The Operational Framework and Early Scientific Yield of the James Webb Space Telescope: A Structured Literature Review on Observation Time Access Policies, Procedures, and Opportunities (Cycles 1–4)

Summary, Step-by-Step Guide to JWST Proposal Success, and Comprehensive Proposal Checklist see: https://circularastronomy.com/2025/10/11/the-91-battle-for-time-the-operational-framework-and-the-dual-anonymous-system-that-selects-the-universes-next-great-discoveries/

I. Executive Summary and Context

I.1. Purpose, Scope, and Methodology of the Review

This structured literature review provides a detailed examination of the operational policies and governance architecture regulating community access to the James Webb Space Telescope (JWST). The analysis encompasses the period from the observatory's inaugural General Observer (GO) Cycle 1 through the finalized policy implementations for Cycle 4.[1] The scope specifically addresses the mechanisms for resource allocation: the community-driven General Observer (GO) program, the historically designated Guaranteed Time Observations

(GTO) program, and the flexible Director's Discretionary Time (DDT) programs.[3]

The analytical focus is twofold. First, the report assesses the effectiveness of the Space Telescope Science Institute (STScI) Time Allocation System (TAS) in managing unprecedented scientific demand, specifically evaluating the efficacy and procedural consequences of the Dual Anonymous Peer Review (DAPR) process and the prioritization dictated by the formal selection criteria (In-field Impact, Out-of-field Impact, and Suitability & Feasibility).[4] Second, the review correlates these allocation patterns with the telescope's early scientific yield, identifying the thematic areas where JWST has delivered paradigm-shifting discoveries.

The core findings confirm that access to JWST is defined by intense, sustained competition, with an overall oversubscription rate consistently approaching 9:1.[5] This high demand has necessitated continuous, adaptive policy evolution, as evidenced by significant structural changes implemented for Cycle 4.[7] Furthermore, the allocation framework has demonstrably succeeded in channelling resources toward transformative science, rapidly accelerating discovery in high-redshift cosmology and exoplanet atmospheric characterization.[9]

I.2. Core Findings on Access Policy Efficiency and Scientific Returns

The immense scientific productivity and operational success of JWST have precipitated an exponential growth in proposal volume, placing significant strain on the peer review infrastructure. The Cycle 3 submission count of 1,931 proposals broke the record for any observatory worldwide, a record subsequently surpassed in Cycle 4, which received 2,377 submissions.[7] This level of institutional pressure necessitated severe policy adjustments, most notably the halving of proposal page limits for Cycle 4, a critical measure intended to manage the reviewer workload and prioritize review efficiency over traditional proposal depth.[12]

The DAPR system, instituted to mitigate bias, has proven overwhelmingly successful in its primary mandate, with 89% of panelists confirming that the procedure effectively focused discussions on scientific merit rather than the identities of the proposing teams.[14] However, maintaining procedural compliance is challenging. The rigorous enforcement of anonymity and page limits resulted in 30 proposals being disqualified in Cycle 4, including 12 for DAPR violations, underscoring the high procedural cost required to maintain the equity and integrity of the selection process.[4]

Analysis of the early scientific output shows a concentration of resources in areas requiring JWST's unique infrared capabilities. The resulting breakthroughs in studying high-redshift galaxies and characterizing exoplanet atmospheres drove STScI to formalize these fields into distinct, high-demand science categories in the Cycle 4 Call for Proposals (CfP).[5]

I.3. The JWST Time Allocation Challenge: Demand vs. Capacity

The James Webb Space Telescope currently represents the most oversubscribed astronomical facility in history. In Cycle 4, investigators requested a total of 75,138 hours against the 8,500 hours available for allocation, resulting in an oversubscription rate of approximately 8.8:1, similar to the 9:1 rate observed in Cycle 3.[6]

A critical observation regarding resource planning pertains to the phenomenon of scientific demand saturation. Despite a substantial increase in available observing time for GO programs in Cycle 4, from 5,500 hours in Cycle 3 to 8,500 hours [15], the overall oversubscription rate remained nearly constant at 9:1.[5] This stability in the competitive ratio, coupled with the submission record of 2,377 proposals in Cycle 4 compared to 1,931 in Cycle 3 [8], indicates that the increase in observational capacity was immediately absorbed by a proportionally larger volume of high-quality submissions. The Time Allocation System is operating at a state of sustained scientific saturation, where the observatory's excellent performance drives an exponentially rising demand that incremental resource increases cannot effectively temper.

II. The Regulatory and Procedural Architecture of JWST Access

II.1. Defining the Pillars of Observation Time (OTA)

The operational framework for JWST is structured around three principal mechanisms for accessing observation time: the General Observer (GO) program for the broad community, the Guaranteed Time Observations (GTO) program for developers, and the Director's Discretionary Time (DDT) program for urgent or strategic observations.[2]

II.1.1. General Observer (GO) Program: The Mechanism for Open Community

Access

The GO program serves as the fundamental mechanism by which the global astronomical community applies for observation time, typically through annual Calls for Proposals administered by STScI.[1] The success of the program is evident in its global engagement; Cycle 3 submissions, for instance, involved 6,291 unique investigators from 57 countries and 47 US states plus the District of Columbia.[18] Canadian Principal Investigators (PIs), as one example of international success, secured nearly 263 hours in Cycle 3, representing a 30% increase in awarded time compared to Cycle 2 results.[19]

GO proposals are categorized by their requested observation length into defined size categories: Very Small, Small, Medium, and Large/Treasury. The total available time for General Observers has fluctuated, beginning with up to 6,000 hours in Cycle 1 [1] and reaching 8,500 hours in Cycle 4.[15] The allocation of resources within these size bins is dynamically adjusted based on the proportional pressure observed within the various scientific categories.[16]

II.1.2. Guaranteed Time Observations (GTO): Legacy Commitment and Initial Science Goals

The GTO program was established to compensate scientists who were instrumental in developing the key hardware, software, or technical knowledge essential for JWST’s operation. This allocation rewards the Principal Investigators of the four science instruments (MIRI, NIRCam, NIRISS, and NIRSpec), the U.S. MIRI Science Lead, and six Interdisciplinary Scientists (IDS).[3]

Collectively, GTO programs accounted for approximately 16% of the observatory’s observing time throughout the first three operational cycles.[3] Following Cycle 3, the allocation of additional GTO programs is not anticipated.[3] These strategic observations were crucial for defining the early scientific landscape. For instance, the NIRSpec Wide survey, part of the NIRSpec Instrument Science Team's GTO, dedicated 105 hours to spectroscopically survey over 3,200 distant galaxies () across the CANDELS fields.[20] Such large-scale foundational datasets, alongside dedicated GTO calibration efforts on debris disks and exoplanets [3], were critical in validating instrument performance and setting initial benchmarks for community research.

The strategic deployment of GTO time, particularly through the Director's Discretionary-Early Release Science (DD-ERS) programs, served as a deliberate mechanism to accelerate community readiness. Although GTO programs consumed a fixed portion of the early operational time, the institutional choice to designate certain GTO programs with no exclusive access period ensured that critical, foundational data became immediately public.[3] This action effectively democratized knowledge about JWST instrument capabilities and data processing pipelines, accelerating the learning curve for the global community. The rapid community adoption and subsequent submission volume observed in Cycles 2 and 3 are, in part, a consequence of this early strategic GTO policy designed to bootstrap the research community.

II.1.3. Director's Discretionary Time (DDT and DD-ERS): Mandates for Urgency and Community Readiness

The DDT program provides the STScI Director with the flexibility to allocate observation time for programs that exhibit exceptional scientific urgency or are time-critical, observations that could not wait until the subsequent main proposal cycle.[3] Standard DDT submissions are restricted in scope and time requested, falling into two primary sub-categories: Time-Critical DD for transient phenomena (e.g., a newly discovered supernova) and Discovery DD for observations of compelling urgency that accelerate discovery, such as crucial follow-up for major facilities planning.[3]

A notable precursor was the Director's Discretionary-Early Release Science (DD-ERS) program, developed during the pre-operational phase. The explicit goals of DD-ERS were to ensure open access to representative datasets and engage a broad cross-section of the astronomical community in familiarizing themselves with JWST data, directly supporting the preparation of high-quality Cycle 2 proposals.[2] DDT continues to facilitate unique, urgent science. For example, the JWST Rocky Worlds Director's Discretionary Time program successfully executed time-sensitive observations of two secondary eclipses of the terrestrial exoplanet GJ 3929b using MIRI photometric imaging.[22]

III. Analysis of Demand, Allocation, and Operational Load (Cycles 1–4)

III.1. Longitudinal Trends in Proposal Submission Volume

The operational history of JWST has been characterized by a relentless surge in proposal submissions, signaling high demand and scientific excitement surrounding the observatory's performance.[17]

Table 1: Longitudinal Trends in JWST Proposal Demand and Allocation (Cycles 1–4)

Cycle	**GO Hours Available (Approx.)**	**Total Proposals Submitted**	**Total Hours Requested (GO/AR)**	**Oversubscription Rate (Hours Requested /Allocated)**	**Key Policy/Operational Change**
1	6,000	1,173	N/A	N/A	Establishment of GTO/DD-ERS [1]
2	N/A	1,601	N/A	N/A	Broke HST Submission Record [7]
3	5,500	1,931	48,320	9:1	System Strain Noted; Policy Review Initiated [17]
4	8,500	2,377	75,138	8.8:1 (Approx. 9:1)	Increased Hours; Reduced Page Limits; Restructured TAC [8]

The submission volume escalated dramatically, rising from 1,173 proposals in Cycle 1 to 1,931 in Cycle 3.[7] This sustained growth resulted in a critical operational stress point. The jump between Cycle 2 and Cycle 3 led the STScI Science Policies Group (SPG) to note that the sheer workload was "straining the traditional process" used for time allocation and archival reviews.[7] This acknowledgment of institutional strain necessitated the comprehensive operational policy review and resulting structural changes implemented for Cycle 4.

III.2. Dissecting Oversubscription: Pressure by Proposal Size Category (Cycle 4)

While the overall oversubscription rate stabilized at approximately 9:1 in Cycles 3 and 4, closer examination reveals significant competitive variation among the proposal size categories. This distribution of pressure is critical for understanding where the most acute resource limitations exist within the STScI selection process.[16]

Table 2: JWST Cycle 4 Competitive Pressure by Proposal Size Category

Proposal Size Category	**Hours Requested**	**Hours Allocated (Approx.)**	**Oversubscription Rate**
Very Small (20 hrs)	10,299	1,950	5.3:1
Small (> 20 and 50 hrs)	26,454	2,900	9.1:1
Medium (> 50 and 130 hrs)	25,610	2,250	**11.4:1**
Large (> 130 hrs)	12,775	1,400	9.1:1

The data for Cycle 4 reveals that the Medium program category experienced the highest competitive pressure, with an oversubscription rate of 11.4:1, significantly exceeding the overall average of 8.8:1.[16]

This disproportionate spike in the competitive pressure for Medium programs suggests a high community consensus regarding the optimal resource scope needed to achieve Grade 2 "Major Advancement" science.[4] Researchers appear to perceive the 50 to 130-hour range as the most efficient commitment necessary to pursue robust, high-impact science that is technically feasible, without incurring the heightened logistical complexity, risk profile, and resource commitment associated with a Large GO program. Consequently, the high competition in this middle tier means that the Telescope Allocation Committee (TAC) must reject a higher proportion of scientifically meritorious proposals in this category compared to the others. This imbalance indicates a structural constraint within the current program sizing model, where the allocated hours for Medium proposals do not reflect the intense consensus demand for this intermediate scope of work.

IV. Peer Review Policy and Criteria: Ensuring Scientific Merit

IV.1. Implementation and Effectiveness of Dual Anonymous Peer Review (DAPR)

IV.1.1. The DAPR Mechanism: Principles of Bias Mitigation and Focus on Science

The cornerstone of JWST's TAS is the Dual Anonymous Peer Review (DAPR), a mechanism designed to uphold the equity and integrity of the proposal review process by concealing the identities of both the reviewers and the proposing team.[4] The explicit goal is to focus the review solely on the scientific merit of the proposal, preventing the influence of reputation or institutional prestige.[4]

The efficacy of DAPR is strongly supported by the community. Survey data from NASA Astrophysics programs, including JWST, indicated that 89% of panelists agreed or strongly agreed that the procedure successfully shifted panel discussions to focus on the science rather than the identities of the team members.[14] To uphold this focus, proposers are strictly mandated to exclude any discussion of the team's expertise, prior experience, institutional acknowledgements, or grant funding sources from the scientific justification narrative.[4] Furthermore, specific investigator roles, such as the work to be done by a student or postdoc, must not be mentioned. The dedicated "Team Expertise and Background" section is only made visible to the TAC *after* the scientific merit rankings have been established, ensuring the initial judgment remains unbiased.[4]

IV.1.2. Compliance Challenges: Procedural Burden and Disqualifications

While DAPR is essential for maintaining fairness, its strict compliance requirements, coupled with the immense volume of submissions, present a significant procedural challenge. The rigorous enforcement of policy, particularly regarding anonymity and proposal length, is a necessity given the intensity of competition. In Cycle 4, STScI investigated 106 proposals for potential violations.[8]

This compliance review resulted in 30 total disqualifications (DQ'ed), including 12 proposals for violating DAPR rules and 14 for exceeding the newly reduced page limits.[8] The substantial number of disqualifications highlights a fundamental tension in the selection framework. The rules designed to ensure equity (DAPR) and manage workload (reduced page limits) collectively impose a significant procedural burden. For highly complex or technically challenging proposals, the necessity to conceal relevant team expertise while simultaneously justifying feasibility with severely restricted narrative space creates a difficult trade-off. Policy mandates designed to increase efficiency and equity inadvertently elevate the risk of disqualifying potentially transformative science if high-caliber teams fail to meticulously comply with the stringent anonymization and length restrictions.[4]

IV.2. The Structured Evaluation Criteria: Scientific Prioritization

The JWST Time Allocation System utilizes a structured grading system based on three core, weighted criteria to evaluate General Observer proposals, focusing on the potential for maximum scientific return from the unique capabilities of the observatory.[4]

The three criteria are: **In-field Impact**, evaluating the transformative potential within the immediate sub-field; **Out-of-field Impact**, assessing the broader implications for other areas of astronomy; and **Suitability & Feasibility**, determining the technical soundness and the necessity of using JWST.[4] Proposals are graded on a 5-point scale, where Grade 1 signifies a "Transformative advancement" and Grade 5 indicates "Limited or no advancement."

For a proposal to be maximally competitive (Grade 1), it must satisfy all three criteria simultaneously, confirming that the proposed program is capable of delivering transformative results in its sub-field, possesses extremely broad and significant implications beyond that field, and can *only* be achieved using JWST's unique capabilities with an extremely efficient and clear path to science.[4]

The Suitability & Feasibility criterion is particularly stringent for GO programs. Proposers must explicitly demonstrate that JWST is required because archival data is insufficient or non-existent, and that the observing plan utilizes telescope resources efficiently. Furthermore, to eliminate the subjective trimming of ambitious proposals by reviewers, the TAC panels are specifically instructed to recommend or reject proposals as written, without modifying the requested number of targets or hours, placing a high premium on robust initial justification.[4]

V. Policy Evolution and System Adaptations (Responding to Volume)

V.1. Challenges of Scale: Structural Changes to the TAC

The sustained, record-breaking proposal submission volume proved operationally challenging for the traditional STScI review structure. The growth from 1,601 proposals in Cycle 2 to 1,931 in Cycle 3 demonstrated that the workload was quickly becoming unsustainable for the existing Telescope Allocation Committee configuration.[7]

In response to this institutional crisis of success, STScI implemented major structural changes for the Cycle 4 review, recruiting the largest TAC ever assembled.[8] The Cycle 4 TAC consisted of an Executive Committee (EC) comprising 2 EC Chairs and 36 Panel Chairs and Vice Chairs, and 183 Discussion Panelists distributed across 18 topical panels.[8] To manage the unprecedented volume of 2,377 submissions, responsibilities were delineated: the EC focused on reviewing the highest-stakes proposals, including Large GO (hours), Treasury GO, Legacy Archival Research (AR), and Pure Parallels. The Discussion Panels were tasked with reviewing Small, Medium, Target of Opportunity (ToO), and Survey programs, a measure implemented to achieve a reduced and more balanced workload across the entire review body.[8]

V.2. Key Policy Shifts in Cycle 4 Call for Proposals (CfP)

The need to adapt to the volume and scientific output of the early cycles resulted in several highly consequential policy shifts formalized in the Cycle 4 Call for Proposals (CfP).

V.2.1. Adjustment of Proposal Boundaries and Page Limits

In Cycle 4, the available prime observation time for the community was significantly increased from 5,500 hours in Cycle 3 to 8,500 hours, reflecting the successful clearance of the backlog from Cycle 1 and the established efficiency of the observatory.[12]

To directly address the operational strain noted by the JWST Users Committee (JSTUC) regarding reviewer workload [7], STScI implemented a substantial reduction in proposal page limits, halving them in most categories.[12] This reduction is a significant procedural alteration that requires proposers to achieve a necessary level of scientific and technical justification in a much more concise format.

V.2.2. Restructuring of Science Categories to Match Observational Demographics

Historically, the JWST science categories drew heavily from Hubble and Spitzer observatory heritage.[7] However, the early scientific output of JWST demonstrated a shift in focus and specialized capability. The categories were therefore adjusted in Cycle 4 to better align with the actual distribution of successful JWST science topics.[15]

New, more defined categories were established, including "High-Redshift Galaxies and the Distant Universe" and "Exoplanet Atmospheres and Habitability".[7] The dominance of these fields—High-z galaxies was the most popular category in Cycle 4 submissions, closely followed by Exoplanet Atmospheres [5]—confirmed the institutional necessity of these new designations.

This refinement of science categories serves a crucial function in the high-volume environment. By establishing narrower, more topical review bins, STScI improves the accuracy of matching proposal keywords with reviewer expertise. This optimized expertise matching strengthens the validity of the DAPR outcome, as it maximizes the likelihood that panelists reviewing a submission are true domain experts capable of accurately assessing the "In-field Impact" criterion, thereby ensuring that even under record submission pressure, the quality of scientific assessment remains high.[4]

VI. Scientific Opportunities and Breakthrough Themes

VI.1. Thematic Prioritization and Early Successes

The allocation process has prioritized fields leveraging JWST's unique access to the infrared spectrum. As noted, the most competitive scientific categories are overwhelmingly "High-z galaxies" and "Exoplanet Atmospheres".[5]

Beyond these flagship areas, the observatory has also catalyzed major growth in dedicated Solar System research. Cycle 4 saw a significant increase, with a 225% increase in allocated hours for Solar System GO proposals compared to Cycle 3. This increase, which outpaced the overall 155% increase in available time, demonstrates JWST's versatility.[16] Successful Solar System programs approved in Cycle 4 include highly specific targets such as studies of Jupiter's circulation patterns and the Great Red Spot (GRS), observations of Uranian satellite , and investigations into the aurorae of Uranus and Neptune.[16]

VI.2. Literature Review: Transformative Findings in Extragalactic Astronomy

JWST observations have fundamentally altered the field of cosmology, delivering data that is prompting a "transformative moment in cosmic research" and necessitating the revision of prevailing science textbooks.[9]

A landmark synthesis paper, resulting from the 2024 ISSI Breakthrough Workshop, compiled the collective insights into the Universe's first billion years. Co-chaired by Angela Adamo, Pascal Oesch, and Antonella Nota, this work charted a new census of early galaxies, detailing their masses, structures, and formation histories, and revealing the unexpected detection of massive black holes at remarkably early times.[9]

In a related high-impact study, researchers led by Haojing Yan utilized JWST's Near-Infrared Camera and Mid-Infrared Instrument (NIRCam and MIRI) to observe deep into the universe, identifying over 300 candidate early galaxies that appeared brighter than expected.[23] This discovery, which relies on JWST's unique capacity to detect redshifted light from the most distant regions, presents findings that "could challenge current ideas about how galaxies formed" during the period when the first stars and galaxies took shape.[23] Such an outcome exemplifies a successful Grade 1 proposal, achieving simultaneous transformative impact within its sub-field and broad implications for cosmology.[4]

VI.3. Literature Review: Exoplanets and Planetary System Science

JWST has rapidly become the pre-eminent facility for characterizing exoplanet atmospheres, a theme recognized by its specific categorization in the Cycle 4 CfP.[15]

Table 3: Key Scientific Areas and Early JWST Breakthroughs (Cycles 1–3)

Research Theme	**Key Study/Finding**	**Representative Author/Team**	**Year (Approx.)**	**Implication/Significance (Grade 1 Outcome)**
Exoplanet Atmospheres	First detection of on an exoplanet (WASP-96b/Bocaprins)	Wakeford et al.	2022	Validated JWST's unique spectroscopic capacity for chemical analysis; shifted atmospheric science focus.[10]
Early Universe/High-z Galaxies	Discovery of unusually bright candidate galaxies (300+ objects)	Haojing Yan et al.	2025	Challenges extant galaxy formation models; implies faster mass assembly in the first billion years.[9]
Planetary Systems	Observations of stellar remnants and protoplanetary	Loïc Albert (PI: Mullaly), Pontoppidan,	C1-C3	Confirmed capacity for high-resolution imaging of

	disks	Ray et al.		complex systems (e.g., planets orbiting white dwarfs).[3]

The rapid deployment of JWST capabilities was showcased in July 2022 with the first exoplanet studied: WASP-96b (Bocaprins). Analysis of its atmosphere by Ohno and colleagues, co-led by Wakeford, resulted in the first definitive identification of carbon dioxide () in an exoplanet atmosphere.[10] This finding immediately validated JWST's extraordinary spectroscopic sensitivity, moving exoplanet atmospheric science from simple detection of water to complex chemical inventory mapping.

In the realm of planetary system dynamics, JWST has confirmed its capacity for technically demanding observations, including imaging spectroscopy of cold exoplanets and protoplanetary disks.[3] Approved programs have focused on highly challenging targets, such as using MIRI imaging to confirm Jupiter-like companions orbiting white dwarf stars, requiring the precise verification of movement relative to the stellar remnants.[19] These efforts, carried out by researchers like Loïc Albert (co-PI on Program 4857), demonstrate the successful execution of complex, high-risk observation techniques that maximize the scientific return from allocated time.[19]

VII. Synthesis and Recommendations for Future Cycles

VII.1. Evaluation of Efficiency and Equity in Time Allocation

The James Webb Space Telescope has established a highly successful, albeit strained, observation time allocation system. The implementation of DAPR has successfully fulfilled its mandate to ensure scientific merit determines selection, with high panel consensus that bias related to team identity has been largely eliminated.[4] This focus has demonstrably contributed to the rapid, transformative scientific breakthroughs observed in the first three cycles.

However, the analysis of Cycles 1-4 also reveals a critical challenge at the intersection of equity and efficiency. While the policies are designed for fairness, the required DAPR anonymity places strict limitations on explaining complex technical approaches or justifying necessary specialized team expertise. When coupled with the mandated severe reduction in proposal page limits (Cycle 4), this increases the difficulty for proposers to satisfy the high standards of the "Suitability & Feasibility" criterion without risking disqualification for non-compliance. The resulting disqualifications, particularly the 12 DAPR violations in Cycle 4, confirm that this trade-off between procedural rigor and scientific clarity remains a significant operational hurdle.[4]

VII.2. Outlook for Proposal Systems in High-Demand Observatories

The operational experience of JWST demonstrates unequivocally that for flagship astronomical facilities generating overwhelming scientific demand, static policies are not sustainable. The continuous evolution of the TAS—from the initial strategic GTO allocations to the necessity of increasing allocated hours, reducing page limits, and executing major restructuring of the TAC—confirms that the operational design must be dynamic and highly reactive to submission pressure.[7] The fact that increased capacity was immediately saturated validates the structural need for continued adaptive management.

Based on the performance data and competitive analysis, the following structural adjustments are warranted for Cycle 5 and beyond:

- **Addressing the Medium Program Bottleneck:** The Cycle 4 data clearly identifies the Medium program category (and hours) as the most resource-constrained area, exhibiting an 11.4:1 oversubscription rate.[16] This intense competition suggests that the current allocation of approximately 2,250 hours to this category is structurally insufficient to meet the consensus demand for high-impact proposals of this scope. STScI should consider mechanisms to alleviate this pressure, either by dynamically shifting a larger proportion of available hours into the Medium size bin or by adjusting the size boundaries to redistribute the competitive load across the categories.
- **Enhancing DAPR Compliance Clarity:** To minimize the risk of high-quality proposals being disqualified on technical grounds, policy guidance for Cycle 5 and subsequent cycles should provide significantly enhanced clarity regarding DAPR-compliant narratives, particularly concerning the necessary level of detail in the "Analysis Plan" section.[4] Providing concrete examples of acceptable technical justification that adheres to anonymity rules will help mitigate the procedural barrier created by the necessary policy trade-offs.
- **Validating the Strategic Value of Early Access:** The success of the GTO and DD-ERS programs in establishing foundational data and rapidly accelerating community proficiency demonstrates the exceptional value of upfront, open-access strategic planning. Future large missions should adopt this model, incorporating substantial

pre-operational and early science programs to rapidly disseminate knowledge and maximize the quality and volume of subsequent open-call proposals.

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