

TO: Donald Trump, President  
 CC: Mike Pence, Vice President; Chairman, National Space Council  
 Scott Pace, Executive Secretary, National Space Council  
 Mick Mulvaney, Director, Office of Management and Budget  
 RE: Scope of Human Spaceflight Program Under Alternative Budget Profiles

For your use as you prepare for the FY19 budget submission, the staff of the National Space Council has produced an analysis on the scope of the human spaceflight program under three alternative funding profiles. This evaluation will inform you of the budget’s impact on opportunities and challenges in the United States’ human spaceflight program, and corresponding policy and political considerations.

**BACKGROUND**

Budget Authority (\$ in millions)	Fiscal Year						
	Operating Plan 2016	Enacted 2017	PBR 2018	Notional			
	2016	2017	2018	2019	2020	2021	2022
<b>NASA Total</b>	<b>19,285.0</b>	<b>19,653.3</b>	<b>19,092.2</b>	<b>19,092.2</b>	<b>19,092.2</b>	<b>19,092.2</b>	<b>19,092.2</b>
Exploration	3,996.2	4,324.0	3,934.1	4,259.7	4,513.3	4,437.9	4,449.9
Space Operations	5,032.3	4,950.7	4,740.8	4,532.8	4,279.2	4,354.6	4,342.6

FIG. 1 – FY18 PRESIDENTIAL BUDGET REQUEST & FY19-22 NOTIONAL

Per the FY18 Presidential Budget Request (Fig. 1), NASA’s budget is notionally projected to remain \$19 billion, adjusted for inflation, through your Administration’s first term. As with recent fiscal years, Congressional appropriators are likely to marginally mark-up the total enacted budget.

The United States’ human spaceflight portfolio currently involves three active programs: the International Space Station (ISS), Commercial Crew and Cargo (C<sup>3</sup>) contracts for ISS resupply, and development of a heavy-lift rocket (Space Launch System; SLS) and a multipurpose crew capsule (Orion). The ISS is scheduled for continual use through 2024, with the possibility of extension. Current C<sup>3</sup> contracts are expected to last through at least 2024. SLS’ first flight with Orion (Exploration Mission 1; EM-1) is scheduled for no earlier than December 2019.

By mandate in the 2010 National Space Policy and the 2017 NASA Transition Authorization Act, NASA is pursuing beyond-Earth-orbit human spaceflight. The agency’s roadmap involves cis-lunar exploration throughout the 2020s followed by missions to Martian orbit and surface in the 2030s and 2040s. NASA has proposed a cis-lunar station concept (Deep Space Gateway; DSG) for the 2020s. Per White House direction, the agency has submitted an updated exploration roadmap (“NSC Report”) to NSC staff. The DSG and NSC Report roadmap are currently unfunded and not written into statute authorizing NASA; however, they are included in this evaluation under the presumption of their approval.

### **CURRENT BUDGET LEVEL (CONSISTENT WITH INFLATION)**

As indicated in agency testimony and feedback, NASA's current budget allows for a cadence of 1 SLS flight per year through the 2020s, beginning with EM-1 in December 2019 or early 2020 and first crewed flight (EM-2) by 2023. Starting with EM-2, each SLS flight will be co-manifested with a component of the DSG; completion of the DSG may require up to 4 SLS flights. Crew may be able to fly on-station at DSG for up to 40 days per mission. DSG will be leveraged as a "staging-point" for missions to Martian orbit and surface in the 2030s and 2040s. Development of capabilities necessary for the Mars campaign, including solar electric propulsion, deep-space habitats, and landing and surface operations technologies, will require funding through the 2020s concurrent with DSG operations. Past 2024, fiscal pressures will make continued ISS operations concurrent with cis-lunar exploration challenging. C<sup>3</sup> resupply of the ISS will accordingly be terminated upon ISS decommissioning.

This budget level should be considered the baseline minimum for NASA to achieve its exploration mandate within current projected schedule. It does not afford NASA significant flexibility to conduct robust lunar exploration while pursuing technology development for Mars or to sustain an American presence in low-Earth-orbit following ISS decommissioning. NASA expects international and commercial partners to leverage DSG for the former and commercial industry to independently develop the latter throughout the 2020s. A marginal level of flexibility is afforded for unanticipated difficulties in capability development through the 2020s, though schedule may be affected. Critical knowledge gaps for deep-space human spaceflight will put long-term pressure on the program, as ISS' limited availability creates significant uncertainty for research prior to conduct of operations.

If pursuing this budget level, your Administration must remain cognizant of the risk of "mission creep" and interface with agency and Congressional leaders to avoid it. As this budget offers only enough resources for NASA to meet its exploration mandate through progression in a phased development roadmap, the agency cannot afford to be diverted from that roadmap. Pursuing ancillary exploration goals, such as lunar exploration, jeopardizes budget prioritization for mid-term technology development. If your Administration wishes to pursue these goals instead, it must make that decision before development begins on Mars-relevant capabilities. Your Administration should proactively work with stakeholders to determine, in the short-term, the future of ISS and potential opportunities for commercial partnership in cis-lunar space. Doing so will allow NASA, potential international partners, and commercial stakeholders to better account for timeline pressures and accordingly prepare capabilities to supplement NASA's roadmap needs.

### **FLAT BUDGET LEVEL**

The programmatic challenges encountered in an inflation-adjusted stable budget are amplified in a flat budget. It offers little buffer against cost-overruns and schedule slippage, potentially jeopardizing the opportunity for cis-lunar human flight within your first term. NASA will need to prioritize budget between operations and space technology development; this may necessitate a slower cadence of flight, which entails safety risk and flight cost increases, or require delay in the development of critical Mars technologies. To maintain currently projected schedule, NASA may need to divert funds from its scientific or planetary exploration portfolios. Otherwise, it is unlikely that a flat budget will enable human missions to Mars by the current mandate of the 2030s. In this budget scenario, pursuit of lunar exploration goals will likely necessitate cancellation or long-term postponement of the Mars campaign; if your Administration wishes to pursue lunar exploration, it will need to work with Congressional policymakers to change NASA's statutory authorization.

With a flat budget, NASA will need to significantly expand its leverage of international and commercial sector capabilities and more deeply integrate them into its proposed mission architecture. In doing so, the agency will need to take inventory of core technological competencies and determine which core mission capabilities it is willing to take off the "critical path" of NASA-internal development. While some historical precedent suggests that international and public-private partnerships may offer NASA cost-savings, these partnerships also risk schedule slips, compromises in hardware safety and reliability, and programmatic decision-making outside of NASA's control. Certain capabilities, particularly if procured from the commercial sector, may not be sustainably available. Your Administration must recognize these tradeoffs if this budget level is to be pursued.

NASA may leverage various options for international and commercial partnership that supplement or replace agency-developed capability. While not the preferred forcing function, this may serve to catalyze more robust partner capabilities. In lieu of a steady SLS cadence to deliver DSG components to cis-lunar space, NASA may procure launch services from one of several commercial heavy-lift rockets currently in development. Doing so may require NASA to significantly scale down the size and weight of DSG. NASA may seek international contribution of critical DSG components instead of developing them itself; however, like ISS' arrangement, this may create schedule pressure on NASA's roadmap and require decision-sharing that eliminates NASA's programmatic autonomy. If your Administration wishes to pursue this budget, it should immediately begin working with State Department personnel to establish dialogue with potential international partners over DSG arrangements.

### **SCALED BUDGET LEVEL**

A scaled NASA budget (e.g. 4% growth a year over your first term) offers the agency considerable flexibility in pursuing exploration goals ancillary to its current roadmap and more certainty in meeting milestones on schedule. It could allow for prolonged operation of ISS, a preferable resolution to current programmatic and research uncertainties. Providing NASA discretionary funds for human spaceflight activities would likewise enable expanded opportunity for partnership with commercial providers and catalytic support for commercial development of low-Earth-orbit and lunar space. This budget scenario increases the likelihood of returning humans to lunar space within your second term, a considerable political win.

As fiscal constraints currently dictate their flight schedule, EM-1 and EM-2 could be moved up should additional budget be provided toward SLS, Orion, and ground support system development and production. In such case, EM-1 may fly before the close of your first term, and EM-2 could fly earlier than the close of your second term. A scaled budget may offer opportunity for additional flights between, or shortly following, EM-1 and EM-2, which would lower flight safety risk and cost. Work on Mars technology development may begin earlier, which could allow for an expedited schedule of deep-space flight.

With a scaled budget, NASA could potentially maintain ISS operation through the 2020s or conduct lunar exploration during the cis-lunar phase of its roadmap; or, depending on the extent of budget increase, both. If NASA opts to maintain ISS through at least 2028, it will afford researchers extra time to resolve technical and biological knowledge gaps about long-term human spaceflight critical for prolonged missions to cis-lunar space and Mars. It will likewise afford commercial industry an anchor to continue economic development of low-Earth-orbit, especially if ISS is more extensively leveraged as a platform for commercial R&D. If NASA pursues lunar exploration, additional funds may be used for scientific surface instruments and payloads, potentially deployed on commercial landers, or conduct experimental in-situ resource prospecting and utilization. Investing in the latter capability would have functional benefit for missions to the Martian surface.

With discretionary funds, NASA could solicit expanded commercial participation in its roadmap while maintaining internal control over “critical path” capabilities. Procurement of low-Earth-orbit commercial space stations for additional research, commercial lunar landers for scientific payload deliver, commercial resource extraction for on-orbit fuel production, and commercial cis-lunar cargo delivery would substantially enhance NASA’s programmatic efforts. The infusion of NASA funding would catalyze commercial capability development, potentially leading to a long-term commercial infrastructure that NASA could sustainably leverage.

## RECOMMENDATIONS

The staff concludes that a significant scaling of NASA's budget over the term(s) of your Administration is necessary for the agency to securely achieve its statutory human exploration goals. However, the staff recognizes that political and fiscal realities likely preclude the availability of additional budget. To ensure available resources are best utilized, we offer the following recommendations:

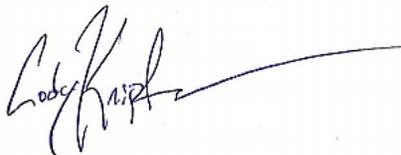
**PROGRAM AND BASELINE BUDGET CONSISTENCY:** NASA requires consistency of purpose and certainty of long-term funding to achieve a multi-year human spaceflight program. Budget planning for a cis-lunar and Mars campaign will occur several fiscal years ahead of employment of funds. Unanticipated changes in program or budget will accordingly hamper programmatic progress and schedule. Your Administration should take steps to ensure that proposed NASA budgets and direction remains stable and consistent throughout your term(s).

**EXECUTIVE BRANCH ADVOCACY:** Inconsistency between Executive Branch and Congressional space policy and budget-setting, particularly over the past two Administrations, has been a source of NASA's mired progress. Leadership in policy direction for NASA has accordingly shifted away from the Presidency to the Legislative Branch. To ensure that your Administration's exploration goals are met, the Executive Branch must elevate human spaceflight from parochial Congressional interest to the national policy agenda. This may be achieved through cross-government engagement on space goals and shaping public opinion, in states with both vested space interests and without, through speeches and visiting engagements

**LEVERAGING PARTNER COMPETENCIES:** The substantial costs and technical challenges involved in beyond-Earth-orbit human spaceflight preclude NASA from achieving ambitious goals alone. The rapid growth of international and commercial competencies and alignment of exploration interests presents good opportunity to supplement NASA's capabilities. Engagement with commercial and international partners will meanwhile solidify the United States' space leadership. Your Administration should proactively interact with commercial and international partners and stakeholders to identify areas of shared interest and cooperation. Policy directives should be issued to both NASA and agencies overseeing regulation of the commercial space sector that direct them to take steps fostering continued commercial development of space.

The staff encourages your Administration to continue its enthusiastic interest in and support for space exploration. NASA truly is what "makes America great."

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