR09 vs. ESAS Delta	(626)	(1197)	(681)	(1117)	(1580)	(1188)	(1648)	(1333)	(1413)	(1092)	(402)	(1124)	(1128)	(1162)	(1219)	(16910)
Passback vs. ESAS Delta	(626)	(1197)	(681)	(1117)	(1580)	(1749)	(2550)	(2948)	(2988)	(2795)	(3386)	(4937)	(5244)	(5558)	(5878)	(43234)

Fig. 1: Constellation budget profiles before and after budget reductions (ESAS=the initial program budget baseline; PMR=Program Manager's Recommendation; PBS=President's Budget Submittal)

Source: "Constellation Program Lessons Learned." NASA, Spring 2011. https://history.nasa.gov/SP-6127.pdf.

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Exhibit 4 NASA's Proposed Reductions to Fund the Constellation Program

Activity	2005	2006	2007	2008	2009	Total
Discontinue SLI	-0.8	-1.2	-1.3	-1.2	-1.4	-5.9
Shuttle retirement	0.0	0.0	0.0	-0.2	-1.3	-1.5
Eliminate ISS research not tied to vision	-0.1	-0.2	-0.3	-0.3	-0.3	-1.2
Human Space Flight related	-0.9	-1.4	-1.5	-1.7	-3.0	-8.6
Defer new space and earth science missions and freeze spending	-0.2	-0.5	-0.7	-0.7	-0.6	-2.7
Reduce space technology and defer institutional activities	-0.15	-0.03	-0.04	-0.05	-0.07	-0.3
Other Reductions	-0.3	-0.5	-0.7	-0.8	-0.7	-3.0
Total Reduction	**-1.3**	**-1.9**	**-2.3**	**-2.5**	**-3.7**	**-11.6**

Source: U.S. Senate. Committee on Commerce, Science, and Transportation. NASA Authorization Act of 2004 (S. 2541) Together with Additional Views. (108 S. Report 418) p.6. https://www.govinfo.gov/content/pkg/CRPT-108srpt418/pdf/CRPT-108srpt418.pdf; Accessed: 7/1/2021.

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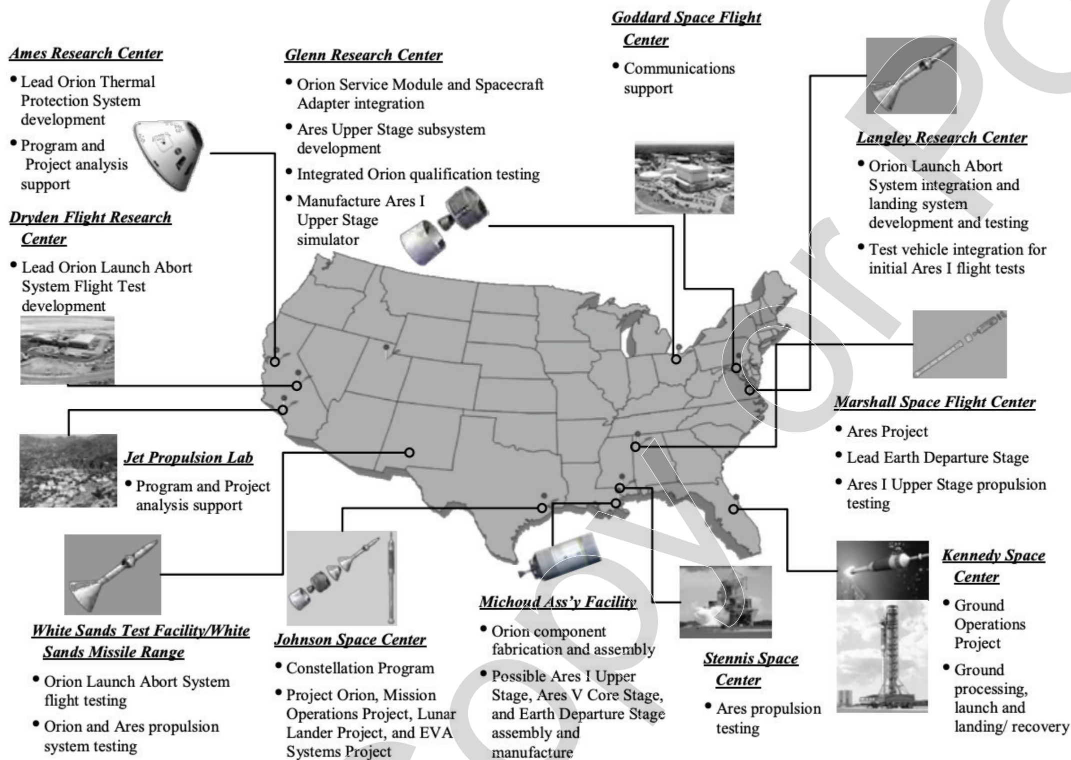
Exhibit 5 Distribution of Constellation Work Assignment



Source: "Constellation Program Lessons Learned." NASA, Spring 2011. https://history.nasa.gov/SP-6127.pdf.

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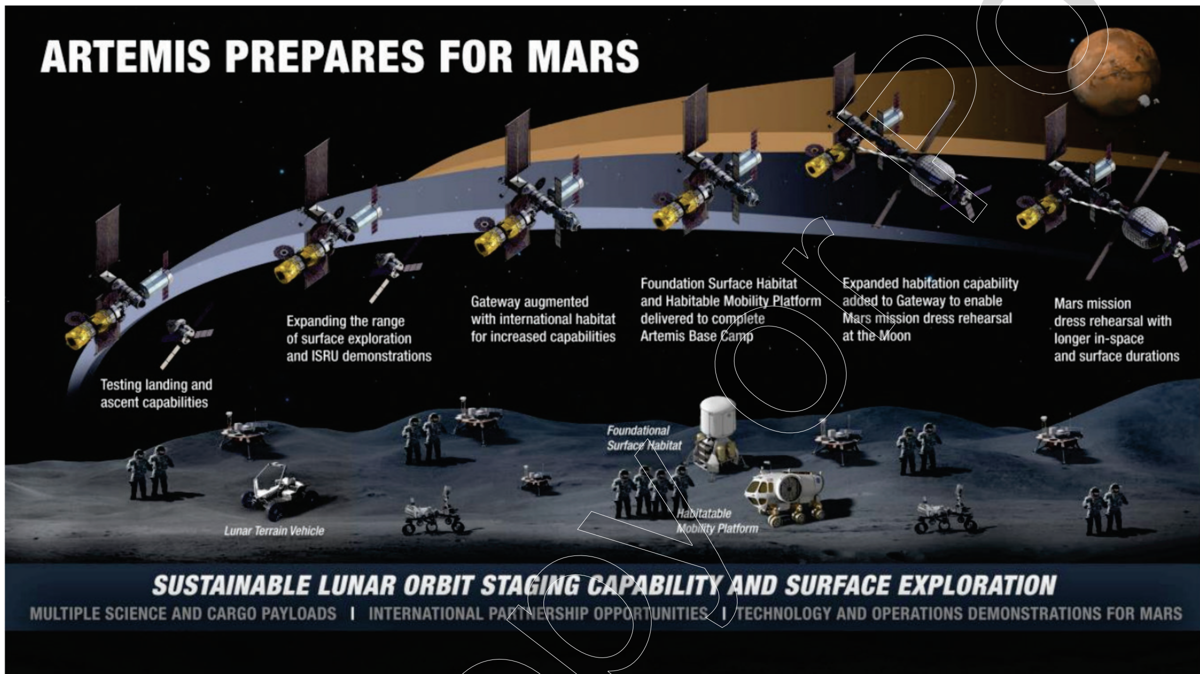
Exhibit 6 Artemis Program Staged Timeline



Source: "NASA's Plan for Sustained Lunar Exploration and Development." Accessed November 5, 2020. https://www.nasa.gov/sites/default/files/atoms/files/a_sustained_lunar_presence_nspc_report4220final.pdf.

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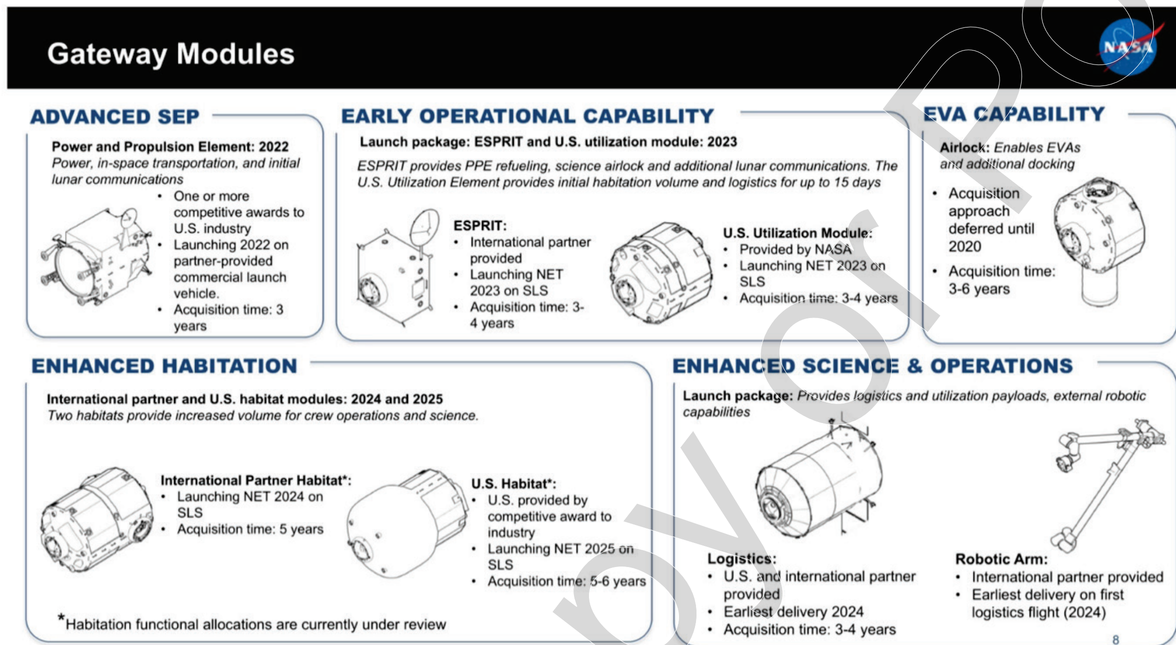
Exhibit 7 Overview of Gateway Modules



Source: Gerstenmaier, William. "Cislunar and Gateway Overview." NASA HQ. Accessed May 30, 2021. https://www.nasa.gov/sites/default/files/atoms/files/cislunar-update-gerstenmaier-crusan-v5a.pdf.

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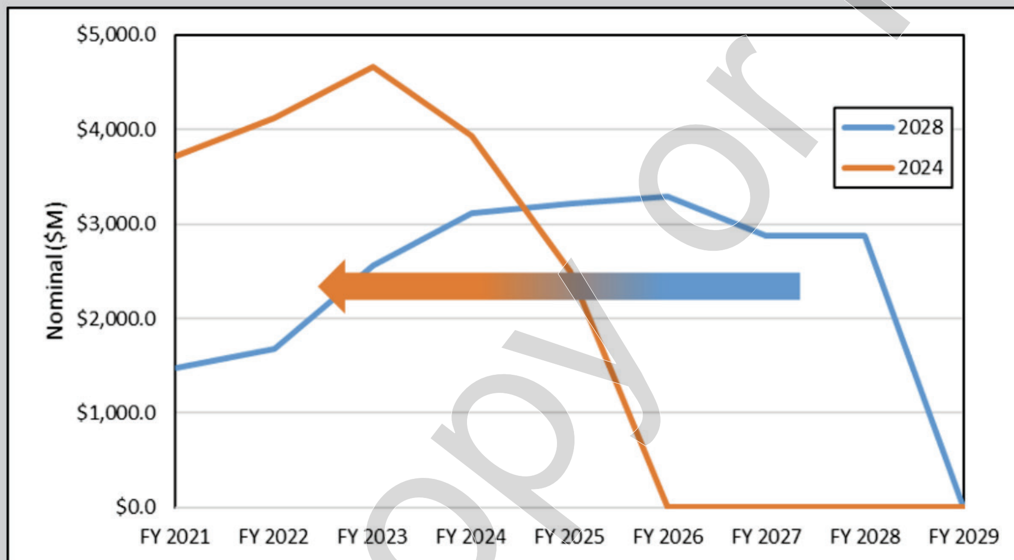
Exhibit 8 Shifted Gateway Budget to Accommodate the 2024 Landing Timeline

Artemis Phase 1 funding requirements represent a more efficient and direct plan than NASA's previous concept of the 2028 landing. While the funding requirements are accelerated and near-term amounts have comparatively increased, overall funding requirements for the 2024 Phase 1 effort are not higher and sustained lunar presence and future exploration are accelerated.



Overall Artemis Phase 1 funding to achieve a 2024 landing is not higher than prior plans for a 2028 landing.

The following table provides a summary of the Artemis Phase 1 funding requirements through FY 2025 that have been addressed in the preceding discussion. While Artemis III is planned for Calendar Year 2024, Fiscal Year 2025 begins on October 1st, 2024, and FY2025 will include costs associated with Artemis III mission operations and logistics, as well as post-demonstration follow-on analysis. The Artemis Phase 1 funding plan reflects the current requirements for Phase 1 within the overall FY 2021 President's request, including current allocation of Artemis budget elements to Artemis Phase 1 and Artemis Phase 2.

$ Millions	FY2021	FY2022	FY2023	FY2024	FY2025	Total
Orion/SLS/EGS (Exploration System Development Programs)	$ 2,894.7	$ 2,070.6	$ 1,487.6	$ 919.0	252.0	$ 7,623.9
Initial Human Landing System	$ 3,222.5	$ 3,553.1	$ 4,100.4	$ 3,571.3	1,719.0	$ 16,166.4
Lunar Suits - *maintained in Gateway budget*	$ 177.3	$ 141.0	$ 94.2	$ 63.1	42.5	$ 518.1
Surface Logistics - *maintained in ACSC budget*	$ 67.6	$ 69.2	$ 141.9	$ 196.0	77.7	$ 552.4
Exploration Technologies	$ 251.0	$ 292.0	$ 268.0	$ 223.0	158.0	$ 1,192.0
LDEP – *maintained in SMD Artemis Science Elements budget*	$ 451.5	$ 517.3	$ 491.3	$ 458.3	-	$ 1,918.3
Total Phase 1 Requirements	**$ 7,064.7**	**$ 6,643.1**	**$ 6,583.4**	**$ 5,430.7**	**2,249.2**	**$ 27,971.1**

Artemis Phase 1 Funding Requirements.

Source: "NASA's Plan for Sustained Lunar Exploration and Development." Accessed November 5, 2020. https://www.nasa.gov/sites/default/files/atoms/files/a_sustained_lunar_presence_nspc_report4220final.pdf.

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Exhibit 9 Artemis Program Obligations and Budget Proposals (in millions of dollars)

Program/Project	Provider	Contract Type	Obligations (as of August 2020)	Total Award Value
Gateway Program			435.0	3,592
PPE	Maxar	Firm-Fixed-Price	90.5	550.6
HALO	Northrup Grumman	Sole-Source, Firm-Fixed Price	114.2	999.3
Logistics Element	-	-	2.8	264.6
Program Mission Execution	-	-	53.0	768.5
Spacesuits	-	-	121.9	863.6
Mission Directorate Support	-	-	0	93.2
Logistics Resupply Services	SpaceX	Firm-Fixed-Price	0.323	7,000
Human Landing System	SpaceX (Starship)	Firm-Fixed-Price	-	2,890[a]

Source: "NASA's Management of the Gateway Program for the Artemis Missions." NASA OIG, November 10, 2020. https://www.oversight.gov/report/nasa/nasa%E2%80%99s-management-gateway-program-artemis-missions.

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