

# Restructuring the Pipeline of Discovery: An Analysis of NASA's Competition Model 2.0 and the Evolution of Principal Investigator-Led Space Science Missions

## Abstract

For more than three decades, the National Aeronautics and Space Administration (NASA) has relied on a competitive, peer-reviewed acquisition framework to select a substantial portion of its robotic space science fleet. Known colloquially within the aerospace community as Principal Investigator-led (PI-led) missions, these projects—spanning the Discovery, New Frontiers, Explorer, and Earth Venture portfolios—have yielded foundational observations across planetary science, astrophysics, heliophysics, and Earth system science. However, the bureaucratic and systems engineering mechanisms governing how these missions are proposed, evaluated, and down-selected have experienced severe procedural inflation. What began in the early 1990s as an agile alternative to multi-billion-dollar agency-directed flagship programs gradually evolved into a resource-intensive, two-step Announcement of Opportunity (AO) cycle requiring nearly three years from initial solicitation to final flight selection. In late October 2026, under the strategic guidance of NASA Administrator Jared Isaacman and Science Mission Directorate (SMD) Associate Administrator Dr. Nicola Fox, the agency unveiled a comprehensive structural reform designated as **Competition Model 2.0 (CM 2.0)**. Framed under the initiative "Faster to Science," CM 2.0 fundamentally alters the mission formulation and procurement architecture across NASA's small, medium, and large competitive mission classes. This article provides an exhaustive technical and policy analysis of the legacy selection paradigm, diagnoses the institutional and economic bottlenecks that necessitated reform, details the structural mechanics of CM 2.0 across distinct mission tiers, and evaluates the scientific, engineering, and workforce implications for NASA field centers, academic institutions, and the commercial aerospace sector.

## 1. Introduction: The Architecture of Space Science Procurement

The scientific exploration of the solar system and the broader cosmos requires translating theoretical questions—such as the composition of early planetary embryos, the dynamics of coronal mass ejections, or the mass balance of terrestrial ice sheets—into physical hardware capable of surviving launch environments and operating autonomously in deep space or low-Earth orbit. Within NASA's Science Mission Directorate (SMD), which manages an annual budget exceeding seven billion dollars across five primary divisions (Astrophysics, Planetary Science, Heliophysics, Earth Science, and Biological and Physical Sciences), flight missions are categorized into two overarching governance models: **directed missions** and **competed**

### **missions.**

Directed missions, commonly referred to as Flagships, represent the agency's largest, most technically complex, and most expensive endeavors. Missions such as the James Webb Space Telescope (JWST), the Mars 2020 Perseverance rover, the Europa Clipper, and the Nancy Grace Roman Space Telescope typically cost between two billion and ten billion dollars. Because these architectures require multi-decadal technology development, complex international partnerships, and deep integration across multiple agency centers, NASA Headquarters directly assigns overall project management to a lead field center—most frequently the Jet Propulsion Laboratory (JPL) in Pasadena, California, or the Goddard Space Flight Center (GSFC) in Greenbelt, Maryland. The scientific community then competes via targeted solicitations to provide individual scientific instruments or participate on science definition and investigation teams.

Conversely, competed missions operate under a Principal Investigator (PI) model. In this paradigm, a single scientist from a university, research institute, industry organization, or NASA center formulates an end-to-end mission concept in response to a periodic federal solicitation known as an Announcement of Opportunity (AO). Historically, the PI has been responsible for assembling a comprehensive consortium comprising scientific co-investigators, a managing institution (often JPL, GSFC, or the Johns Hopkins University Applied Physics Laboratory), and an industrial aerospace partner (such as Lockheed Martin, Northrop Grumman, Ball Aerospace/BAE Systems, or Redwire) to build the spacecraft bus and integrate the payload. While the PI-led paradigm successfully democratized mission conception and generated high scientific return per dollar, the mechanics of the competition process gradually degraded in efficiency. By the mid-2020s, the average timeline required to move a medium- or large-class competed mission from the release of an Announcement of Opportunity to a Step 2 selection had ballooned to approximately 35 months—nearly three full years before a mission even officially entered advanced design and hardware fabrication. Even smaller missions, designed to be rapid and responsive to emerging scientific priorities, required roughly 32 months to navigate the competitive gauntlet.

Recognizing that this procedural drag was consuming hundreds of thousands of person-hours in uncompensated proposal writing, stoking destructive internal competition between NASA's own engineering centers, and erecting insurmountable barriers to entry for scientists outside elite, well-funded institutions, NASA leadership initiated a systemic overhaul. Announced in October 2026, Competition Model 2.0 (CM 2.0) aims to compress selection timelines by 40 to 45 percent, decouple initial scientific peer review from premature industrial systems engineering, standardize commercial spacecraft bus utilization, and reallocate institutional responsibilities at Goddard and JPL.

## **2. Historical Context: Evolution of the Two-Step AO Process**

To understand why NASA's selection machinery required structural intervention in 2026, one must examine the historical evolution of NASA project management and the progressive accumulation of risk-aversion protocols within the Announcement of Opportunity framework.

## 2.1 The "Faster, Better, Cheaper" Era and the Birth of Discovery

Prior to the 1990s, robotic planetary and astrophysical exploration was dominated by infrequent, multi-billion-dollar missions such as Viking, Voyager, Galileo, and Cassini. While scientifically transformative, these projects suffered from prolonged development gestation periods and vulnerability to congressional cancellation during fiscal contractions. In 1992, under Administrator Daniel Goldin, NASA inaugurated the Discovery Program within the planetary science portfolio, closely modeling it on the existing Explorer program in astrophysics and space physics.

The governing philosophy of the era—known as "Faster, Better, Cheaper" (FBC)—sought to launch smaller, focused missions on strict cost caps and compressed 36-month development schedules. Early successes, such as the Mars Pathfinder lander (including the Sojourner rover) and the Near Earth Asteroid Rendezvous (NEAR) Shoemaker mission, validated the concept that a tightly integrated team led by a single Principal Investigator could achieve focused scientific objectives at a fraction of Flagship costs. In the 2000s, this competitive ladder was expanded to include the New Frontiers program (medium-class planetary missions capped around one billion dollars, such as New Horizons, Juno, and OSIRIS-REx), Earth Venture missions, and most recently, the Astrophysics and Heliophysics Probe Explorers class (capped around one billion to 1.5 billion dollars excluding launch).

## 2.2 The Legacy Lifecycle Architecture (NPR 7120.5)

Under NASA Procedural Requirements (specifically NPR 7120.5, *NASA Space Flight Program and Project Management Requirements*), every spaceflight project progresses through a highly structured lifecycle divided into distinct formulation and implementation phases:

- **Pre-Phase A (Concept Studies):** Initial ideation, broad trade studies, and drafting of the Step 1 AO proposal.
- **Phase A (Concept and Technology Development):** The competitive down-select phase (Step 2). Selected finalist teams receive fixed seed funding (ranging from one million to five million dollars depending on mission class) to conduct a nine-to-twelve-month Concept Study, culminating in a bulky Concept Study Report (CSR) and an intensive multi-day site visit by an independent evaluation panel.
- **Phase B (Preliminary Design and Technology Completion):** Following the down-selection of a single winning mission from Phase A, the project conducts detailed baseline design, concluding with a Preliminary Design Review (PDR) and Key Decision Point C (KDP-C), where NASA commits to a formal agency cost and schedule baseline.
- **Phase C/D (Final Design, Fabrication, Integration, Test, and Launch):** Hardware manufacturing, environmental testing, spacecraft integration, and launch campaign.
- **Phase E/F (Operations, Sustainment, and Closeout):** In-space prime science operations, data archiving, and eventual decommissioning.

## 2.3 The Creep of Step 1 Proposal Complexity

Following several high-profile mission failures in the late 1990s (most notably the Mars Climate Orbiter and Mars Polar Lander), combined with later cost overruns on complex PI-led missions like the Kepler Space Telescope and the InSight Mars lander, NASA instituted increasingly stringent risk verification protocols. Specifically, the Aerospace Corporation and internal NASA

standing review boards developed the **Cost and Technical Evaluation (CATE)** methodology—an independent probabilistic modeling framework designed to assess whether a proposed mission could realistically execute its technical scope within the advertised cost cap and schedule constraints.

Because passing the CATE hurdle in Step 1 became just as critical to survival as achieving an "Excellent" rating on scientific merit, proposing teams began shifting massive engineering workloads backward into Pre-Phase A. By the 2020s, a competitive Step 1 proposal was no longer a conceptual blueprint; it was practically a preliminary engineering design document.

| <b>Lifecycle Metric / Feature</b> | <b>Early Discovery/Explorer Era (1990s)</b>                                            | <b>Legacy Two-Step AO Model (2010–2025)</b>                                                                                        | <b>Impact on Scientific &amp; Engineering Community</b>                                                                                  |
|-----------------------------------|----------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Step 1 Proposal Scope</b>      | Conceptual science case, high-level instrument descriptions, rough orbital trajectory. | Exhaustive science traceability matrices, full subsystem block diagrams, thermal/power margins, and complete industrial schedules. | Required up to two years of pre-solicitation engineering and millions of dollars in internal research and development (IRAD) investment. |
| <b>Pre-Phase A Team Formation</b> | Small academic science team paired with a single aerospace partner.                    | Exclusive "locked-in" marriage between PI, a major NASA Center (JPL/GSFC) or APL, and a prime spacecraft contractor.               | Prevented smaller universities from competing unless previously courted by a major NASA center's business development office.            |
| <b>Total Selection Timeline</b>   | Approximately 12 to 18 months from AO release to flight selection.                     | Approximately 32 to 35 months from draft AO release to Step 2 down-selection.                                                      | Created multi-year gaps where engineering teams were held in limbo and scientific careers stalled awaiting review outcomes.              |

|                        |                                                                         |                                                                                                                                |                                                                                                                                          |
|------------------------|-------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Center Dynamics</b> | Centers acted primarily as technical repositories and oversight bodies. | JPL and GSFC competed aggressively against one another and against academia for Step 1 victories to maintain workforce levels. | Duplicated engineering efforts across the agency; prevented cross-center sharing of proprietary technical solutions during competitions. |
|------------------------|-------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------|

### 3. Diagnosing the Bottleneck: Systemic Flaws in the Legacy Model

In the years immediately preceding the October 2026 announcement of Competition Model 2.0, multiple external advisory bodies—including the National Academies of Sciences, Engineering, and Medicine (NASEM), the NASA Office of Inspector General (OIG), and dedicated independent review boards—highlighted deep structural pathologies in how SMD selected and managed missions. Three primary failure modes emerged from these assessments.

#### 3.1 The Uncompensated Burden and the "Pay-to-Play" Barrier

In the legacy AO architecture, submitting a credible Step 1 proposal for a Discovery, New Frontiers, or Probe mission required between three million and ten million dollars of internal investment prior to the government awarding a single dollar of Phase A study money. This funding was drawn from NASA center overhead accounts (such as internal investment funds at Goddard or JPL), university endowments, and aerospace corporate Bid and Proposal (B&P) budgets.

Consequently, a scientific Principal Investigator with a groundbreaking measurement concept could not simply write a proposal with a small team of university colleagues. To survive the Step 1 Technical, Management, and Cost (TMC) review, the PI had to convince the business development gatekeepers at JPL, GSFC, or the Applied Physics Laboratory—along with a major aerospace prime contractor—to invest millions of dollars and dozens of systems engineers into writing the proposal.

This dynamic created an informal, non-transparent pre-selection filter. Center management teams naturally gravitated toward established investigators with extensive flight heritage and conservative, low-risk engineering designs. Early-career researchers, scientists at Minority Serving Institutions (MSIs) or R2 universities, and investigators proposing novel measurement techniques were frequently locked out of the process before the official NASA peer-review panels ever convened. As Associate Administrator Nicola Fox noted in her October 2026 directive, the legacy structure forced researchers to spend far too much of their professional

careers proposing how to do science rather than actually conducting scientific research.

### **3.2 Fratricidal Competition and Workforce Destabilization at JPL and Goddard**

A second critical vulnerability involved the institutional health of NASA's premier science centers: the Jet Propulsion Laboratory (a Federally Funded Research and Development Center managed by Caltech) and the Goddard Space Flight Center. Throughout 2023 through 2026, both institutions experienced severe workforce turbulence due to fluctuations in major project funding, most notably the restructuring of the Mars Sample Return (MSR) architecture and budgetary pressures across the Earth Science and Astrophysics portfolios.

Under the legacy competition model, JPL and GSFC relied heavily on winning competed PI-led missions to sustain their core engineering workforces between major Flagship builds. During any given Discovery or Explorer AO cycle, JPL and Goddard might collectively sponsor eight to twelve competing Step 1 proposals. Each proposal team operated behind strict institutional firewalls to preserve procurement integrity.

This structure yielded two perverse outcomes:

1. **Redundant Overhead Expenditure:** The agency was effectively paying (via center overhead rates and indirect funds) for dozens of isolated engineering teams at its own centers to generate redundant mission architecture studies, knowing that 80 to 90 percent of those proposals would be rejected at Step 1 or Step 2.
2. **Talent Hoarding and Siloing:** Because Goddard and JPL were locked in zero-sum competition for mission management work, subject-matter experts at one center were legally prohibited from advising or assisting a proposal team anchored at the rival center. Rather than deploying NASA's collective civil service and contractor talent to solve the hardest technical problems on the highest-priority science concepts, institutional energy was dissipated in inter-center rivalry.

### **3.3 The Underutilization of the Maturing Commercial Space Sector**

Between 2016 and 2026, the global commercial space sector underwent a structural transformation. Driven by venture capital investment, Department of Defense proliferated low-Earth orbit constellations (via the Space Development Agency), and NASA's own Commercial Lunar Payload Services (CLPS) program, private industry moved from fabricating custom, bespoke spacecraft buses over five-year cycles to operating high-rate production lines for modular, high-performance satellite platforms. Companies such as Rocket Lab, Blue Origin, Impulse Space, Apex, York Space Systems, Astrobotic, Firefly Aerospace, and Intuitive Machines demonstrated capabilities extending well beyond low-Earth orbit, encompassing cislunar trajectories, interplanetary cruise stages, and high-data-rate optical communications. Yet, NASA's legacy AO process struggled to integrate these rapid commercial capabilities. Because legacy Step 1 proposals penalized any deviation from historical NASA cost models and traditional aerospace military-standard parts verification, proposal teams frequently defaulted to expensive, heritage spacecraft designs just to score a "Low Risk" rating from conservative TMC review panels. When teams did attempt to propose commercial fixed-price buses or rideshare architectures within traditional Explorer or Discovery templates, the rigid two-step evaluation rubrics—designed for bespoke agency hardware—created contractual friction,

schedule misalignment, and mismatched risk postures.

## 4. The Architecture of Competition Model 2.0 (CM 2.0)

Unveiled in October 2026 by Dr. Nicola Fox in alignment with Administrator Jared Isaacman's agency-wide mandate to accelerate operational execution, **Competition Model 2.0 (CM 2.0)** represents the most substantial restructuring of NASA's science acquisition process since the inception of the Discovery Program.

Rather than applying a uniform, bureaucratic template across all scientific investigations, CM 2.0 establishes a tiered, tailored evaluation framework governed by four core operational principles:

1. **Science Merit Opens the Door:** Decoupling initial scientific evaluation from heavy industrial engineering so that first-time teams and established institutions compete on equal intellectual footing in Step 1.
2. **NASA Centers Strengthen Missions:** Transitioning JPL and GSFC from competing proposal clearinghouses into collaborative implementation partners assigned during Step 2 for larger mission classes.
3. **Commercial Capabilities for Every Mission Type:** Mandating the evaluation and incorporation of commercial spacecraft buses, subsystems, and "Science as a Service" models wherever they provide cost or schedule advantages.
4. **Strict Cost and Schedule Discipline:** Utilizing Phase A implementation studies to perform explicit complexity and scope trades before baseline confirmation, accompanied by strict termination consequences for projects that breach established control thresholds during implementation.

### 4.1 Restructuring Step 1: The Simplified Three-Element Proposal

The centerpiece of CM 2.0 for two-stage competitions (encompassing Probes, New Frontiers, Discovery, Mid-sized Explorers, and Earth Explorers) is a radical reduction in the volume and technical granularity required for Step 1 proposals. Under the new policy, approximately **50 percent of the material previously mandated in an Announcement of Opportunity response is eliminated.**

Instead of submitting a multi-volume systems engineering treatise backed by locked-in aerospace prime contractors, Step 1 proposing teams are assessed exclusively on three foundational elements:

1. **The Science Case:** A rigorous articulation of the fundamental scientific questions to be answered, their alignment with National Academies Decadal Survey priorities, and the transformative nature of the expected discoveries.
2. **The Science Implementation Plan:** A detailed specification of the required physical measurements, instrument performance parameters (such as spectral resolution, sensitivity, cadence, and signal-to-noise thresholds), data calibration strategies, and science team organizational structure.
3. **A Proof-of-Concept Mission Design:** A high-level engineering feasibility demonstration verifying that the proposed instruments can realistically be accommodated within the mass, power, volume, and orbital trajectory constraints of the mission class cost cap, without requiring fully negotiated industrial subcontracts or exhaustive subsystem

schematics.

By stripping away the requirement for mature spacecraft bus engineering and detailed integrated master schedules in Step 1, NASA drastically lowers the financial barrier to entry. A Principal Investigator at a regional university or independent research institute can formulate a competitive Step 1 proposal focused on scientific innovation and instrument physics, competing directly on intellectual merit rather than institutional business development budgets.

## 4.2 Restructuring Step 2: Collaborative Mission Implementation Studies

Under the legacy model, teams surviving the Step 1 down-select spent Phase A refining their already-formed industrial partnerships in isolation, culminating in a high-stakes Concept Study Report where NASA reviewers acted strictly as external judges.

CM 2.0 replaces the traditional isolated Phase A Concept Study with a collaborative **Mission Implementation Study (MIS)**. For large and medium-large competed missions—specifically Astrophysics and Heliophysics **Probes**, Planetary **New Frontiers**, and Planetary **Discovery** missions—teams selected to advance from Step 1 are paired directly with a dedicated **NASA Implementation Team** anchored at either the **Goddard Space Flight Center (GSFC)** or the **Jet Propulsion Laboratory (JPL)**.

During this Step 2 Mission Implementation Study, the PI's science team and the assigned NASA Center implementation team work collaboratively to:

- Translate the Step 1 Proof-of-Concept into a rigorous, flight-ready engineering architecture.
- Conduct systematic trade studies between bespoke agency subsystems and commercially available spacecraft buses and components.
- Identify technical, schedule, and supply-chain risks early in the formulation process when scope adjustments and descope options can still be traded against scientific requirements without breaking cost caps.
- Evaluate the concept across three explicit final selection dimensions: **Scientific Merit**, **Science Implementation Merit**, and **Mission Implementation Merit**.

Crucially, by assigning Goddard or JPL to support Step 2 finalists rather than forcing those centers to compete against one another in Step 1, NASA eliminates duplicate proposal expenditures, stabilizes the engineering pipeline at its two primary robotic spaceflight centers, and ensures that every finalist concept benefits from the agency's deepest reservoirs of spaceflight systems engineering expertise.

## 5. Tiered Mission Class Breakdown Under CM 2.0

Because the technical complexity of landing a nuclear-powered rotorcraft on Titan (such as the New Frontiers *Dragonfly* mission) differs fundamentally from deploying a constellation of low-Earth orbit ionospheric CubeSats, CM 2.0 stratifies its procedural reforms across four distinct mission tiers.

| Mission Tier & Specific | Approx. Cost Cap | Legacy Selection | CM 2.0 Selection | Key Structural & Institutional |
|-------------------------|------------------|------------------|------------------|--------------------------------|
|-------------------------|------------------|------------------|------------------|--------------------------------|

| Programs                                                                                                    | (Excluding Launch)                         | Architecture & Timeline                                                                                     | Architecture & Timeline                                                                 | Shifts                                                                                                                                                           |
|-------------------------------------------------------------------------------------------------------------|--------------------------------------------|-------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Tier 1: Flagship Missions</b><br><br><i>(Directed Strategic Missions across all SMD Divisions)</i>       | Greater than \$1.5 Billion to \$5+ Billion | Agency-directed to a lead NASA Center; instruments and science teams competed via targeted solicitations.   | <b>Unchanged.</b><br>Remains agency-directed with competed science/instrument elements. | Process was previously reformed following independent large-mission studies; maintains strict phased gate reviews and commercial subsystem evaluations.          |
| <b>Tier 2: Large &amp; Medium-Large PI-Led</b><br><br><i>(Astro/Helio Probes, New Frontiers, Discovery)</i> | \$500 Million to \$1.5 Billion             | Heavy Two-Step AO; ~35 months from AO to Step 2 down-select; full industrial consortium required at Step 1. | <b>Streamlined Two-Step AO; ~19.5 months</b> (up to 45% reduction).                     | Step 1 reduced by ~50% (3 core elements). Step 2 conducts a Mission Implementation Study paired directly with a NASA implementation team at <b>JPL or GSFC</b> . |
| <b>Tier 3: Medium Explorer Class</b><br><br><i>(MIDEX, Earth Explorer)</i>                                  | \$300 Million to \$400 Million             | Heavy Two-Step AO; ~35 months to selection; heavy upfront institutional B&P burden.                         | <b>Streamlined Two-Step AO; ~19.5 months</b> (up to 45% reduction).                     | Follows the simplified Step 1 / Step 2 Mission Implementation Study framework, but widens Step 2                                                                 |

|                                                                                                                                        |                               |                                                                       |                                                                       |                                                                                                                                                                         |
|----------------------------------------------------------------------------------------------------------------------------------------|-------------------------------|-----------------------------------------------------------------------|-----------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                                                                                                                        |                               |                                                                       |                                                                       | implementation eligibility to include <b>universities, non-profits (e.g., APL, SwRI), and commercial industry partners</b> alongside NASA centers.                      |
| <b>Tier 4: Small Missions &amp; Payloads</b><br><br><i>(SMEX, Missions of Opportunity, Earth Venture, Rideshares, Hosted Payloads)</i> | \$20 Million to \$200 Million | Two-Step AO process; ~32 months from solicitation to final selection. | <b>Single-Stage Competition; ~19 months</b><br>(up to 40% reduction). | Eliminates the multi-year two-step loop entirely. Heavily leverages mature commercial satellite buses, rapid rideshare manifests, and "Science as a Service" data buys. |

## 5.1 Deep Dive: Tier 1 — Flagships (Directed Strategic Missions)

As outlined by Dr. Fox, CM 2.0 leaves the overarching governance of Flagship missions intact, noting that the agency had already instituted substantial management reforms for its largest strategic assets in the wake of the James Webb Space Telescope independent review boards and the *Large Mission Study* reports. In the Flagship regime—exemplified by ongoing preparations for the Habitable Worlds Observatory (HWO) in Astrophysics and the Uranus Orbiter and Probe priority in Planetary Science—NASA Headquarters assigns overall systems integration and project management to a lead NASA Center during early Pre-Phase A. However, CM 2.0 reinforces that Flagship architectures are no longer insulated from commercial integration. Even on multi-billion-dollar directed missions, lead centers are now mandated to continually survey the commercial landscape at regular intervals to procure commercial subsystems, optical communications relays, launch architectures, and spacecraft

platforms rather than defaulting to in-house bespoke fabrication.

## 5.2 Deep Dive: Tier 2 — Probes, New Frontiers, and Discovery

Tier 2 represents the core battleground where the legacy AO process experienced its greatest friction. Missions in this tier are highly complex robotic explorers:

- **Probes (Astrophysics and Heliophysics):** Inspired by the National Academies' *Pathways to Discovery in Astronomy and Astrophysics for the 2020s* (Astro2020) decadal survey, the Probe Explorers class bridges the massive gap between Medium Explorers (~300million) and Flagships (3+ billion). Just weeks prior to the CM 2.0 announcement, in September 2026, NASA advanced the first Astrophysics Probe mission—**PRIMA** (PRobe far-Infrared Mission for Astrophysics)—into Phase B development. Managed by JPL with a \$1.2 billion lifecycle cap targeting a 2033 launch, PRIMA features a cryogenically cooled 1.8-meter far-infrared telescope designed to study the co-evolution of galaxies and supermassive black holes, as well as planet-forming disks. While PRIMA navigated the legacy two-step process, future Probe competitions will operate under CM 2.0.
- **New Frontiers:** Medium-large planetary missions constrained to specific decadal survey targets (e.g., Comet Surface Sample Return, Lunar South Pole-Aitken Basin Sample Return, Ocean Worlds inquiries).
- **Discovery:** Principal Investigator-defined planetary missions open to any solar system target outside New Frontiers restrictions, capped around \$500 million to \$600 million.

Under CM 2.0, cutting the timeline from AO release to Step 2 selection from **35 months to 19.5 months** fundamentally alters the rhythm of planetary and astrophysical research. By stripping out 15.5 months of schedule drag, a scientific team can propose an investigation, complete peer review, partner with JPL or Goddard for the Mission Implementation Study, and reach Phase B confirmation within a single political administration or graduate student tenure cycle. Furthermore, because the NASA implementation team from JPL or GSFC works directly alongside the PI during Step 2, the resulting baseline design entering Phase B is actually *more* technically mature regarding agency risk posture than legacy Concept Study Reports, which frequently suffered from optimistic contractor cost assumptions that unraveled immediately after selection.

## 5.3 Deep Dive: Tier 3 — MDEX and Earth Explorers

The Medium-Class Explorer (MDEX) program in Astrophysics and Heliophysics, alongside the newly structured Earth Explorer line within the Earth Science Division (formulated to implement recommendations from the Earth Science Decadal Survey regarding Earth System Explorer observables such as greenhouse gases, ice elevation, and atmospheric winds), occupies an intermediate engineering regime.

While Tier 3 missions adopt the exact same two-stage timeline compression (reducing selection from 35 months to 19.5 months via the simplified three-element Step 1 proposal and Step 2 Mission Implementation Study), NASA introduced a vital institutional distinction between Tier 2 and Tier 3. Whereas Tier 2 Mission Implementation Studies are restricted to NASA's two flagship robotic centers (JPL and GSFC) to preserve core deep-space agency competencies, **Tier 3 implementation remains open to a broader ecosystem of managing organizations.** Specifically, leading academic laboratories and non-profit research institutes with proven

full-mission management capabilities—such as the Johns Hopkins University Applied Physics Laboratory (APL), the Southwest Research Institute (SwRI), the University of California, Berkeley Space Sciences Laboratory (SSL), the Laboratory for Atmospheric and Space Physics (LASP) at the University of Colorado Boulder, and major commercial aerospace integrators—are fully eligible to conduct the Step 2 Mission Implementation Studies and manage the flight project. This preserves the vibrant multi-institutional ecosystem that has historically made the Explorer program one of NASA’s most productive training grounds for space systems engineers and project managers.

## **5.4 Deep Dive: Tier 4 — Small Explorers (SMEX), Earth Venture, and Missions of Opportunity**

Perhaps the most aggressive structural streamlining in CM 2.0 occurs at the lower end of the cost spectrum: Small Explorers (SMEX), Earth Venture Missions and Instruments (EVM/EVI), Missions of Opportunity (MoO, such as contributing an instrument to an international partner’s spacecraft or deploying a high-altitude balloon/suborbital payload), hosted payloads on commercial satellites, and dedicated rideshare missions (such as theSIMPLEx program in planetary science or CubeSat constellations in heliophysics).

Historically, requiring a \$150 million SMEX mission or a \$35 million Earth Venture instrument to endure a two-step, 32-month evaluation process was widely criticized as bureaucratic overkill. In many instances, the two-step selection process took longer than the actual physical assembly and testing of the satellite itself. Moreover, the rapid pace of commercial small-satellite technology meant that electronic components and commercial bus architectures proposed in Step 1 were completely obsolete by the time the mission exited Step 2 nearly three years later.

CM 2.0 **eliminates the two-step process entirely for Tier 4 missions, transitioning them to a single-stage competition.** By consolidating scientific, technical, and programmatic review into a unified single-step architecture, NASA projects that the time from solicitation release to final flight selection will drop from **32 months to approximately 19 months—a 40 percent reduction.** This single-stage cadence allows small missions to ride the momentum of commercial satellite production lines and frequent commercial launch manifests (such as SpaceX Transporter missions or Rocket Lab Electron deployments), fulfilling the original Explorer philosophy of frequent, high-cadence access to space.

## **6. Quantitative Analysis of Timeline Compression**

To appreciate how CM 2.0 achieves a 40 to 45 percent reduction in selection duration without compromising scientific peer review or technical due diligence, it is instructive to examine the sequential activities that consumed 35 months under the legacy model versus the compressed workflow.

### **6.1 Where Did the 35 Months Go in the Legacy Process?**

In a traditional two-step Announcement of Opportunity for a Discovery or MIDEX mission, the calendar elapsed through the following sequential gates:

1. **Draft AO Release to Final AO Release (6 to 9 months):** Headquarters released a draft solicitation, collected hundreds of community questions regarding cost caps, launch

vehicle assumptions, and programmatic constraints, and adjudicated revisions across multiple NASA directorates.

2. **Final AO Release to Step 1 Proposal Submission (3 to 4 months):** Proposing teams finalized their multi-hundred-page documents, locked in subcontractor pricing letters, and submitted their packages (though in reality, teams had already been working for 12 to 24 months prior to the Draft AO).
3. **Step 1 Peer Review, TMC/CATE Analysis, and Down-Select (8 to 10 months):** Separate panels of scientists evaluated intrinsic science merit while armies of systems engineers and cost analysts conducted probabilistic CATE modeling on every submitted spacecraft design. This massive analytical burden created a nearly year-long bottleneck at NASA Headquarters.
4. **Step 2 Phase A Concept Study Execution (9 to 12 months):** The two to four down-selected finalist teams received Phase A funding, refined their industrial baselines, authored thousand-page Concept Study Reports, and prepared for physical site visits.
5. **Step 2 CSR Evaluation, Site Visits, and Final Selection (5 to 7 months):** Review panels traveled to contractor facilities, ran second-round CATE models, briefed the SMD Associate Administrator, and finalized the agency selection decision.

## 6.2 Mechanics of the 19.5-Month CM 2.0 Workflow

Under Competition Model 2.0, time savings are extracted primarily by eliminating redundant upfront engineering evaluations in Step 1 and restructuring how Phase A studies are conducted:

| Process Phase                          | Legacy Two-Step Duration               | CM 2.0 Target Duration | Primary Mechanism of Time Compression                                                                                                                              |
|----------------------------------------|----------------------------------------|------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>AO Release to Step 1 Submission</b> | ~9 to 12 months<br>(incl. Draft cycle) | <b>~4 to 5 months</b>  | 50% reduction in required proposal content; no need to negotiate complex industrial subcontractor agreements or detailed subsystem schematics prior to submission. |
| <b>Step 1 Review &amp; Down-Select</b> | ~8 to 10 months                        | <b>~4 to 5 months</b>  | Reviewers evaluate only the Science Case, Science Implementation Plan, and                                                                                         |

|                                                      |                   |                       |                                                                                                                                                                                                             |
|------------------------------------------------------|-------------------|-----------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                                      |                   |                       | Proof-of-Concept. Eliminates full-scale probabilistic CATE modeling on dozens of unselected Step 1 proposals.                                                                                               |
| <b>Step 2 Mission Implementation Study (Phase A)</b> | ~9 to 12 months   | <b>~6 to 7 months</b> | Direct integration of pre-established JPL/GSFC implementation teams (or qualified Tier 3 centers) eliminates contractor onboarding friction; standardized commercial bus catalogs accelerate trade studies. |
| <b>Step 2 Evaluation &amp; Final Selection</b>       | ~5 to 7 months    | <b>~3 to 4 months</b> | Continuous insight by NASA implementation personnel during the study reduces the need for prolonged adversarial post-submission auditing and multi-month CATE reconciliation.                               |
| <b>Cumulative Duration</b>                           | <b>~35 Months</b> | <b>~19.5 Months</b>   | <b>Net reduction of ~15.5 months (~44–45% faster to Phase B initiation).</b>                                                                                                                                |

## 7. Commercial Integration and "Science as a Service"

A defining pillar of Competition Model 2.0—reflecting both the evolution of the aerospace market by 2026 and the strategic priorities of NASA Administrator Jared Isaacman—is the deep embedding of commercial space capabilities across every mission tier.

Historically, NASA treated the spacecraft bus (the structural frame, solar arrays, batteries, reaction wheels, star trackers, propulsion tanks, and flight computers) and the scientific payload (telescopes, spectrometers, magnetometers, radar arrays) as a single integrated, custom-engineered system. While this approach made sense in the 1970s and 1980s when every deep-space mission pushed the fundamental boundaries of avionics and propulsion, by the mid-2020s, basic spacecraft bus operations in low-Earth orbit, geostationary orbit, and even cislunar and inner-planetary regimes had become thoroughly commoditized.

### 7.1 Mandatory Commercial Bus Evaluation

Under CM 2.0, Dr. Fox explicitly established that mission teams are expected to utilize **commercial spacecraft platforms (buses) and commercially available subsystems** wherever they offer technical, schedule, or cost advantages. Rather than spending millions of dollars of NASA engineering time redesigning a standard three-axis stabilized satellite bus or a Hall-effect solar electric propulsion stage from scratch, Step 2 Mission Implementation Studies will systematically survey commercial production lines.

This approach builds directly on recent agency milestones. For example, in June 2026, NASA selected three commercial lunar providers—Astrobotic, Firefly Aerospace, and Intuitive Machines—to deliver four new scientific payload suites to the Moon in late 2028 under the Commercial Lunar Payload Services (CLPS) framework. Similarly, the rapid maturation of high-energy commercial kick stages and interplanetary transfer vehicles has demonstrated that private vendors can deliver scientific payloads to Lagrange points, near-Earth asteroids, Mars, and Venus at fixed prices dramatically below traditional cost-plus aerospace contracts.

### 7.2 "Science as a Service" and Data Procurement Models

Beyond purchasing commercial hardware, CM 2.0 expands upon SMD's recent **Science as a Service Request for Information (RFI)**. In traditional NASA procurement, the government buys and owns the physical spacecraft, assumes all development and launch risks, operates the mission via civil service and contractor flight controllers, and processes the raw telemetry. Under emerging "Science as a Service" paradigms integrated into CM 2.0:

- **Turnkey Mission Delivery:** A proposing PI team can specify the calibrated scientific measurements required at a given orbital destination, while a commercial vendor provides the end-to-end spacecraft, launch integration, and mission operations on a milestone-based, fixed-price service contract—freeing the PI team to focus almost exclusively on instrument calibration and scientific analysis.
- **Commercial Data Buys and Hosted Payloads:** Particularly within the Earth Science and Heliophysics divisions, where commercial constellations already monitor terrestrial weather, radio occultation profiles, hyperspectral surface reflectance, and space weather environments, CM 2.0 streamlines the procurement of commercial observational

datasets and the hosting of NASA sensors aboard commercial communications or Earth-observation buses.

## 8. Governance, Risk Management, and Cost Discipline

A recurring critique whenever NASA attempts to accelerate selection timelines or reduce upfront proposal documentation is the danger of **underestimating technical complexity and cost**. In the spaceflight engineering community, this tension is often framed through the lens of the classic project management iron triangle: cost, schedule, and performance (or risk). Critics of the 1990s "Faster, Better, Cheaper" initiative rightfully pointed out that stripping away systems engineering rigor in the name of speed occasionally led to underfunded projects flying with fatal single-point failures.

NASA's architecture for CM 2.0 directly confronts this historical vulnerability by **shifting where and how technical rigor is applied, rather than eliminating it**, and by pairing streamlined selection with strict post-selection cost enforcement.

### 8.1 Moving Risk Identification from Adversarial Auditing to Collaborative Formulation

In the legacy AO process, risk identification was largely adversarial. A proposing team would spend two years constructing a Step 1 proposal designed to hide or minimize perceived risks so that NASA's external TMC reviewers wouldn't penalize them. Because the team was locked into a fixed spacecraft architecture and industrial partner from Day 1, if a technical flaw or cost growth surfaced during Phase A, the team had very little flexibility to alter the mission's fundamental geometry without invalidating their entire proposal.

Under CM 2.0, because Step 1 only requires a Proof-of-Concept mission design, the architecture remains deliberately fluid entering Step 2. During the Step 2 Mission Implementation Study, the NASA Implementation Team from Goddard or JPL is not an adversarial auditor grading a finished paper; they are co-architects tasked with finding every hidden technical vulnerability *before* the mission baseline is locked in.

As outlined in the CM 2.0 framework, **Phase A estimates generated during the Mission Implementation Study will explicitly inform complexity and scope trades**. If the joint PI/NASA study team discovers that a three-instrument payload exceeds the thermal or mass margins of a standard commercial bus, or that a cryogenic cooler carries high schedule risk, they can immediately trade scope—such as simplifying an instrument mode, adjusting the orbital inclination, or selecting a higher-capacity commercial bus—during Step 2. Consequently, when the mission is finally selected at the end of the 19.5-month cycle to enter Phase B, its cost, schedule, and risk postures have been vetted from the inside out by NASA's own premier implementation engineers.

### 8.2 Hard Cost Caps and the Consequence of Termination

Over the past decade, NASA's Science Mission Directorate struggled with "pipeline clogging"—a phenomenon where a handful of medium or large missions experienced severe cost overruns during Phase B/C/D (often due to supply chain disruptions, contractor underperformance, or late technology maturation), forcing SMD to raid funding from future Announcement of Opportunity lines, delay upcoming launches, or cancel smaller missions just

to bail out the overrunning project. High-profile examples in the early-to-mid 2020s, such as the restructuring of the Geospace Dynamics Constellation (GDC), the cancellation of the VIPER lunar rover following cost and schedule growth, and the protracted redesign of Mars Sample Return, underscored the destructive impact of cost growth on the broader scientific community.

To protect the high-cadence pipeline promised by CM 2.0, Associate Administrator Fox issued an unmistakable mandate regarding **Cost and Schedule Discipline**:

*"Rigorous cost and schedule control remains mandatory across every mission class. Phase A estimates will inform complexity and scope trades. Therefore, breaches of control thresholds will carry real consequences of up to, and including, mission termination. That discipline is how we keep the pipeline flowing for everyone."*

From a systems management perspective, this policy signals a transition from "too big to fail" bailouts toward strict portfolio stewardship. By establishing realistic complexity trades during the Step 2 Mission Implementation Study and holding selected teams to hard control thresholds during Phase B and Phase C, SMD aims to ensure that cost growth on a single Discovery or Explorer project cannot starve the directorate of the funds required to release the next competition on schedule.

## 9. Broader Implications for the Scientific and Aerospace Ecosystem

The rollout of Competition Model 2.0—beginning with a virtual agency-wide Town Hall on October 26, 2026, and phased implementation across upcoming solicitations—carries profound structural implications for the three primary pillars of the United States space science enterprise: academia, NASA field centers, and the commercial aerospace industry.

### 9.1 Democratizing Scientific Leadership in Academia

For university-based researchers, CM 2.0 represents a major corrective toward meritocratic accessibility. Under the legacy paradigm, the cohort of Principal Investigators capable of winning a Discovery or Explorer mission was heavily skewed toward senior scientists at a small cluster of elite institutions who possessed decades of institutional memory and deep personal networks within JPL, Goddard, or Lockheed Martin.

By evaluating Step 1 proposals strictly on the **Science Case**, **Science Implementation Plan**, and a high-level **Proof-of-Concept**, CM 2.0 decouples scientific creativity from corporate business development machinery. An associate professor at a public university with a novel spectrometer concept or a brilliant observational strategy for magnetospheric reconnection can assemble a focused science team and submit a Step 1 proposal without needing three million dollars of institutional backing. If the science case is judged by peers to be among the most compelling in the nation, NASA itself steps in at Step 2 to provide the heavy systems engineering and mission implementation horsepower via GSFC or JPL (for Tier 2) or facilitates pairing with qualified implementation partners (for Tier 3). This structural shift is explicitly designed to broaden the demographic, geographic, and institutional diversity of NASA flight Principal Investigators.

### 9.2 Rebalancing the Roles of Goddard Space Flight Center and JPL

For the civil service and contractor workforces at NASA's Goddard Space Flight Center and the Jet Propulsion Laboratory, CM 2.0 resolves a longstanding institutional paradox. Over the past decade, as congressional appropriations fluctuated and Flagship cadence shifted, both centers faced acute anxieties regarding how to maintain critical engineering skills—such as entry, descent, and landing (EDL) specialists, deep-space navigation teams, optical alignment engineers, and radiation-hardened avionics architects—when a center failed to win a major AO step-down.

Under CM 2.0, NASA Headquarters explicitly intends to **direct Mission Implementation Study and project implementation work to GSFC and JPL where appropriate**. This transition achieves three vital institutional objectives:

1. **Elimination of Inter-Center Fratricide:** Goddard and JPL no longer need to spend tens of millions of dollars of internal overhead constructing rival Step 1 proposals designed to defeat one another.
2. **Cross-Center Collaboration:** When a brilliant science concept advances to Step 2, NASA can assign the center whose specific technical competencies best match the mission profile—or even construct blended multi-center implementation teams drawing on JPL's deep-space navigation heritage and Goddard's instrument integration facilities simultaneously.
3. **Workforce Retention and Predictability:** By smoothing out the feast-or-famine cycle of blind AO competitions, center directors can manage engineering workforce allocations predictably across multiple fiscal years, preserving critical national capabilities for future strategic endeavors.

### 9.3 Reshaping Industrial Aerospace Strategy

For traditional aerospace prime contractors (such as Lockheed Martin, Northrop Grumman, and BAE Systems) as well as emerging space companies (such as Rocket Lab, Blue Origin, Impulse Space, and Apex), CM 2.0 forces a significant pivot in business development strategy. In the legacy era, major prime contractors often captured missions by locking in an exclusive teaming agreement with a prominent PI and a NASA center two years *before* an AO was released, effectively freezing out competitors before the government ever saw a proposal. Under CM 2.0, because Step 1 requires only a Proof-of-Concept and delays detailed mission implementation trades until the Step 2 study conducted alongside NASA's implementation team, early exclusive lock-ins lose much of their strategic leverage.

Instead, aerospace vendors are incentivized to compete on the **actual technical maturity, cost-effectiveness, and production readiness of their spacecraft buses and subsystems during Step 2 and single-stage Tier 4 competitions**. Companies that maintain active, flight-proven product lines with transparent pricing, modular payload interfaces, and predictable delivery schedules will be positioned to capture a high volume of tasks across SMEX, MIDEX, Discovery, and Probe implementations, while contractors relying on bespoke, high-overhead design studies may find themselves bypassed during Phase A complexity trades.

## 10. Potential Challenges and Implementation Risks

While Competition Model 2.0 addresses the most acute pathologies of the legacy selection

system, the transition to this new architecture is not without operational risks and potential unintended consequences. As NASA rolls out CM 2.0 in stages and refines the mechanics through community feedback, four primary challenges warrant close analytical scrutiny:

### **10.1 The Step 1 "Floodgate" Problem and Peer Review Bandwidth**

A classic dilemma in research administration occurs whenever the barrier to submitting a proposal is significantly lowered: the total volume of submissions increases dramatically. In the legacy AO process, the sheer difficulty and multi-million-dollar expense of assembling a Step 1 package acted as a brutal natural filter, typically limiting Discovery or MIDEX rounds to roughly 15 to 30 submissions.

By cutting the required Step 1 material in half and removing the requirement for an established industrial consortium, NASA may easily see the number of Step 1 proposals double or triple in upcoming solicitations. While a surge of creative ideas is scientifically desirable, evaluating 60 to 80 mission proposals within a compressed four-to-five-month window will place immense strain on NASA's peer-review infrastructure. SMD will need to carefully structure its review panels—potentially utilizing phased triage protocols or rigorous Proof-of-Concept plausibility checks—to ensure that reviewers are not overwhelmed and that superficial concepts with fatal physical flaws do not crowd out well-engineered proposals.

### **10.2 Defining the Boundary of the "Proof-of-Concept"**

The intellectual linchpin of the new Step 1 evaluation is the **Proof-of-Concept Mission Design**. Striking the exact regulatory calibration for this document will be delicate. If NASA writes the AO guidelines too loosely, proposing teams might propose scientifically dazzling instrument suites that violate basic thermodynamic, mass, or orbital mechanics constraints, wasting valuable Step 2 slots on unbuildable concepts.

Conversely, if risk-averse review panels begin subtly rewarding Step 1 proposals that sneak extra engineering detail into their Proof-of-Concept sections, an "arms race" will quickly resume. Well-funded institutions will once again spend millions of dollars pre-engineering their Step 1 submissions to look safer than bare-bones academic submissions, quietly recreating the very inequality CM 2.0 was designed to abolish. NASA Headquarters will need to enforce strict page limits, standardized parametric templates, and explicit instructions prohibiting review panels from grading engineering maturity beyond basic physical and programmatic feasibility in Step 1.

### **10.3 Navigating the Cultural Marriage in Step 2**

For Tier 2 missions (Probes, New Frontiers, Discovery), pairing an external university Principal Investigator with an assigned NASA implementation team from JPL or Goddard at the start of Step 2 requires rapid organizational integration. In the legacy model, the PI and the managing center had usually worked together for two years prior to Step 1 submission, building interpersonal trust and shared technical vision.

Under CM 2.0, a PI who wins Step 1 independently must immediately form a cohesive partnership with a JPL or GSFC implementation team and compress a massive Mission Implementation Study into roughly six to seven months. Ensuring that the Principal Investigator retains genuine scientific authority over scope trades during Step 2—rather than being steamrolled by a large NASA center's institutional preferences—will require clear governance

charters and active mediation from the SMD Program Office.

## 10.4 Balancing Center Workshare Against Academic and Commercial Growth

Finally, while directing Tier 2 implementation work to Goddard and JPL stabilizes those crucial agency centers, independent institutions that previously competed to manage Discovery or New Frontiers missions—most notably the Johns Hopkins University Applied Physics Laboratory (which successfully managed *New Horizons*, *MESSENGER*, *Parker Solar Probe*, *DART*, and the *Dragonfly* rotorcraft) and the Southwest Research Institute—will watch closely to see how NASA defines the boundary between center-directed implementation and external eligibility. While CM 2.0 explicitly preserves university and industry eligibility for MIDEX, Earth Explorer, and all Tier 4 small missions, maintaining healthy opportunities for non-NASA research institutes in larger planetary and astrophysical endeavors will remain an important topic of dialogue during the staged rollout.

## 11. Conclusion: Realigning Process with Scientific Discovery

The overarching trajectory of space science in the late 2020s is defined by an unprecedented convergence of scientific ambition and technological capability. Across the solar system and beyond, Decadal Surveys have outlined compelling inquiries: probing the subsurface oceans of icy moons for prebiotic chemistry, mapping the far-infrared universe to witness the birth of the first planetary systems, monitoring Earth’s coupled climate and ecological reservoirs with sub-meter precision, and forecasting the dynamic space weather environment as human explorers return to the lunar surface under the Artemis program. Simultaneously, the commercial space economy has lowered launch costs and transformed spacecraft manufacturing from a cottage craft into an industrial enterprise.

For too long, however, the bureaucratic machinery governing how NASA selected its competed science missions operated out of sync with this technological momentum. A 35-month selection cycle that consumed half a decade of a scientist’s career before a single piece of flight hardware was bent—and that required millions of dollars in corporate underwriting just to enter the room—had become unsustainable.

By introducing **Competition Model 2.0**, NASA’s Science Mission Directorate has executed a comprehensive structural course correction. Through cutting Step 1 proposal requirements in half to focus on scientific merit, compressing selection timelines by up to 45 percent (down to 19.5 months for two-stage missions and 19 months for single-stage small missions), transforming Goddard and JPL from warring competitors into collaborative Step 2 implementation partners, and institutionalizing commercial spacecraft platforms alongside rigorous cost discipline, CM 2.0 realigns the acquisition process with its fundamental purpose. If executed with discipline and transparency, this reformed architecture promises to shift the intellectual energy of the scientific community away from the friction of perpetual proposal writing and back toward the rapid, high-cadence exploration of the cosmos.