

Astro2020 White Paper for State of the Profession Considerations

On

Funding Strategy Impacts and Alternative Funding Approaches for NASA's Future Flagship Mission Developments

**(NOI Title submitted as: Alternative funding approaches for
future large strategic missions)**

Decadal White Paper

Thematic Area:

Considerations for Understanding and Improving the Cost and
Schedule Performance of the Development of NASA's Flagships

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1 Key Issue and Overview of Impact on the Field

1.1 Summary of the Issue:

- NASA has historically struggled with estimating the final cost and schedule duration of its large “flagship” missions.
- The accuracy of cost estimates and schedule planning increases with concept maturity. Early assessments necessarily underestimate the total mission cost and schedule, and lead to inevitable cost growth and schedule delays.
- Cost and schedule assessment “checkpoints” should be made throughout a NASA flagship mission’s “Formulation Phase”. As the concept develops, more accurate cost and schedule estimates are made.
- At each of these checkpoints through the end of Phase B, accurate funding for the next block of work can be determined and allocated, thus enabling cost and schedule growth to be anticipated and controlled.
- A final cost assessment at the start of Phase C, NASA’s Key Decision Point C (“KDP-C”), will provide the highest fidelity cost estimate and allow for an informed commitment from the Agency to complete the mission’s implementation on schedule and within budget.
- Funding of NASA’s flagships has required annual Congressional appropriations that are unstable in two ways: (1) the funding profile (total amount of funding for a given year) is not based on what a project needs, rather, it is based on what funding is available, forcing an inefficient project execution whereby a project must defer work; (2) Continuing Resolutions (CRs) are the norm preventing necessary year-to-year funding increases that are necessary to complete new work.
- Fully funding multi-year blocks of work based on each cost and schedule assessment checkpoint will provide budget stability and allow project schedules to be executed efficiently and optimally. Multi-year funding mechanisms have been for ~70 years for large projects within the Department of Defense (DoD), and could be applied to NASA’s flagship missions.
- Using these methods to control cost and schedule growth will enable NASA to complete more flagship missions at a higher cadence.

Why do NASA’s flagship missions cost significantly more and take longer to complete than originally planned? What steps can be taken to improve their cost and schedule performance during development? While there are a myriad of reasons that contribute to NASA’s flagship development cost and schedule overruns that have been documented in many lessons learned publications¹⁻¹⁷, some lessons keep showing up multiple times. This white paper focuses on one of these: Funding. In particular, we advocate to choose to assess the total funding needed at a few development gates/design level maturities, and distinctly, choose to implement funding methods already used for other government flagship-level projects, to greatly improve on NASA’s development cost and schedule performance.

Process to establish increased confidence and accuracy in cost assessments:

While immature mission concepts and immature cost assessments are historic reasons for not understanding and appreciating the full development costs and schedules needed to bring NASA’s ‘one-off’, ground-breaking, flagship missions to fruition, NASA and the Astro2020 Decadal have vastly improved upon both of these issues.

In 2010, the Decadal Survey in Astronomy and Astrophysics (“Astro2010”) contracted with The Aerospace Corporation to perform cost and risk assessments using the Cost and Technical Evaluation (CATE) process. This was the first time such an assessment was performed as part of a Decadal Survey. Although all of the large mission concepts were assessed through this rigorous process, not all of the large mission concepts were at the same level of maturity. Mature mission concepts *and* mature cost assessments are **both** needed. If the concepts being evaluated are not mature enough, the cost assessments are not going to be mature enough.

For the 2020 Decadal Survey in Astronomy and Astrophysics (“Astro2020”), NASA improved upon this process. In January of 2015, NASA solicited input from the community on which large strategic (“flagship”) mission concepts should be studied in preparation for Astro2020. In 2016, after a year of community-solicited input, NASA chartered four community-endorsed flagship mission concept studies that are now community-led by Science and Technology Definition Teams (STDTs)^{18, 25}. Each concept study was assigned to a NASA center for engineering, technology, science, and study support. These mission concepts have been studied in detail for 3.5 years (January 2016- August 2019) with significant resources to bring their point designs to Concept Maturity Level 4 (CML4)¹⁹, the maturity level at which accurate cost and risk assessments can begin to be made. This is the first time, **ever**, that all community-endorsed, flagship mission concepts will have achieved this level of detailed maturity prior to a Decadal Survey. In addition, the Aerospace Corporation will perform Technical, Risk, and Cost Evaluation (TRACE) assessments on all of the point designs developed by these four flagship mission concept teams. Hence, Astro2020 will be the first time that all flagship missions submitted by NASA will have achieved the same level of detailed maturity, and be rigorously assessed for cost and technical risks using a uniform process. This represents a significant improvement in understanding each missions’ science return as a function of cost.

However, this is not the last step in understanding and controlling a large mission’s lifecycle costs. After the Decadal survey recommends agency priorities, we recommend assessing the cost and risk of the prioritized mission at multiple points in its development including up to the mission development’s Key Decision Point-C (“KDP-C”), the point at which the development officially ends Formulation at the end of Phase B and enters the beginning of Implementation known as Phase C. Performing a final cost assessment at KDP-C ensures the mission has reached a maturity level commensurate with achieving an accurate cost estimate suitable for appropriating the remaining required funding to complete the mission’s development³.

**Process to disburse funds to enable better mission development cost and schedule performance:
The Funding Profile and Funding Stability Matter:**

Even if NASA’s flagship missions have early and accurate cost assessments, their current funding implementation method all but guarantees development cost and schedule overruns. Once a flagship mission is prioritized by the Decadal and approved by NASA for development, there are historic and repeated issues with the funding methodology during their developments that have been cited^{1-11, 20-21} as significant contributors to their cost and schedule overruns, namely, back-loaded funding profiles and unstable funding.

NASA’s budget is appropriated on an annual basis. Flagships are supposed to receive an annual budget from Congress at the beginning of every fiscal year (FY). Congress has passed a NASA budget on-time only 7 times in the history of NASA¹. Continuing Resolutions (CRs) are the norm for NASA’s budgets. CRs

go into effect when a budget is not passed and there is a lapse in funding. A CR forces a status quo budget level from the previous year, hence, a CR does not allow for an increase in project budget needs.

The total funding amount including reserves, the funding profile, and the funding stability for any large project across the government (NASA, DoD, etc.) are matters out of the control of any given flagship mission's project manager and project management team. Even the best of the best of project managers will fail to deliver on a mission's development cost and schedule performance without addressing the issue of the total amount of funds disbursed to the project, and, in particular, **when** those funds are disbursed to the project. These are the issues of an appropriate funding profile and stable funding. Congress has recognized, since the 1950s, the importance of appropriate and stable funding for large DoD development projects such as aircraft carriers, submarines, tankers, fighter jets, and helicopters^{3, 12-17}. NASA would greatly benefit from embracing this approach and have Congress and others recognize the importance and impact that this type of funding would have on NASA's flagship developments compared to how NASA's flagships are currently funded. As mentioned, Congress has been consistently providing appropriate and stable funding through multiple vehicles: *No-Year Funding*, *Incremental Funding*, *Multiyear Procurement (MYP)*, *Block Buy Contracting (BBC)*, *Economic Order Quantity (EOQ) Authority*, *Advance Procurement (AP)*, and *Cost-to-Complete Procurement Funding*. NASA's flagship missions are of similar (and, arguably, even greater) caliber national assets that deserve and need the same type of full-funding policy that the DoD large projects have benefited from for more than half a century. Each of NASA's flagships is a "one-off", unique, complex system, state-of-the-art, national-asset, the scientific discoveries of which are admired not only nationally, but world-wide. NASA's flagships fundamentally change the human race's understanding of our universe and our place in it, forever.

There are three distinct funding aspects of current NASA flagships that have a significant impact on the mission's development cost and schedule: (1) total funding amount including reserves, (2) funding profile (timing/phasing of the funding), and (3) funding stability. In the following sections, these funding attributes are discussed in terms of their current methods and impacts while alternative funding approach solutions are offered along with their associated benefits.

1.2 How it impacts the field of astronomy and astrophysics:

The community-at-large, including the public, Congress, the astronomical community, academia, federal government agencies, industry, NASA itself, and even international partners rightfully and justifiably complain when NASA says a mission will cost X and take Y time to be developed and in the end costs significantly more than X and takes significantly longer than Y to be launch-ready. Understandably, everyone wants better cost and schedule performance on NASA's flagship mission developments while not compromising the mission's on-orbit performance. The cost of NASA's flagship missions should not only be better understood going into development, but also better understood in terms of recognizing and explicitly acknowledging the impact that the funding implementation method has on a mission's development^{1, 3, 20-21} cost and schedule performance. With proper funding estimates and execution of disbursing the funding, NASA will vastly improve on the cost and schedule performance of their flagship missions, thus, enabling better execution planning of NASA's entire portfolio of missions.

1.3 Why it should be addressed in the Survey.

Astro2020 and the community have a stake in the cost and schedule performance of NASA's flagship missions. NASA and the community love the awe-inspiring science discoveries of these missions like the Hubble Space Telescope (HST), Mars Science Lab (MSL), Cassini, Chandra, Galileo, and Voyager.

Astro2020 will assess the science, feasibility, executability, and cost of the four large, strategic, mission concepts submitted by NASA. The science per dollar value (of all classes and sizes) of missions plays a big role in their evaluation. One of the biggest considerations of a mission is its development cost. If the community understands the big picture regarding the different knobs that can be turned and their impact to enable NASA's flagship missions to have better development cost and schedule performance, this may lead to more trust in NASA by the public and may lead to more flagship missions over the decades because NASA would then be able to execute the development of flagship missions more efficiently and effectively.

In addition to prioritizing NASA's next astrophysics flagship's science goals, the Astro2020 Decadal committee may want to understand and acknowledge to the community *the significance that the funding implementation method* has on the cost and schedule performance of NASA's flagship developments.

It is the intent of this White Paper to lay out the arguments for, and hopefully convince the Astro2020 Decadal committee to make recommendations to NASA that might help address the issue of full and stable funding (a repeated lesson^{1-17, 20-21}) to help improve NASA's flagship mission's development cost and schedule performance - for the benefit of all stakeholders. Several funding options are offered including ways of funding different portions for different phases of development^{1, 3, 12-17, 20-21}. These different funding methodologies follow what others entities have recommended³ for NASA and are in close alignment with how other government agencies have funded their flagship large projects for ~ 70 years and continue to do so today¹²⁻¹⁷.

2 Strategic Plan: *A plan of action or policy designed to achieve a major goal.*

Before addressing the strategy that can be implemented, we will first describe the ideal end goal to enable a predictable mission cost and a method of funding to enable the most efficient execution of a flagship's development. We will then identify NASA's current flagship funding methods and issue. Finally, we will propose solutions.

2.1 The Ideal Goal: More Accurate Cost Assessments and An Efficient Mission Development Execution Enabled by a Full Funding Policy:

2.1.1 End Goal #1: More Accurate Cost Assessments at Several Increasing Mission Maturity Levels:

By virtue of each of NASA's flagships being unique and unrivaled in what they can achieve scientifically for humankind, they typically have equally unique and unrivaled technologies that need to be matured and architectures that need to be informed by those technologies. This process takes time. As we've established, accurate cost estimates cannot be assessed without mature concepts and designs. Therefore, in addition to making a single cost estimate at the time of the Decadal Survey, the ideal scenario would be to assess costs with appropriately-sized error bars for each maturity level achieved. As the development matures, the error bars should get smaller, and a final cost assessment should be performed once the mission has reached the necessary maturity level at NASA's Key Decision Point-C ("KDP-C").

2.1.2 End Goal #2: An Efficient Development Execution Enabled by an Executable Funding Profile:

Once a flagship mission has a final, mature cost estimate at KDP-C including appropriately assessed cost reserves, one of several full-funding policies (described in Section 2.3.2 of this white paper) will enable a

flagship project team to execute the remainder of the development of the mission. This development must follow an integrated master schedule that has been carefully orchestrated from the start to the finish. From components to assemblies, to subsystems and systems, up to the observatory level, all of these developments need to happen on-time, and often parallel to one another. Punctual funding enables execution of these critically-timed milestones to procure, build, integrate, and test hardware starting with the lowest level assemblies up to the highest level of observatory integration, test, verification, and validation. The goal is to successfully complete the development as efficiently as possible. Any of several full funding policies already used elsewhere in the government¹²⁻¹⁷ will enable this as described in Section 2.3.2.

2.1.3 In Summary:

Per many past NASA flagships lessons learned¹⁻¹¹ and recommendations by others³, there are paths forward to achieve more accurate cost assessments and funding methods that will enable NASA's flagship developments to perform significantly better on cost and schedule.

2.2 NASA's Current Flagship Development and Funding Methods and Issues:

Summary of the current funding issues combined

Immature mission concepts beget -> Inaccurate Cost Estimates -> beget Low-Level Initial Funding -> begets a non-optimized and inefficient development schedule -> begets longer and more expensive developments -> begets delaying the next flagship -> begets fewer flagships -> begets community frustration

Congress appropriates funding for NASA's flagships annually in a budget line item. Annual appropriations for NASA's flagships typically start off with a relatively small budget wedge that is often based on what funding is available and not on what a project actually needs to accomplish that year's tasks. Year after year, the project's annual budget slowly ramps, again usually based on available funding each fiscal year. The budget pressure that restricts available funds has recently been caused by the previous flagship mission that is completing its development, verification, and launch.

During this time of restricted funding, several critical steps in the new flagship's development are occurring:

1. As per current NASA guidance, technologies are continuing to be developed to TRL 6 by the new mission's Preliminary Design Review (PDR)²⁰⁻²¹. These undemonstrated technologies increase the risk to the mission development (to some an unacceptable amount of risk)^{1, 3, 20-21}.
2. A "marching army" is fielded to begin detailed design of the system. Since many of the technologies have not been fully developed, there can be To-Be-Resolved (TBRs) and To-Be-Determined (TBDs) in the formal requirements²⁰⁻²¹.
3. The science scope may still be in flux, therefore, the science requirements and all lower level requirements are still in flux^{1, 3, 20-21}.
4. Contractors are being identified and agreements are being finalized while the final design is not yet mature²⁰⁻²¹.

While all of these things are happening, the project is receiving fewer resources than it needs, all because of (a) the early underestimated mission cost, and (b) insufficiently available funds from the budget wedge. Because the project receives less funding than what is needed to enable a nominal parallel development program, the project is forced to defer work from the very beginning. Deferment of work has cascading and

compounding consequences for a complex mission. A typical flagship is a complex system of systems with interdependent layers of nested subsystems, and with a nominal sequence of hardware developments to enable an optimized development schedule. Any deferment of work lengthens the overall development schedule, and thus requires the marching army to remain on the project for a longer period of time, thus costing more and taking longer to complete the work. Consequently, this delays the next prioritized Decadal mission. For instance, JWST was prioritized in the 2000 Astro Decadal. For many reasons, some mentioned in this white paper as well as other reasons described in published lessons learned¹⁻³, JWST has, understandably, taken longer to develop than originally planned. WFIRST was prioritized in the 2010 Decadal. But the delays to JWST have, in turn, delayed the start of the development of WFIRST. Only when the previous flagship mission's development is nearing completion, does a "budget wedge" open up for the next Decadal priority mission. And, the available "budget wedge" may or may not be commensurate with what the next flagship needs, thereby starting the issue and impact cycle all over again.

According to the 2012 NASA Office of Inspector General (OIG) Report, "NASA's Challenges to Meeting Cost, Schedule, and Performance Goals", Report No. IG-12-021, pg. 25, *"In general, managers may be forced to invest time and effort re-planning tasks to fit unexpected funding profiles, deferring critical tasks to later phases of development, or de-scoping or discontinuing lower priority tasks to keep project costs within the revised budget profile. When it occurs in the early phases of a project, inadequate funding decreases management's ability to identify and address key risks. For example, when planned funding does not materialize, project managers may defer development of critical technologies to a time when integration of those technologies may be more difficult or when the cost of material and labor may be greater. For example, the JWST Independent Cost Review Panel noted that deferred work on that Project cost two to three times more than original estimates. In addition, shifting tasks to later project phases may require managers to sustain a workforce longer than originally planned or add shifts in an attempt to make up for lost time, both of which can lead to increased costs. Furthermore, as some tasks are contingent on completion of other deliverables, shifting tasks to later phases can have a cascading effect on a project's master schedule resulting in even higher costs."*¹

*"The single biggest challenge to managing a project at NASA is budget uncertainty. A project develops a budget to successfully accomplish the implementation of the project and, invariably, through the review process that budget is deemed unaffordable and [the] project is challenged to succeed with less. A typical approach is for the project to be cut in the near years with the cuts replenished in the out years causing the funding profile to be back loaded - the very thing it should not be. Starved for resource[s] early, the project is left to make inefficient decisions – take on technical risks or defer work - that will come home to roost later. On top of that is the annual uncertainty of budget approval - both in amount of budget and timing of approval – so at each fiscal year boundary the project is force[d] to consider changes to their plan that will impact efficient execution of their plan. After a few years the plan the project is executing on looks nothing like the plan – schedule and budget wise – the project embarked on at the beginning. Some of that change can be considered driven by internal events like technologies not panning out as planned, parts issues, etc. but the bulk of it is driven by external forces altering their budget."*¹

2.3 Solution Strategies:

The two distinct NASA flagship development funding implementation aspects are the (1) assessment of the total amount of funding needed including reserves, and (2) disbursement of the funding including the funding profile (timing/phasing of the funding) and the funding stability. Each of these is addressed separately as they each have different recommended solutions.

2.3.1 Total Funding Cost and Risk Assessment:

Accurate cost and risk assessments inform the total funding needed. The mission concept maturity informs the cost estimate confidence levels and the risk assessments inform the amount of funding reserves required. The cost assessment should start with larger error bars in the earlier phases of development. As the mission progresses and matures, the errors bars should get smaller. The risk assessment should inform the amount of reserves a mission development needs. As the mission development progresses and matures, the amount of reserves required should decrease over time.

A mission's required total funding and risk assessment needs to be increasingly accurate for each subsequent phase along a mission's development timeline. As previously stated, independent cost and risk assessments should not happen just once³, rather upon entering different phases ("gates") of a mission's development, where the last gate occurs at the mission's Key Decision Point-C (KDP-C). The development phases of NASA's missions consist of Formulation (Phases A and B) (and arguably, this should include Pre-Phase A²⁰⁻²¹ and see Section 2.3.1.1 of this white paper) and Implementation (Phases C and D).

- **Prior to the Decadal**, the mission concepts need to reach a certain level of maturity (CML4) in order to be placed in appropriate cost "boxes" i.e., cost ranges within some level of confidence. As stated in section 1.1 of this white paper, this has been accomplished for all four (4) Astro2020 large strategic (flagship) mission concept study teams from having studied their concepts for over 3.5 years. Each STDT-community-led team has prioritized science goals and developed science traceability matrices; performed architecture, technology, and engineering trades; designed telescopes and instruments that can accomplish their science goals; developed technology roadmaps including costs and schedules to bring all technologies to TRL 6; generated detailed master equipment lists (MELs), and produced development schedules - all criteria to achieving concept maturity level 4 (CML4)¹⁹. The flagship mission concept teams have developed point designs that should be considered *proof-of-concept* point designs in a trade space of many potential designs that could be developed in the future. **This has been achieved for the four Astro2020 flagship mission concepts.**
- **In Pre-Phase A**, NASA should stand up a Project Office for the highest priority flagship mission concept to oversee, perform, and enable maturation of several things during Pre-Phase A to (a) mature all technologies to TRL6, including performing subscale system demonstrations²⁰, (b) mature the architecture, (3) mature the science requirements based on the Astro2020 Decadal recommendations, (4) mature the plans and tools for system verification including Systems Engineering Modeling and Analysis, facility and transportation planning, to name some of the major activities that should be matured before entering into Phase A. Eventually, the technologies that mature and become the most promising inform and influence the final architecture. Fund these activities for a limited time period on an annual basis before entering into Phase A.
 - o **Benefits:** By maturing the mission architecture and concept earlier in the development (Pre-Phase A), there are many benefits:
 1. This minimizes risk early in the development reducing the overall cost and risk by performing the maturation process with a significantly smaller "marching army".
 2. This enables the necessary iteration of science requirements to evolve while being informed by the architecture, technologies, and other internal or external factors.

3. This enables clearer understandings of the best locations for interfaces and their requirements for the eventual design such that when those designs are developed, there are fewer TBRs and TBDs.
4. This reduces the known risks off the critical path where once on the critical path schedule, there is a large army that is hustling to meet those deadlines, etc.

Pre-Phase A ends when all technologies are at TRL6 including validating the mission architecture with subscale system demonstrations and maturing the science requirements with a community-led science steering committee. At the end of Pre-Phase A, a higher fidelity cost and risk assessment should be performed.

- **In Phases A and B**, given all technologies are at TRL6 now, the architecture has been demonstrated with subscale system demonstrations, the science requirements have been cyclically matured and vetted with stakeholders, and a higher fidelity cost and risk assessment has been independently performed, a specific point design can be initiated at the start of Phase A and developed through Phase B with their normal NASA milestone requirements developed. Independent cost and risk assessments should be performed at the end of both Phase A and Phase B. Fund Phases A and B with the needed resources and needed funding profile with multi-year appropriations.
- **By KDP-C**, the mission design will be mature with well-defined and clear requirements flowed down to all subsystems and components with established interface requirements. The expected science performance characteristics should be validated through modeling with technical error budgets flowed down to all hardware. “Breadboard” testbeds and pathfinders should have verified the technical specifications of the design as well as informed integration, alignment, and test procedures. This validated maturity level will enable a final independent cost and risk assessment that can be used for the final appropriation with a full funding mechanism required to execute the remainder of the mission’s development in Phases C and D.

At each of the above flagship mission’s development phases, the cost and risk assessments should inform the total funding amount for the next phase, such that along the development timeline, the cost assessment error bars are getting smaller while the reserve posture and assessments are decreasing over time. Although the reserve assessments should decrease over time for the known risks, adequate reserves should still enable accommodating the unknown risks. Historical databases of actual mission costs should inform these funding decisions.

2.3.2 Method of Disbursing the Funding to Enable an Executable Mission Development:

After KDP-C, with a mature cost assessment in hand, Congress should appropriate the funding using any of the several Full-Funding Policy methods currently benefiting all DoD flagship missions.

Full Funding Policy Methods/Options Available to DoD Large Projects:

Here are some Full Funding Policy methods and options available to all DoD large projects^{3, 12-17, 20-21} that would benefit NASA’s flagship development cost and schedule performance. Brief definitions are provided for each funding type below:

- **No-year (Zero-year) Funding:** All funding for building/developing DoD large projects is appropriated all at once in a single lump sum before starting the development.
- **Incremental Funding:** The funding for building DoD large projects is appropriated in 2 or more year increments, typically ~2-5 years, and in amounts that do not limit long-lead items being purchased or

does not limit the development of anything due to lack of funding in a given year. In other words, this is still front-loaded funding. However, each year requires an appropriation bill to be passed by Congress.

- **Multiyear Procurement (MYP) and Block Buy Contracting (BBC), and Economic Order Quantity Authority¹⁶:**

Multiyear procurement (MYP) and Block Buy Contracting (BBC) are contract funding mechanisms that allow a certain percentage of savings, sometimes less than 5% to sometimes greater than 15%, over the traditional contracts that require annual renewal by Congress by allowing a single contract to be valid for several years' worth of funding without having to renew the contract each year. This is allowed for a limited number of defense acquisition programs.

- o **Multiyear Procurement (MYP)¹⁶:**

Under a MYP contract, a single contract requires congressional approval in the first year that enables stable funding for two to five years' worth of procurement without requiring Congressional annual renewal in the following years. MYPs must be approved in both a DoD appropriations act and a non-DoD appropriations act. However, to qualify for an MYP contract, a program must meet legal criteria according to statute, 10 U.S.C. 2306b.

- o **Block Buy Contracting (BBC)¹⁶:**

BBC also requires congressional approval for a single contract in the first year for several years' worth of procurement, however, it is more flexible for several reasons, namely:

- a) There's no permanent statute governing the use of BBC.
 - b) BBC only needs to be approved in a single appropriations act.
 - c) There are no legal criteria required to qualify for a BBC (because there is no statute governing its use).
 - d) A BBC can cover more than five years of planned procurement.
 - e) BBCs are less likely to include cancellation penalties.

- o **Economic Order Quantity (EOQ) Authority¹⁶:**

This provides the authority to allow a few select "long-lead" items to be procured in the first or second year usually for "batch items".

- **Advance Procurement (AP) Funding^{16, 22}:**

This provides the authority to disburse funds one or two years prior to the procurement of the entire system usually for long lead items for that system. The amount disbursed in an AP is subtracted from the full system procurement appropriation. It is similar to EOQ acquisitions.

We recommend No-Year Funding for the Implementation phases (Phases C and D) for NASA's flagship missions. However, there may be benefits to MYP or BBC and EOQ funding. A procurement specialist team should investigate the most viable options for NASA's flagships.

Funding Stability

As stated previously, NASA's budget is appropriated on an annual basis. Flagships are supposed to receive an annual budget from Congress at the beginning of every fiscal year. Congress has passed a NASA budget on-time only 7 times in the history of NASA¹. Continuing Resolutions (CRs) are the norm for NASA's budgets. CRs go into effect when a budget is not passed and there is a lapse in funding. A CR forces a status quo budget level from the previous year, hence, a CR does not allow for an increase in project budget needs. This can exacerbate a smaller funding wedge in the early years of a project's development, and can tie the hands of the project team such that they are not able to execute their planned schedule¹.

If there is inadequate, unstable funding from year to year to allow a project to execute its work on its planned schedule, then the project must defer work or take on “unfunded” increased risk. Deferring work, originally planned to be accomplished in early years, forces that work to be performed in later years and interrupts the extremely complex, timed-developments, and well-orchestrated integrated master schedule that was carefully planned at the beginning of the project. Deferral of work has a cascading and compounding effect on cost and schedule implications for the remainder of a flagship’s development. Thus, deferring work will increase the development schedule, and hence will increase the overall cost to complete its development.

Any one of the several full-funding policies afforded for DoD’s large projects could fix NASA’s flagship funding stability issues of annual CRs and annual appropriations. The predictability of Congress not passing an annual budget has too much history, especially for a flagship project’s nominal development schedule of 10-15 years. We recommend a No-Year funding policy for NASA’s flagships.

Summary:

There are multiple issues that cause NASA’s flagships to cost more and take longer than originally planned^{1-11, 20-21}. These issues have been documented in many lessons learned publications¹⁻¹⁷, and many have been repeated multiple times. Funding stability is one of these repeated offenders. This white paper addressed NASA’s flagship funding implementation/execution issues, its causes, impacts, and recommendations. The reason for writing this white paper was to show that, even if NASA figured out all other¹⁻¹⁷ issues (not addressed in this white paper) for why NASA’s flagships cost more and take longer to develop, any project manager cannot deliver on cost and schedule during a flagship mission’s development without addressing the funding issues. Given NASA’s flagship funding dilemmas, No-Year Funding may be the best full-funding vehicle option to enable the most efficient development of NASA’s flagships that would facilitate expediency of funding to overcome NASA flagship’s current challenges. Rather than incrementally appropriating resources to NASA’s flagships based on the amount of funding available in an overall “NASA wedge” (and not based on what the project needs) a project should be appropriated the funds when needed based on the timing of the required mission developments. By explicitly acknowledging the role and impact that the funding method (amount and its timing) has on a flagships development cost and schedule performance, this may influence those that can take action to do so.

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