National Aeronautics and Space Administration

NASA

EXPLORE SCIENCE

Writing Successful Proposals: OBSERVATIONS FROM NASA

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Context for Today's Talk

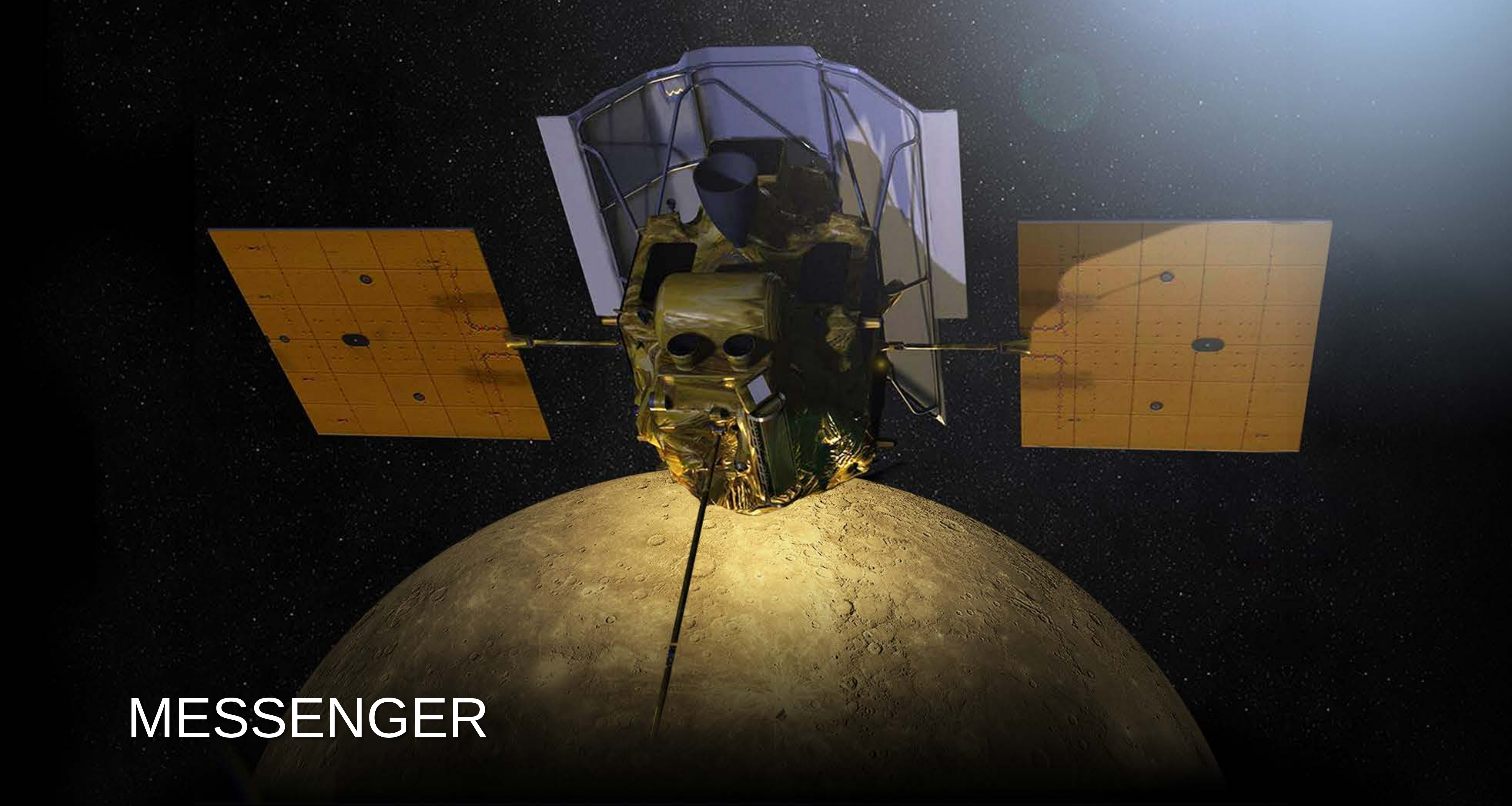
- Only focused on Announcements of Opportunity, not ROSES selections
- Large and increasing number of NASA science missions led by PIs
- Proven high rates of mission success across science disciplines resulting from PI-class missions management methodology
- Process of becoming a PI is complex and involves many stakeholders, with more than 80% of all submitted mission proposals failing at Step 1
- Will use historical data to discuss our view of process and philosophy, questioning how we can do better
- Already changed proposal process and will without doubt, do it again
- Note, some comments reflect views of the current NASA Science Associate Administrator and leadership team
- Today’s talk is being webcast and recorded; all content will be made available on science.nasa.gov/researchers/new-pi-resources

Imagine Being a PI…

- You receive a call from me informing you that your mission was selected for development
- Your life changes in a heartbeat; you have already invested a significant fraction of at least two years with your project, and know strengths and weaknesses of your partners and team
- You have survived two major down-selects; you have managed to raise support measured in millions of dollars and in work-years from your team
- You know you have lots of autonomy, but you have lots of responsibility as well; you will represent your mission, NASA, and an entire science discipline
- You know that you need to keep your mission within the cost cap or NASA can cancel it; this is how NASA controls risk
- You know this will be one of the toughest things you will ever do; you WILL have problems and the team and your community are depending on you to succeed

Should You Aspire to Be a PI?

- Being a PI is not for everyone - you can be a successful scientist without ever leading a mission and it typically takes more than two proposals to win
- Most organizations are not equipped to support a PI-class proposal
- Being a PI will keep you constantly busy for four or more years, delaying other options and decreasing your publication rate
- Your life will be taken over, including evenings and holidays
- You do it because you truly desire it; it is the most important thing you want to do
- NASA is always in the market for great PIs, including people with great ideas who have not proposed in the past



MESSENGER

Motivation for This Talk

- NASA Science has observed a lack of diversity across all dimensions in PI-led proposals compared to the science community at large; we are looking to develop aspiring PIs
- Our philosophy to missions is evolving and your proposals should recognize:
  - We want a new technology on each mission launch
  - We are comfortable with taking technical risks if necessary to achieve great science, but are willing to cancel missions and payloads to manage risk
  - We continue to learn and actively adjust how we manage missions
- Our hope is this data-rich presentation will help you understand the proposal writing, review and selection process

Agenda

Introduction

NASA Peer Review, Process, Nomenclature

Proposal Focus Areas

- Transformational Science
- Effective Leadership
- Excellent Team
- Strategic Partners
- System Design
- Management

Missions of Opportunity

Future Questions

Final Thoughts

NASA SCIENCE

AN INTEGRATED PROGRAM

Planetary Science

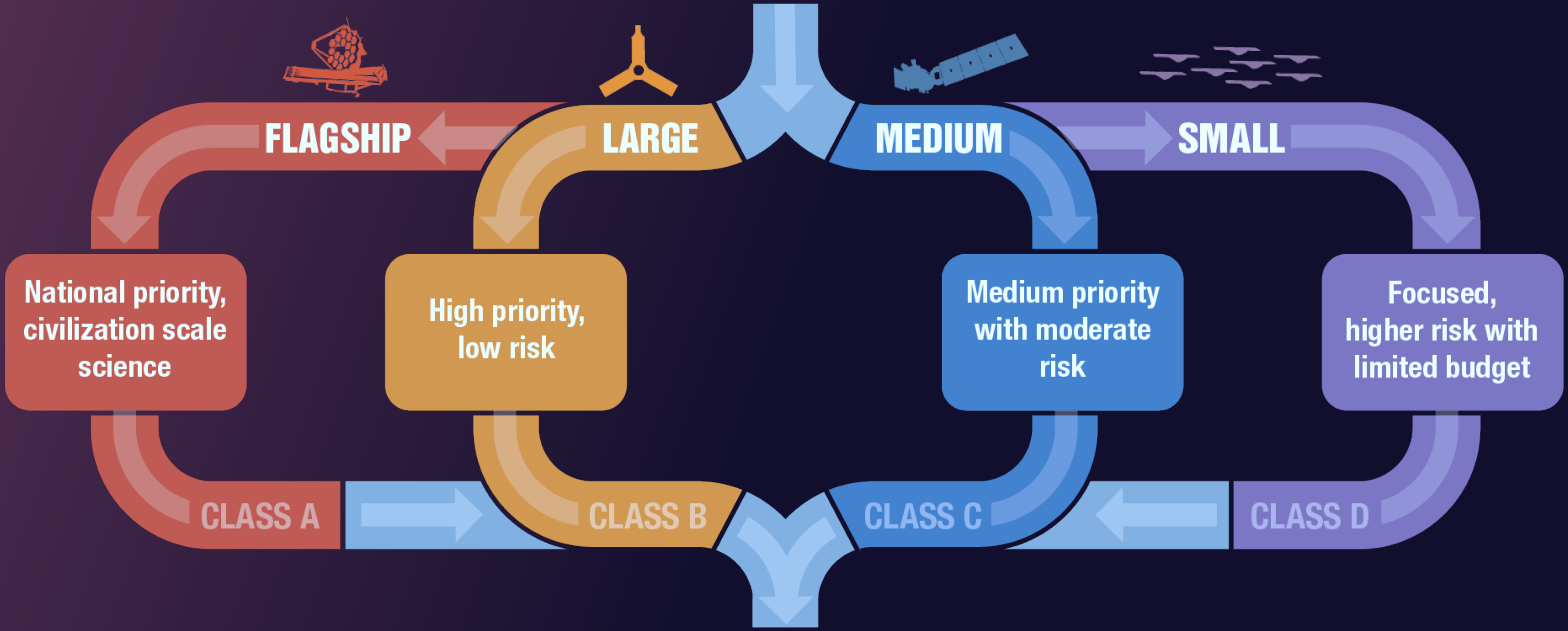
Earth Science

Joint Agency Satellite Division

Astrophysics

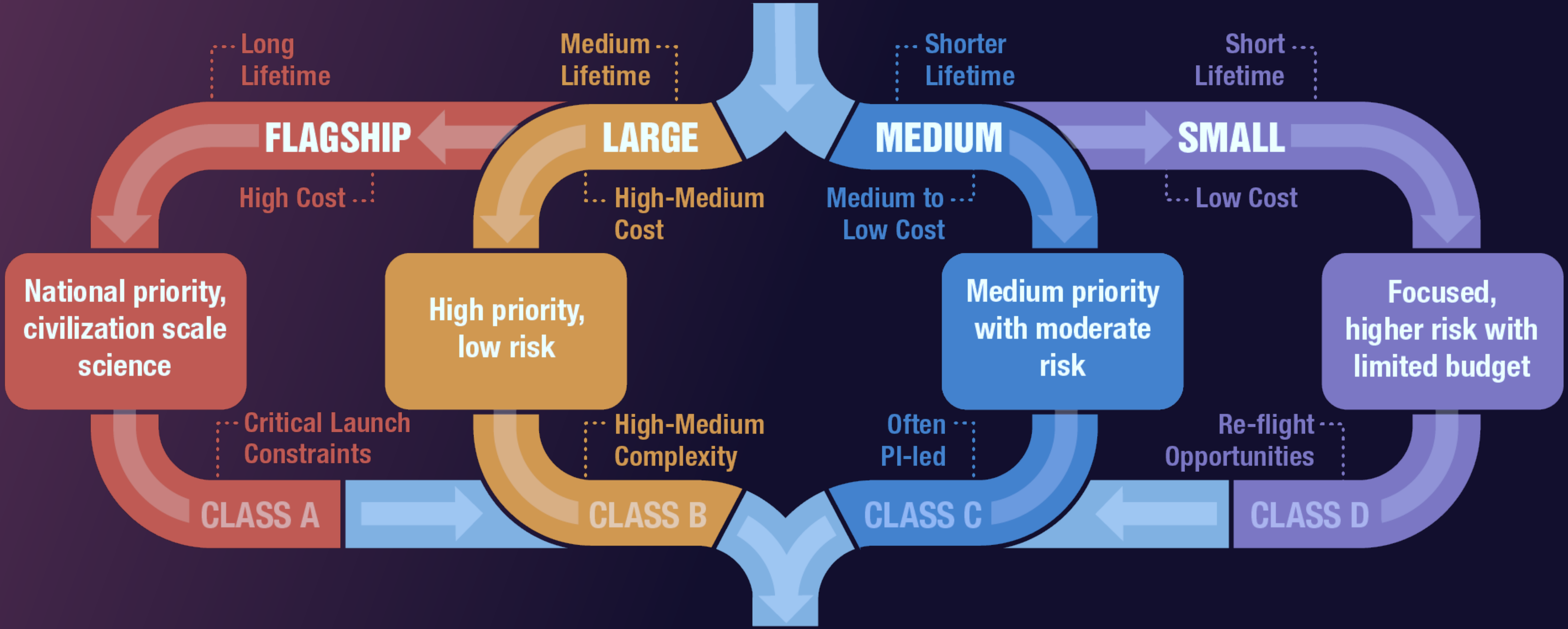
Heliophysics

Balanced Mission Portfolio

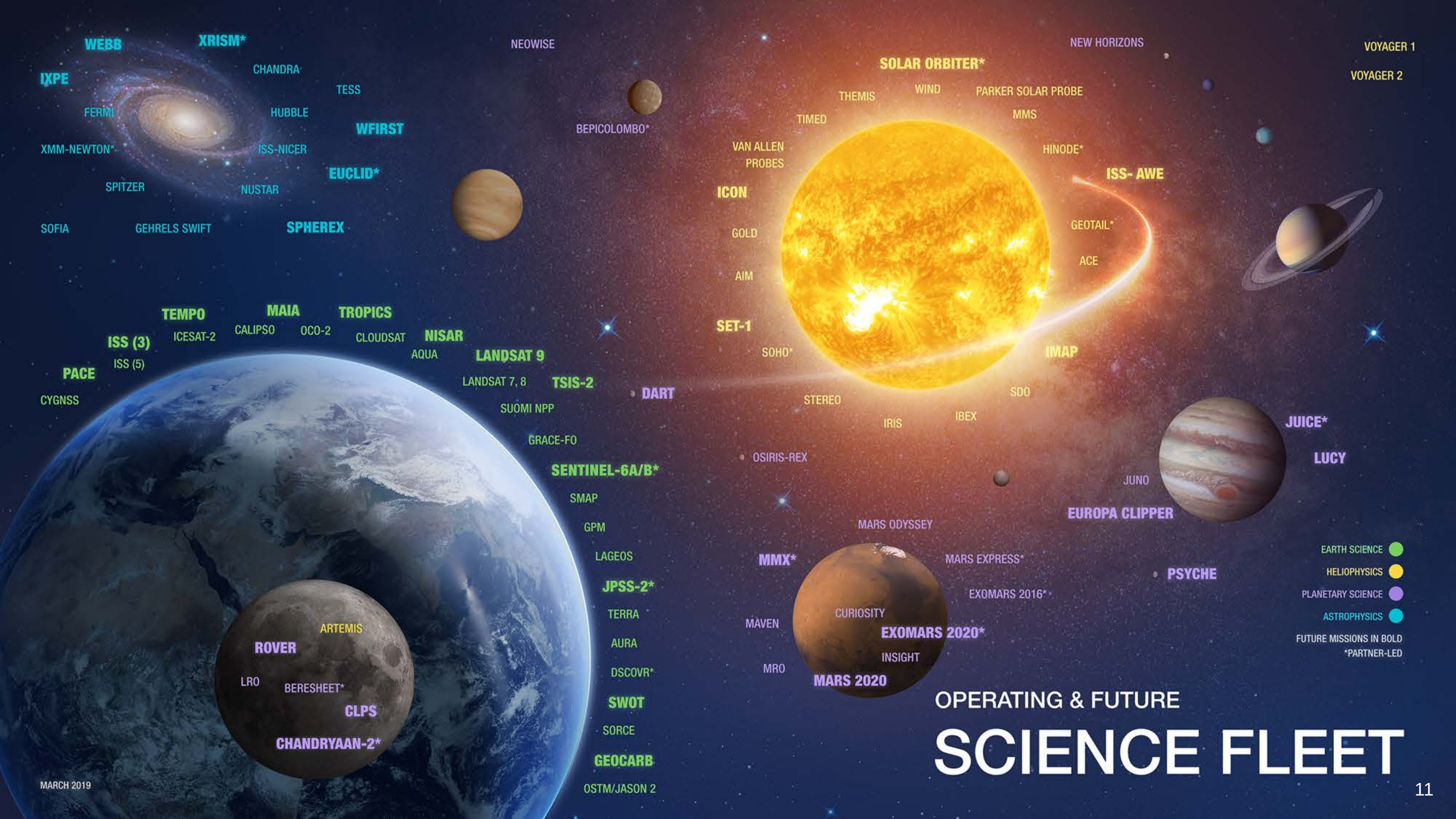


Great Science

Balanced Mission Portfolio



Great Science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MARCH 2019
EARTH SCIENCE
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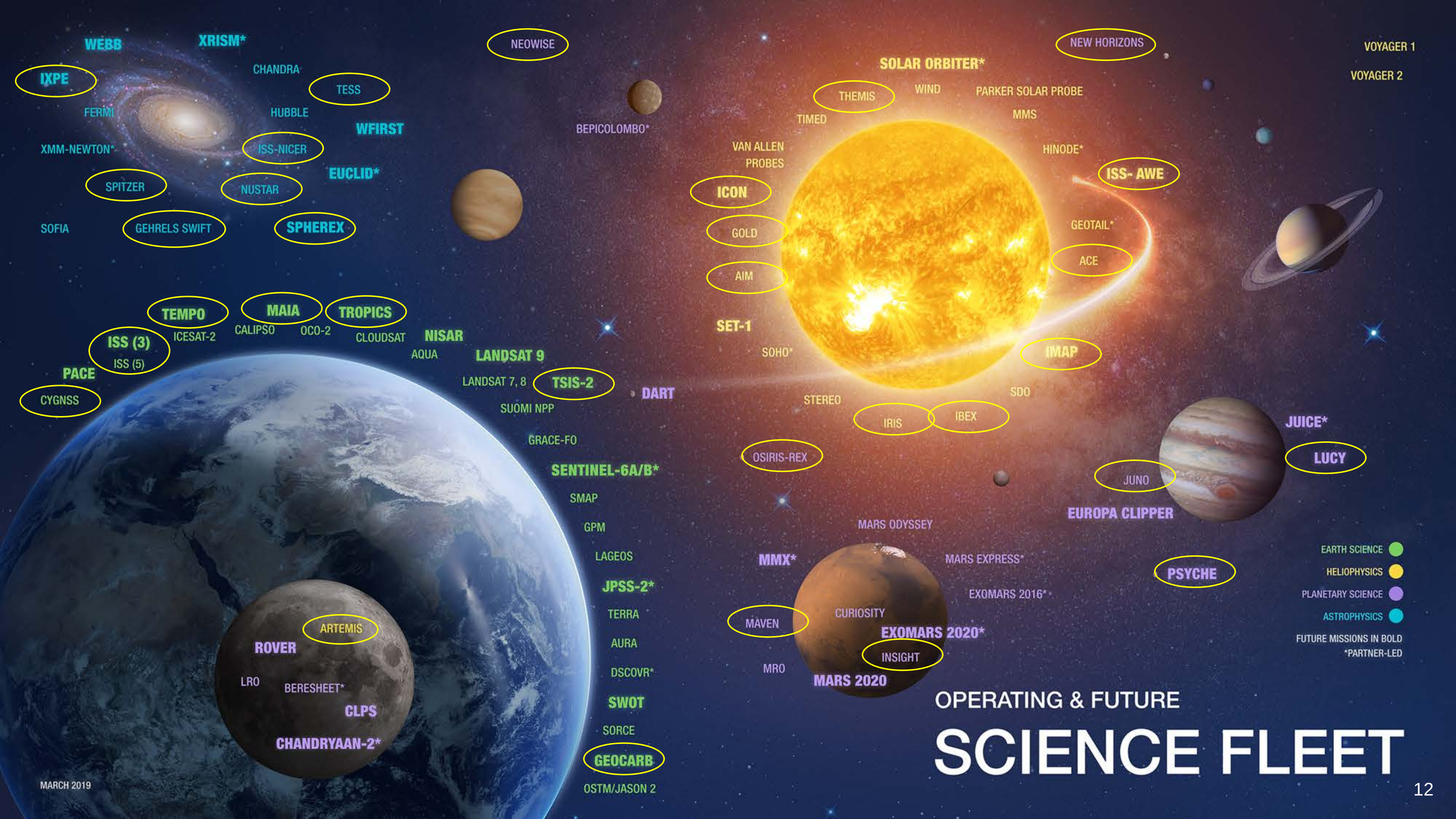
PLANETARY SCIENCE
ASTROPHYSICS
FUTURE MISSIONS IN BOLD
*PARTNER-LED
OPERATING & FUTURE
SCIENCE FLEET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Solicitations Across NASA Science

	Low-Cost AO's	Medium-Cost AO's	High-Cost AO's
Astrophysics	Small Explorers, Missions of Opportunity	Medium-Size Explorers	Astrophysics Probes?
Earth Science	Earth Venture Instruments, Earth Venture Missions, Earth Venture Continuity	Earth System Explorer	
Heliophysics	Small Explorers, Missions of Opportunity	Medium-Size Explorers, Solar-Terrestrial Probes	
Planetary Science	Small, Innovative Missions in Planetary Exploration	Discovery	New Frontiers

For target release dates of future solicitations, see the "SMD AO Planning List" available from the Science Office for Missions Assessments website, https://soma.larc.nasa.gov/

Nomenclature

Announcement of Opportunity (AO)	Call for science investigations requiring a spaceflight mission
Mission of Opportunity (MOO)	Focused proposals to leverage specific flight opportunities
Technical, Management, and Cost (TMC)	Engineering, cost, schedule, etc. review of a mission proposal
Preliminary Major Weakness (PMW)	Potential major weakness sent to proposers for clarification
Clarification	When a proposing team points to the places in their proposal that explain away a preliminary major weakness
Plenary	Meeting of all evaluators in the same place, at the same time
Categorization	Process by which proposals are assigned selection priorities based on their evaluations
Steering	Process through which fairness of an evaluation process is judged
Debriefing	Formalized discussion between NASA and proposers regarding the strengths and weaknesses in their proposal
Step 1	First phase of a mission competition where proposals are submitted, evaluated, and selected to conduct a Concept Study
Concept Study	Period of time when a team fleshes out their mission concept; results are described in a Concept Study Report (CSR)

Nomenclature

Step 2	Second stage of a mission competition where Concept Study Reports are evaluated; not all AO’s have a second step; *e.g.,* Earth Venture Instruments
Down-selection	When NASA chooses which Step 2 Concept Studies to continue towards flight
Form A	Evaluation form where strengths and weaknesses of a proposed spaceflight investigation’s Science Merit are recorded
Form B	Evaluation form where strengths and weaknesses of a proposed spaceflight investigation’s Science Implementation Merit are recorded
Form C	Evaluation form where strengths and weaknesses of a proposed spaceflight investigation’s TMC Feasibility are recorded

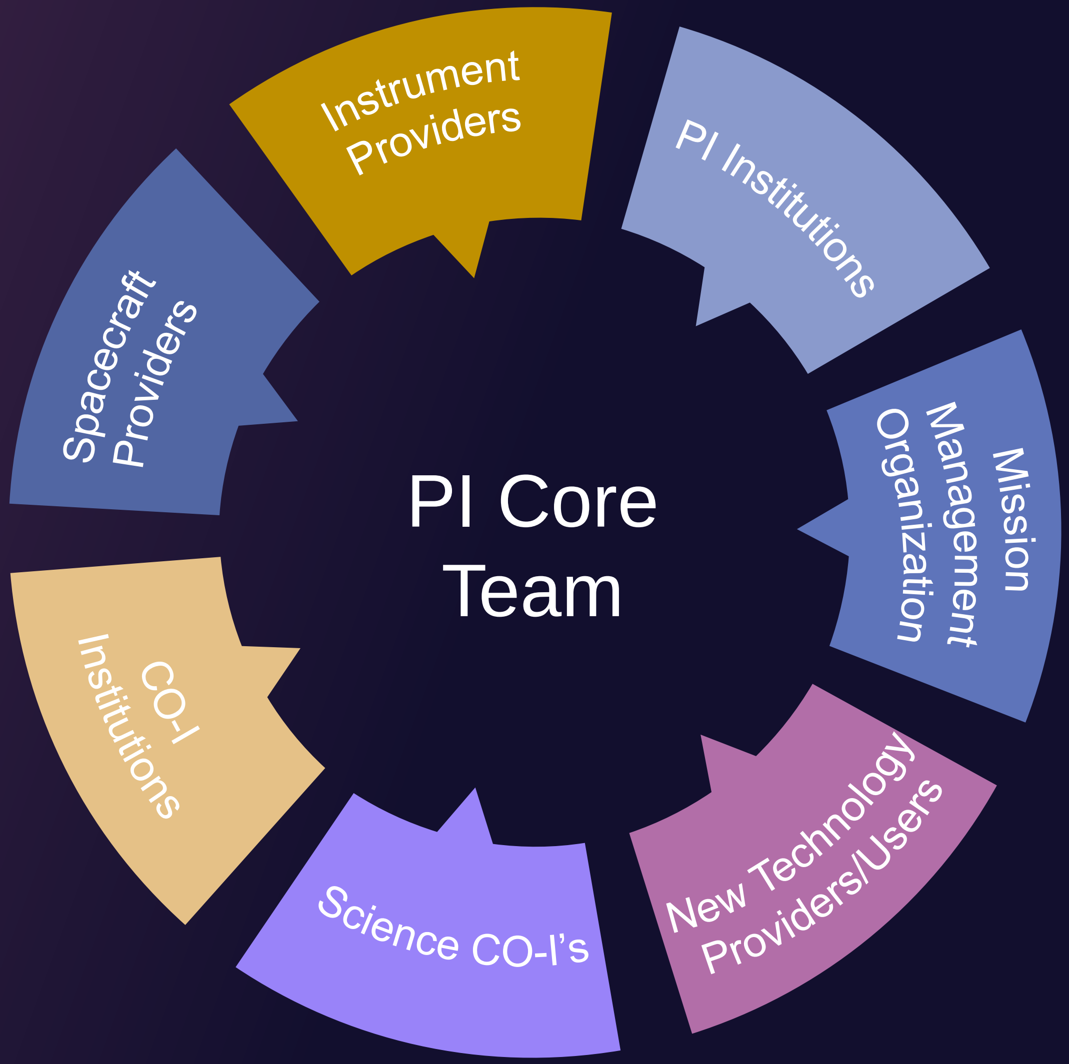
Baseline and Threshold Science Mission Proposals

Baseline Science Mission: If fully implemented, would achieve full science objectives

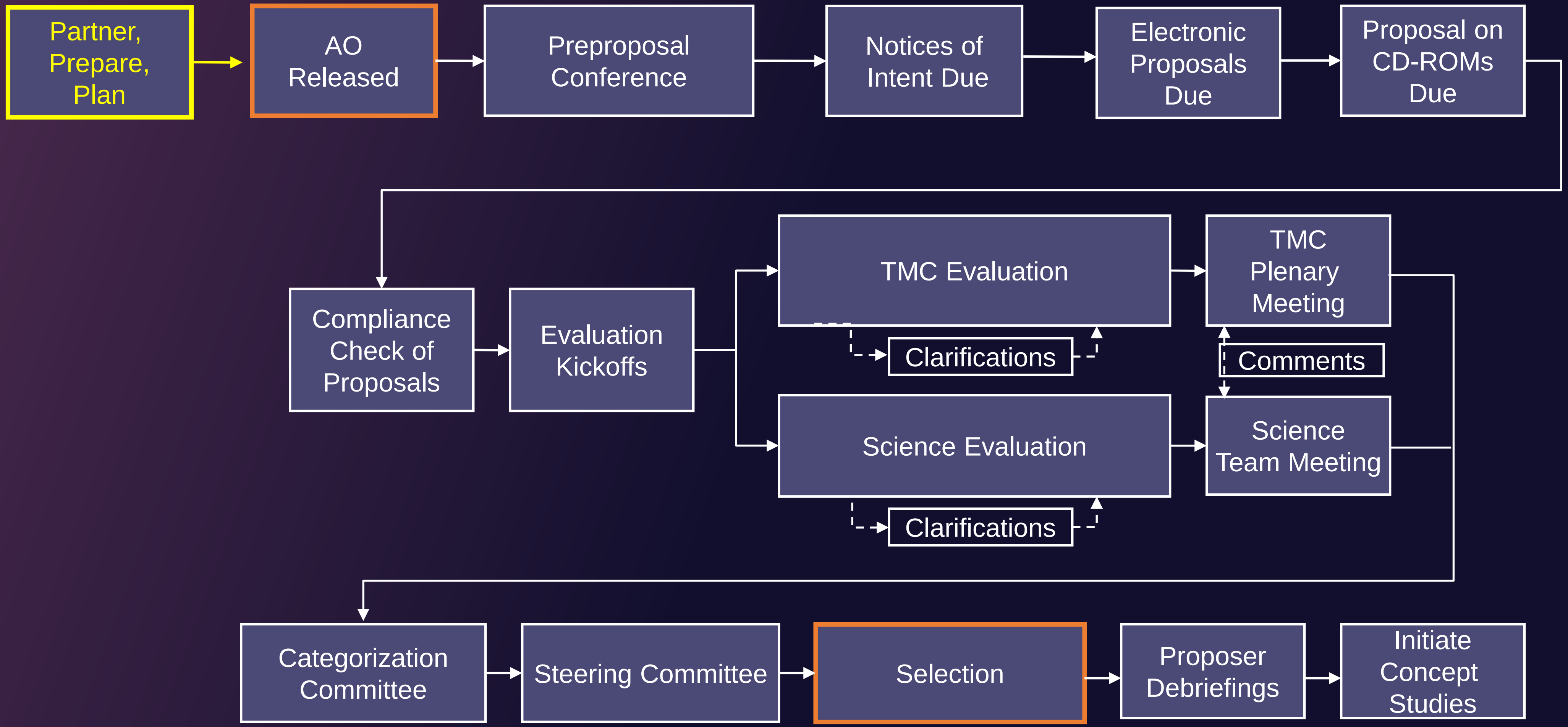
Threshold Science Mission: Reduced version that would achieve minimum science acceptable

- NASA evaluates the Baseline Science Mission and the adequacy of the Threshold Science Mission
- The difference between the two missions provides resiliency in the face of cost and schedule pressures
- Reducing mission scope (descoping) by eliminating instruments or degrading their performance requirements may save time and money
- For some mission architectures, the Baseline Science Mission may be the same as the Threshold Science Mission

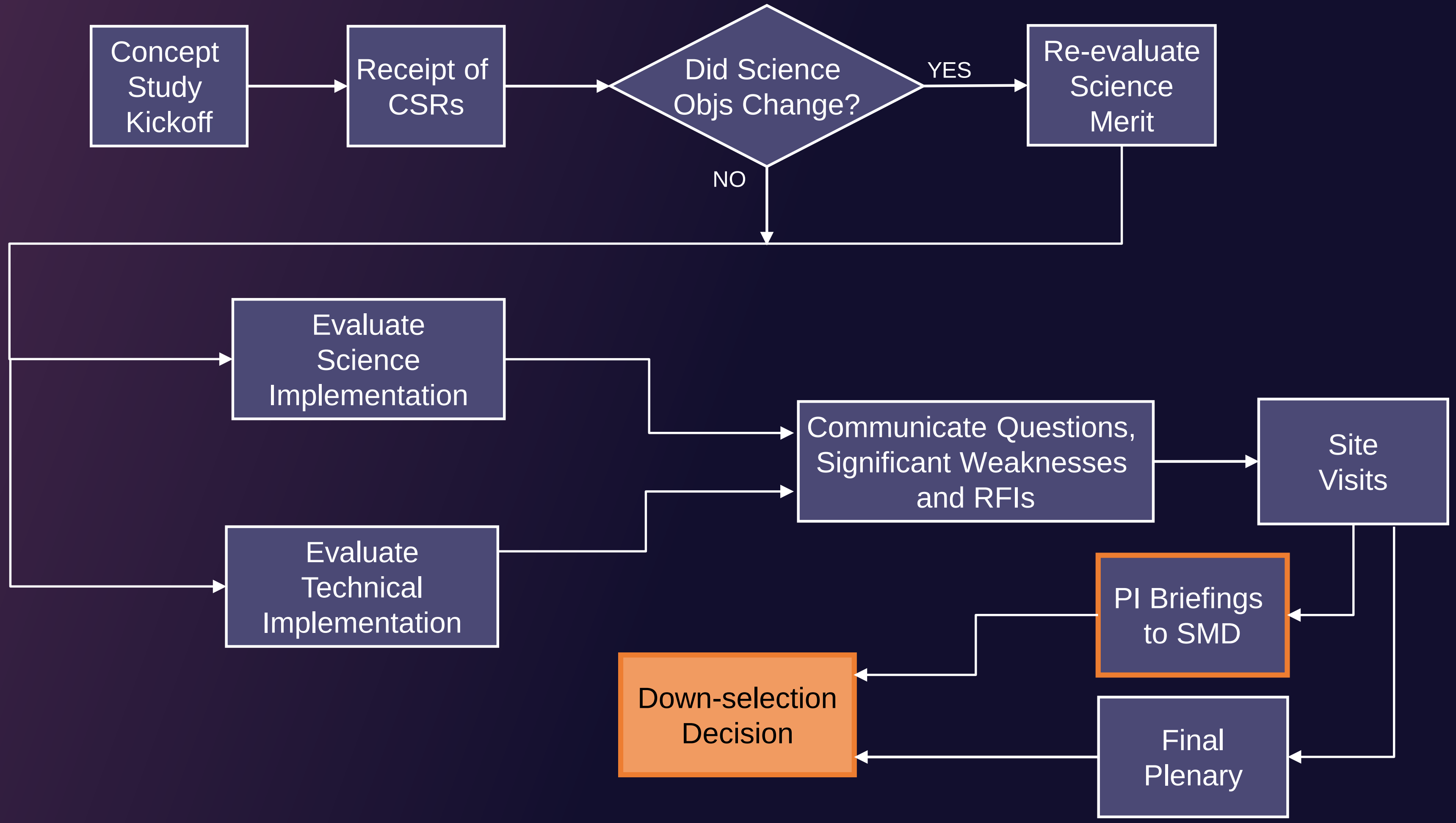
Key Stakeholders



Step-1 Process



Step-2 Process



Scientific Merit (Form A) and Scientific Implementation Merit (Form B)

Form A - Scientific Merit

- Compelling nature and scientific priority of the proposed investigation's science goals and objectives
- Programmatic value of the proposed investigation
- Likelihood of scientific success
- Scientific value of the Threshold Science Mission

Form B - Scientific Implementation Merit

- Merit of the instruments and mission design for addressing the science goals and objectives
- Probability of technical success
- Merit of the data analysis, data availability, and data archiving plan and/or sample analysis plan
- Science resiliency
- Probability of science team success

Summary Evaluation	Basis for Summary Evaluation
Excellent	A comprehensive, thorough, and compelling proposal of exceptional merit that fully responds to the objectives of the AO as documented by numerous and/or significant strengths and having no major weaknesses
Very Good	A fully competent proposal of very high merit that fully responds to the objectives of the AO, whose strengths fully outbalance any weaknesses
Good	A competent proposal that represents a credible response to the AO, having neither significant strengths nor weaknesses and/or whose strengths and weaknesses essentially balance
Fair	A proposal that provides a nominal response to the AO, but whose weaknesses outweigh any perceived strengths
Poor	A seriously flawed proposal having one or more major weaknesses; e.g., an inadequate or flawed plan of research or lack of focus on the objectives of the AO

Mission Implementation Feasibility and Cost Risk (Form C)

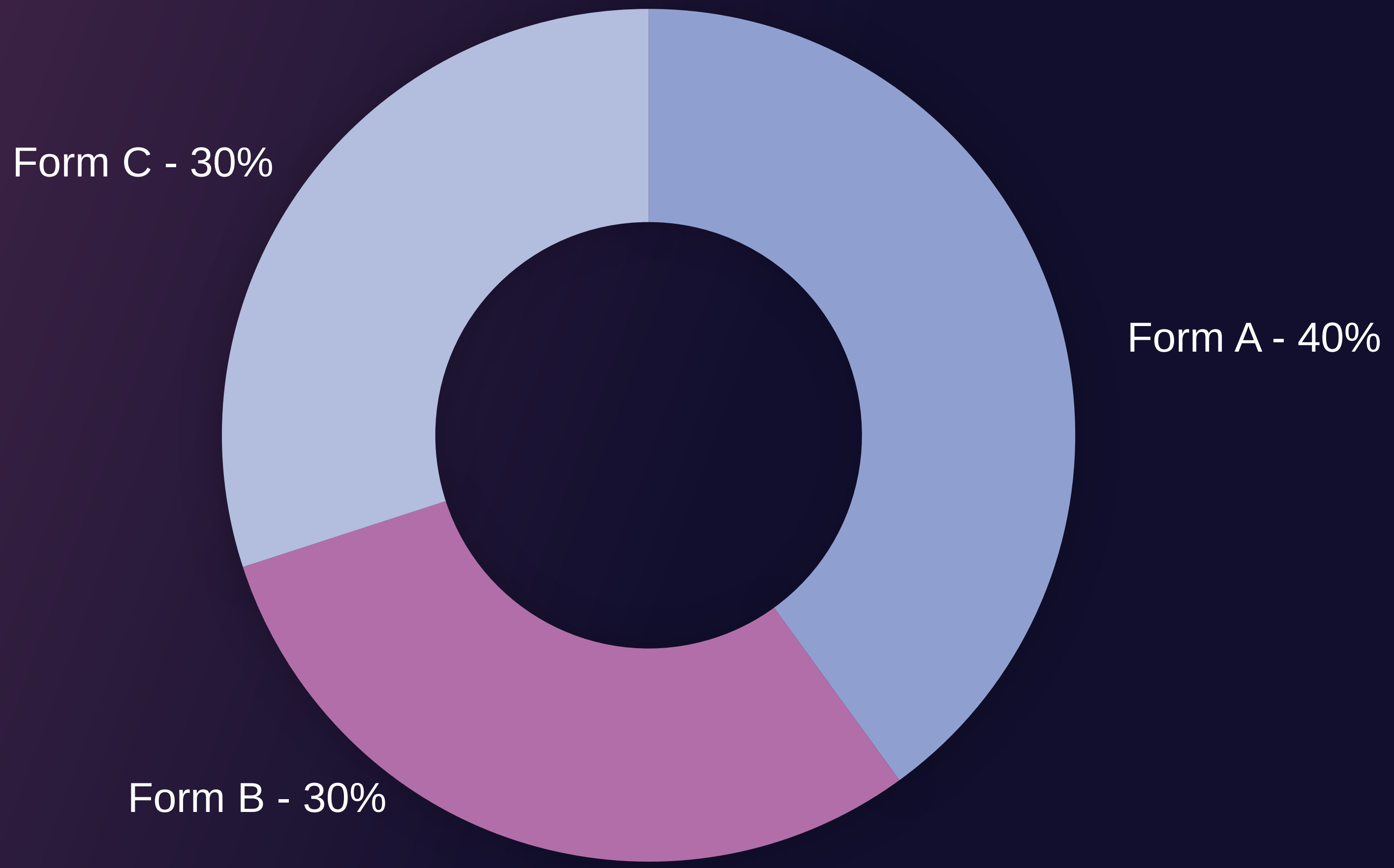
Form C – Mission Implementation Feasibility

- Adequacy and robustness of the instrument implementation plan
- Adequacy and robustness of the mission design and plan for mission operations
- Adequacy and robustness of the flight systems
- Adequacy and robustness of the management approach and schedule, including the capability of the management team
- Adequacy and robustness of the cost plan, including cost feasibility and cost risk

Summary Evaluation	Basis for Summary Evaluation
Low Risk	There are no problems evident in the proposal that cannot be normally solved within the time and cost proposed; problems are not of sufficient magnitude to doubt the proposer's capability to accomplish the investigation well within the available resources
Medium Risk	Problems have been identified, but are considered within the proposal team's capabilities to correct within available resources with good management and application of effective engineering resources; investigation design may be complex and resources tight
High Risk	One or more problems are of sufficient magnitude and complexity as to be deemed unsolvable within the available resources

See standard AO template: https://soma.larc.nasa.gov/StandardAO/sao_templates.html

Approximate Relative Weights of Evaluations in Categorization



Note: This is not an exact algorithm that is used by the panel to determine the category of a proposal; a low score on any one Form cannot be mitigated by high scores on the other two

Categorization

Category I

Well-conceived, meritorious, and feasible investigations pertinent to the goals of the program and the AO's objectives and offered by a competent investigator from an institution capable of supplying the necessary support to ensure that any essential flight hardware or other support can be delivered on time and that data can be properly reduced, analyzed, interpreted, and published in a reasonable time. Investigations in Category I are recommended for acceptance and normally will be displaced only by other Category I investigations.

Category II

Well-conceived, meritorious, and feasible investigations that are recommended for acceptance, but at a lower priority than Category I, whatever the reason.

Category III

Meritorious investigations that require further development. Category III investigations may be funded for further development and may be reconsidered at a later time for the same or other opportunities.

Category IV

Proposed investigations which are recommended for rejection for the particular opportunity under consideration, whatever the reason.

Selection Considerations

Sources of Information

- Focus is on Category I and Category II proposals
- All inputs from Reviews, HQ Briefings
- Home division recommends one more multiple selection

Key Participants

- Division Directors of all Divisions or their Representatives
- Deputies focused on Research, Programs, Exploration, etc.
- Representatives from Offices of Chief Engineer, Safety and Mission Assurance, General Counsel, etc.

Decision-making

- All above inputs are advisory
- Final decision by AA or representative in case of conflicts or perceived conflicts

About the Data

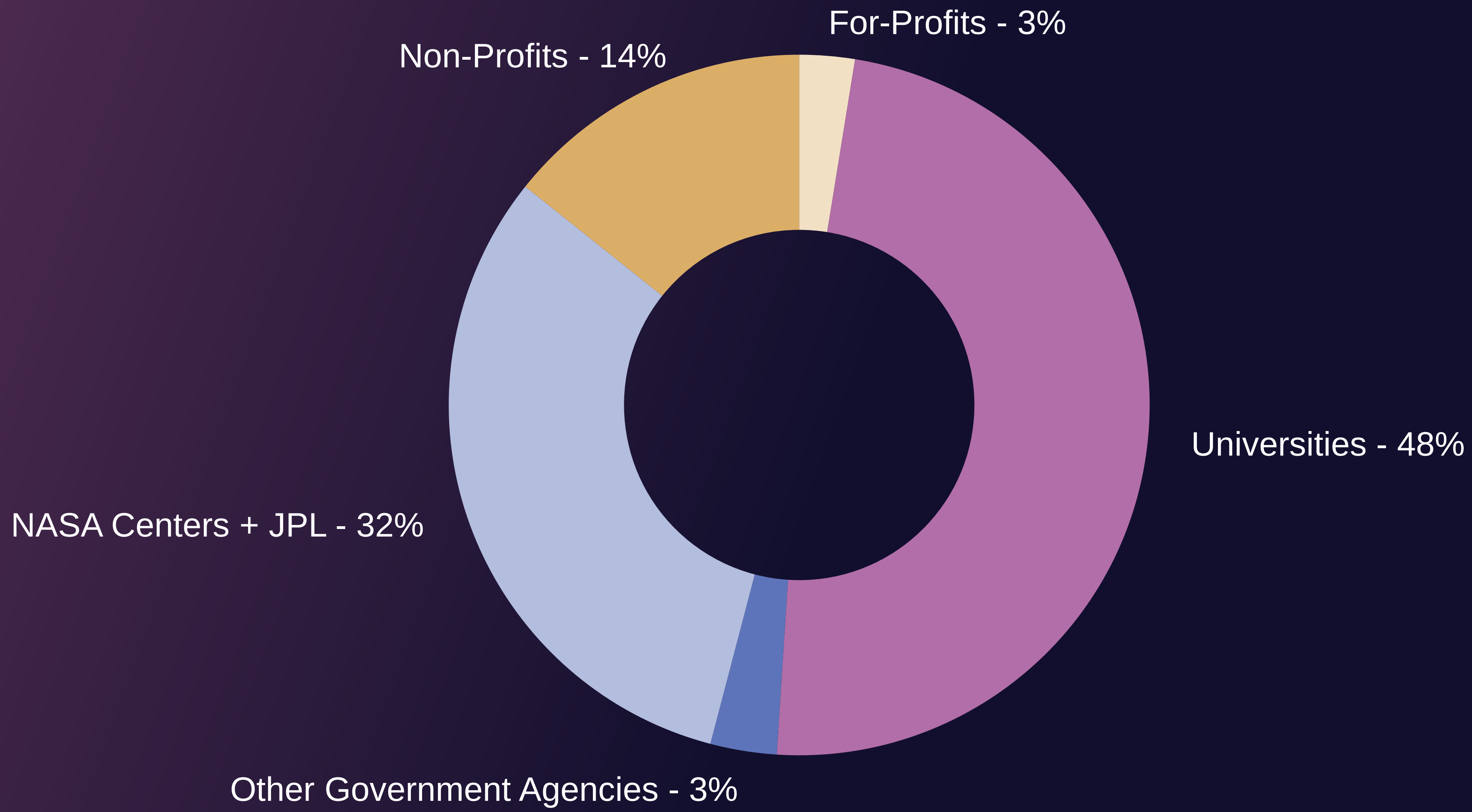
Sources

- SMD database of 392 Step 1 full mission proposals submitted from 1996-2017
  - Includes nine programs from all science divisions
  - Does not include most recent SIMPLEx or Missions of Opportunity
  - Common Causes of TMC Major Weaknesses (from: *Lessons Learned, Vol. 1: Proposals, B.R. Perry,* et al. (2009), https://soma.larc.nasa.gov/tmcll/ManagementFindingsStudy-to-post-R3.pdf)

Caveats

- Cost categorization
  - Low-cost AO's: Cost caps are less than or equal to $250M (FY19)
  - Medium-cost AO's: Cost caps are greater than $250M (FY19) and less than or equal to $650M (FY19)
  - High-cost AO's: Cost caps are greater than $650M (FY19)
- Analysis currently does not include Missions of Opportunity – comments at end of presentation
- Availability of information regarding proposal length and team composition only available for proposals submitted since 2006

PIs Come from a Variety of Organization Types

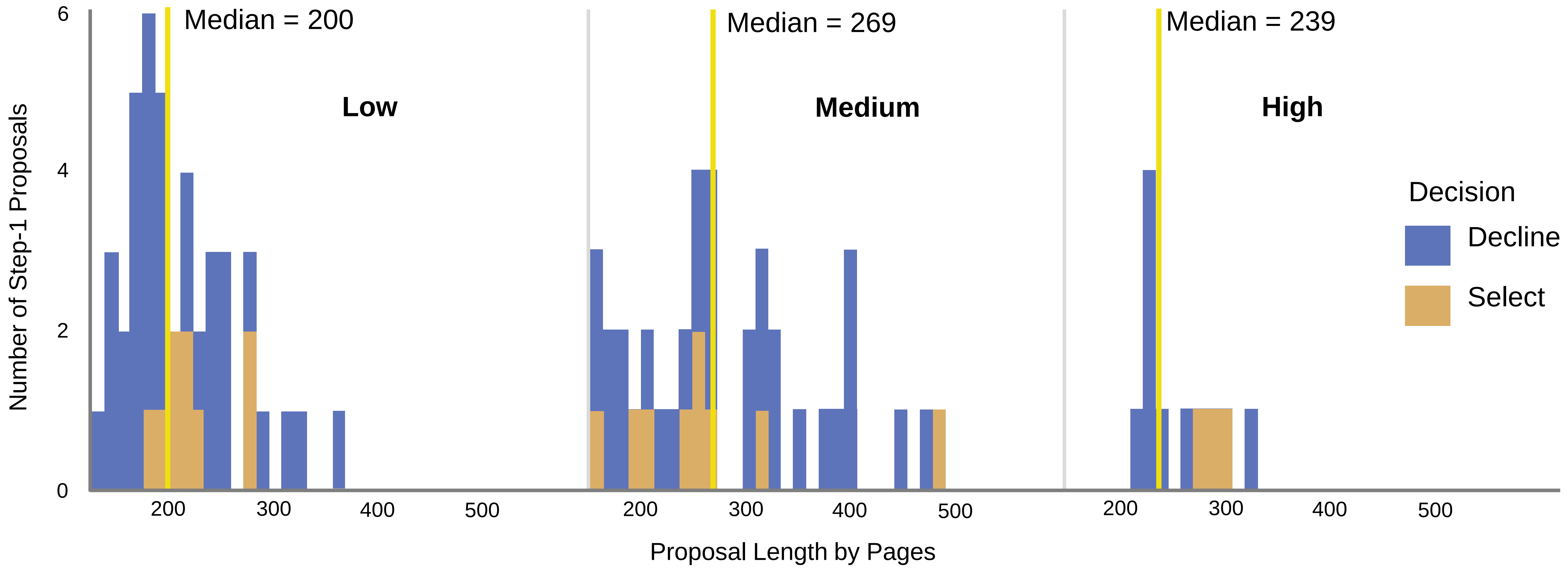


How Many Proposals Submitted?

More proposers in low and medium cost classes and fewer in high cost class, resulting in higher competition for each solicitation

	Number of Calls	Total Number of Proposals Submitted	Average Number of Proposals Submitted	Selection Rate from Submitted Proposals
Low	8	176	21	17%
Medium	9	193	20	16%
High	3	25	8	28%
Overall	20	394	20	17%

Length of Step-1 Proposals by Cost Cap



- Low cost AO's proposals are statistically shorter in length than other AO cost cap classes
- Proposal length has no correlation to selection

WRITING A SUCCESSFUL PROPOSAL:
FOCUS AREAS

Transformative Science

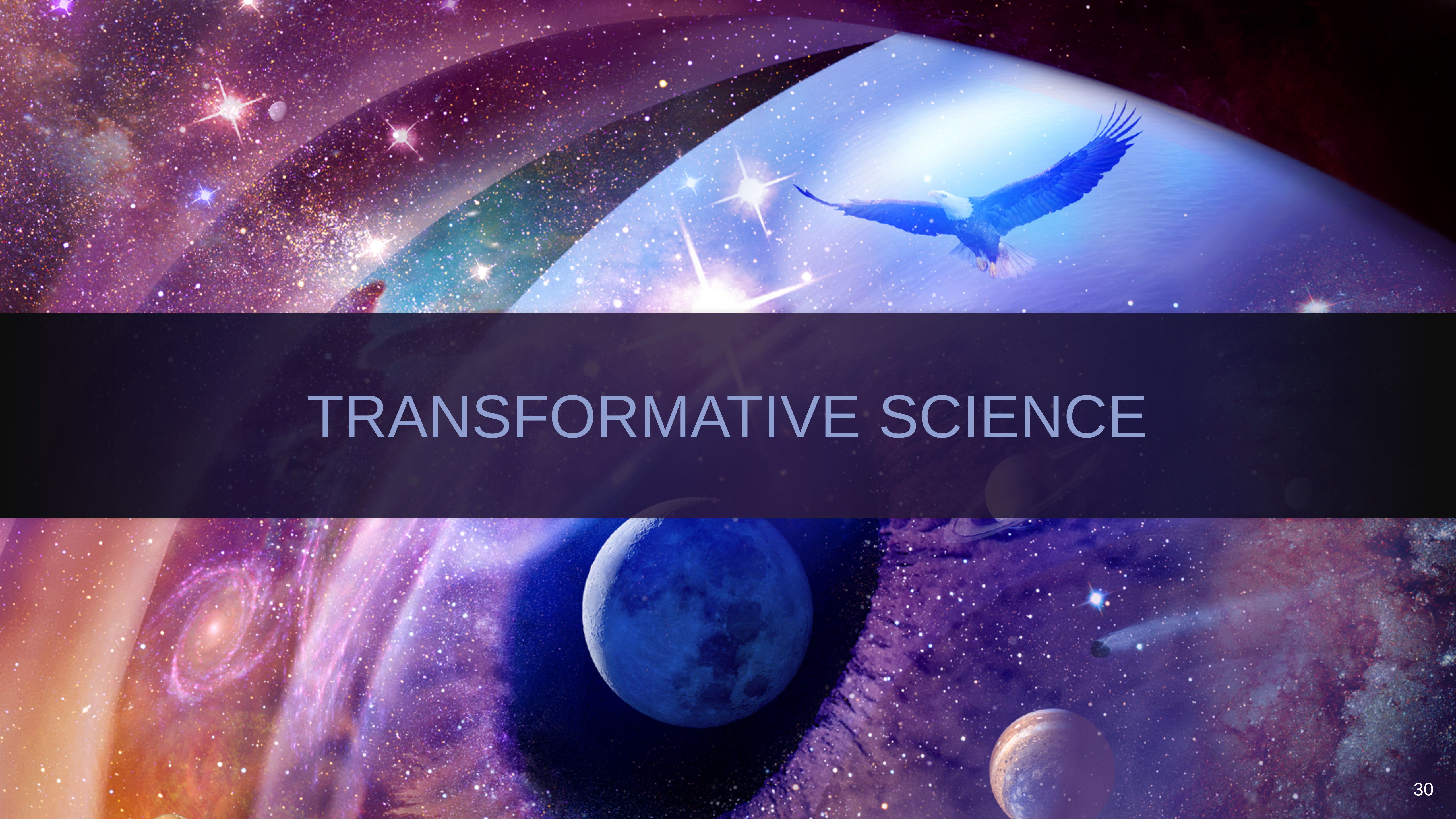
Effective Leadership

Excellent Teams

Strategic Partners

System Design

Management



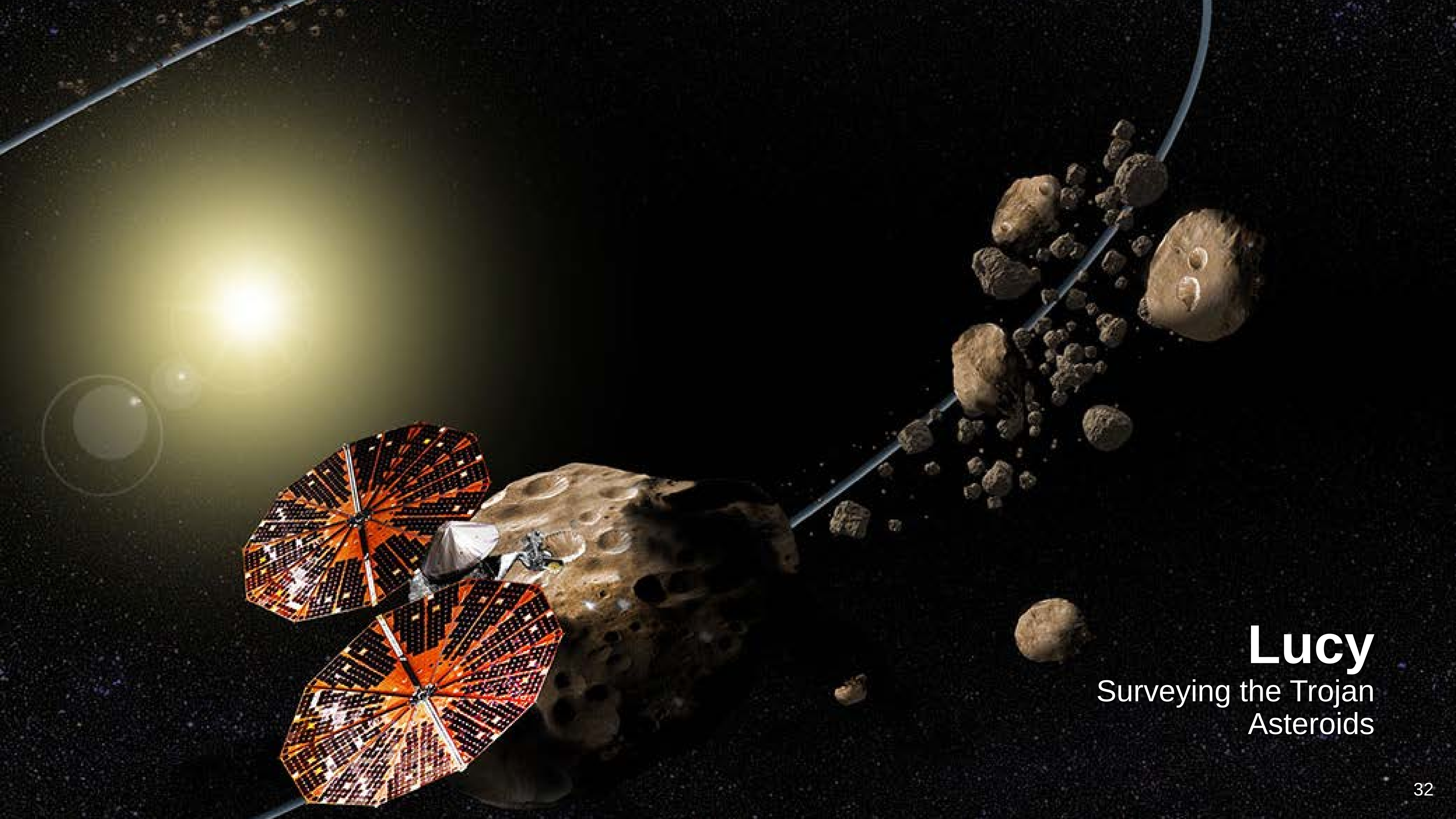
TRANSFORMATIVE SCIENCE

What is Transformative Science?

- Anchored in Decadal priorities
- Achieves a significant leap in capability or understanding (i.e., 10x, clear threshold, new location, etc.)

When is a Mission Appropriate?

- Science can only be acquired in space and must be achievable
- When there is a strong answer for, “why now?”
- Science impact and appeal is consistent with mission cost



Lucy

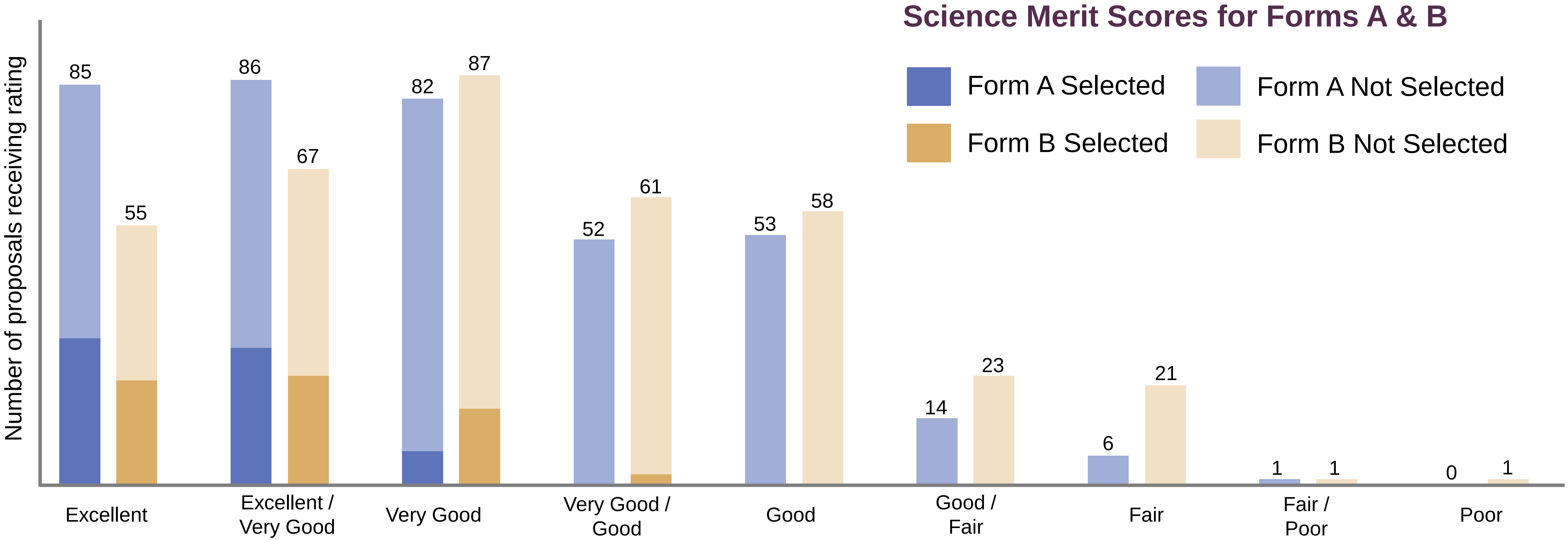
Surveying the Trojan Asteroids

TESS

Transiting Exoplanet
Survey Satellite

Data: Transformative Science

- Every selected Step 1 proposal has had Science Merit of Very Good (VG) or above
- Majority of selected Step 1 proposals have Science Implementation Merit of VG or above
- Incremental science is not enough



Categories and Selections

- Few Category II and no Category IV mission proposals have been selected
- Few proposals have been awarded technology funding

Category	Count	Selected	Declined	Tech Funding	Selection Rate
I	93	64	29	0	69%
II	68	3	64	1	4%
III	33	0	26	7	0%
IV	198	0	198	0	0%
Total	**392**	**67**	**317**	**8**	**17%**

Key Takeaways on Transformative Science

At Step 1

- There is often insufficient focus on this: No mission flies with only good science
- Target audience is educated group of scientists who are often not domain experts - explain simply and well. Do not communicate at too low a level, either.
- Make science beautiful – want to tell a compelling story about discovery and exploration

At Step 2

- Preparation matters when you give the 'talk of your life'
- If the importance of science is not clear or not communicated sufficiently, it can derail your success!

EFFECTIVE LEADERSHIP

What is an Effective Leader?

- Trustworthy – NASA and community depend on PI
- Shares NASA's values and sets consistent culture – excellence, leadership, integrity, teamwork, safety
- Scientifically credible – spokesperson to science community and beyond
- Know what you don't know, and be willing to learn – excellence comes from your team
- Listen first and then be decisive – make informed decisions and stick to them
- Able to make hard decisions that may trade science to maintain integrity of overall mission
- Know how to lose and persevere – without perseverance, you will never succeed
- Be aware that you are spending taxpayer's money

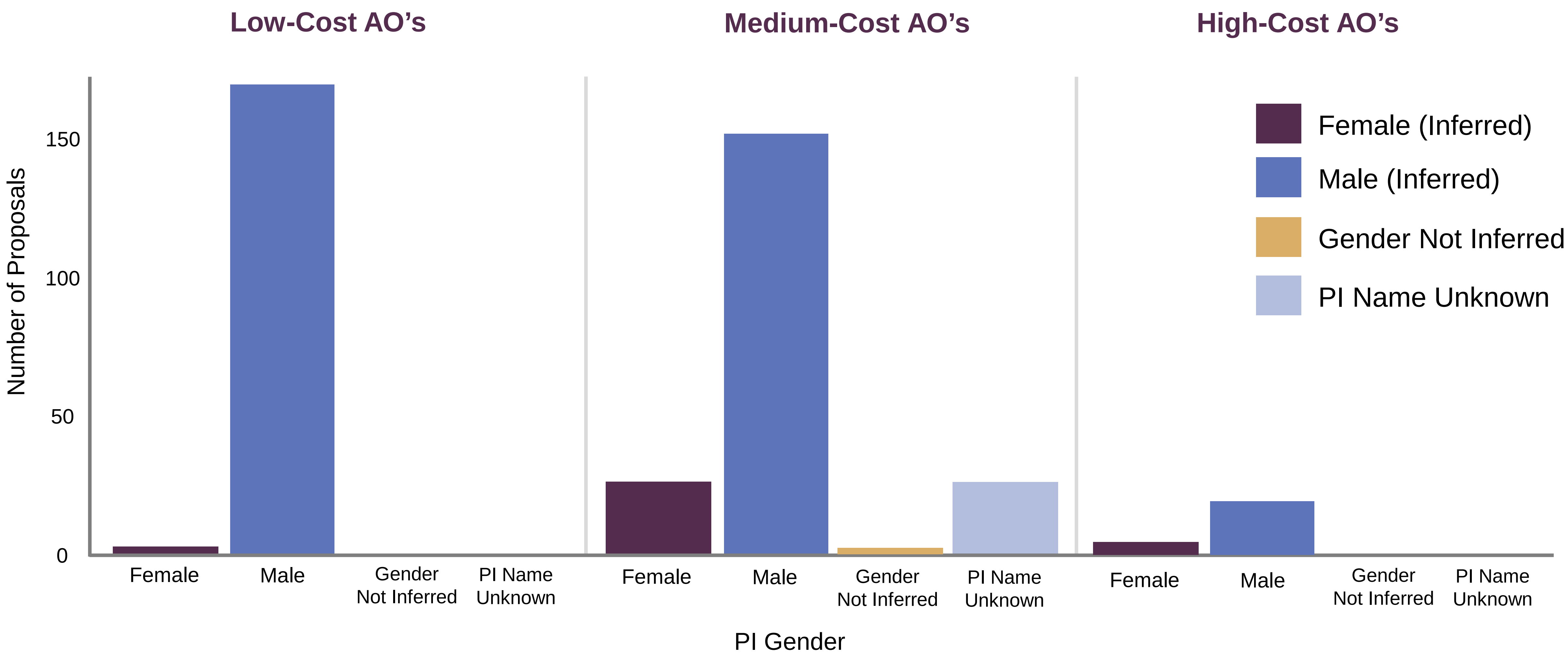
Skills and Experiences that Make You Effective

- Demonstrated leadership
- Understands and has worked with NASA missions in formulation, development, and operations
- May have developed space instruments
- Basic bilingual capabilities in science and engineering, understands tenets of systems engineering
- Ability to make science accessible for multiple audiences – without it, tough to motivate own team or give Step 2 presentation
- Know how to work within NASA's culture; focus on successes, not obstacles
- A 'glass-half-full' attitude – difficult for a pessimist to inspire
- Is perfectly ok to ask for help, and knows when to ask!

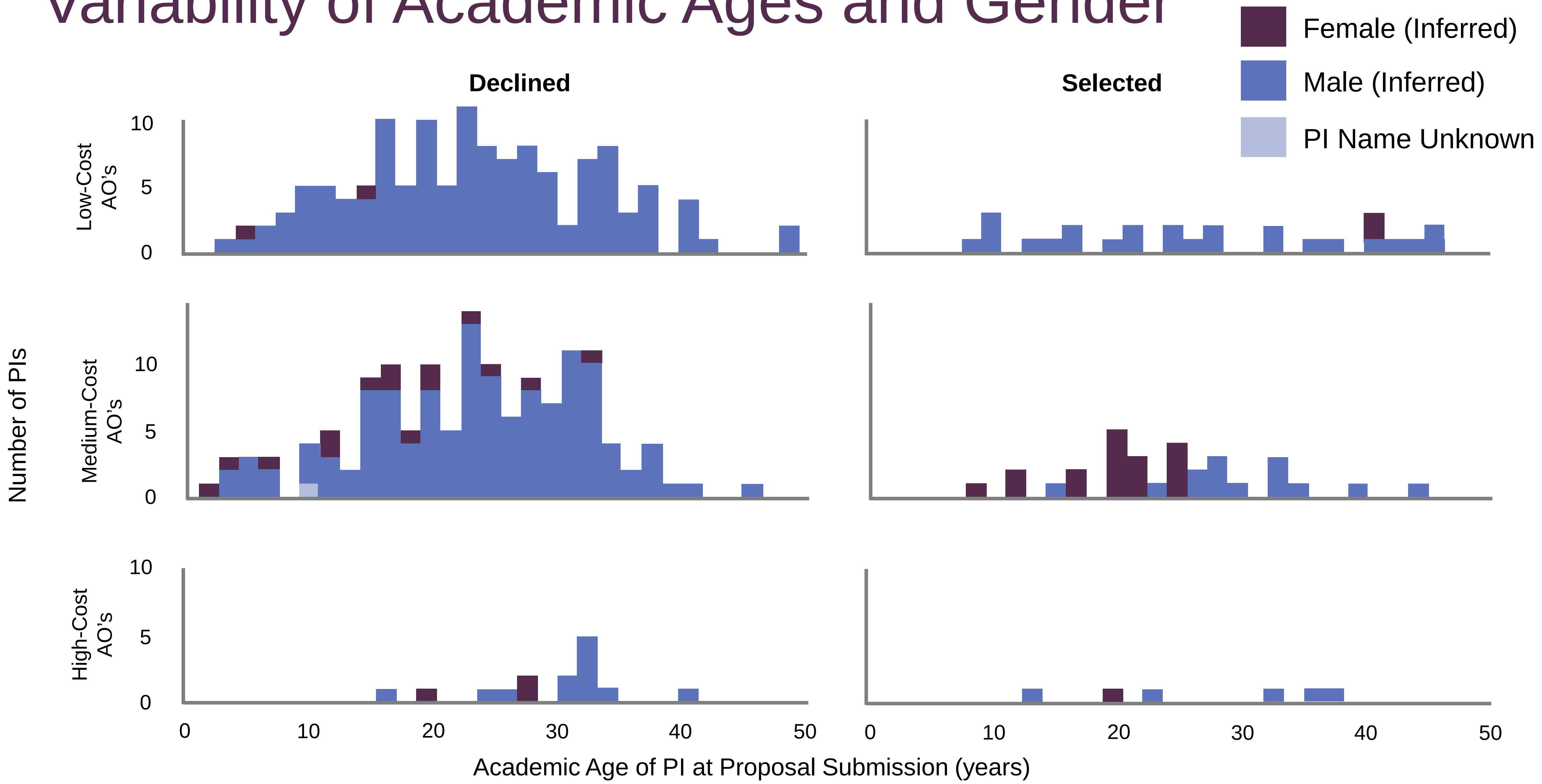
Excellence through Diversity

- Research shows that excellence of teams and diversity go hand-in-hand, especially in innovative activities; excellent teams require diverse opinions and perspectives, and foster a sense of community by encouraging healthy behavior through actions
- While there are no specific evaluation criteria for team diversity, NASA Science cares about all dimensions of diversity across our entire portfolio
- In this presentation, we will focus on gender diversity because it's easiest for us to infer
- We recognize when gender diversity is ignored, other types of diversity are also ignored –we limit the number and types of ideas and implementations, and open ourselves to the risk of group-think adding weakness to proposals
- team size should match the work required and the skills needed; teams should be built with diversity in mind from the beginning, not as a afterthought
- We want to promote opportunities for everyone without artificially changing these numbers – no quotas!

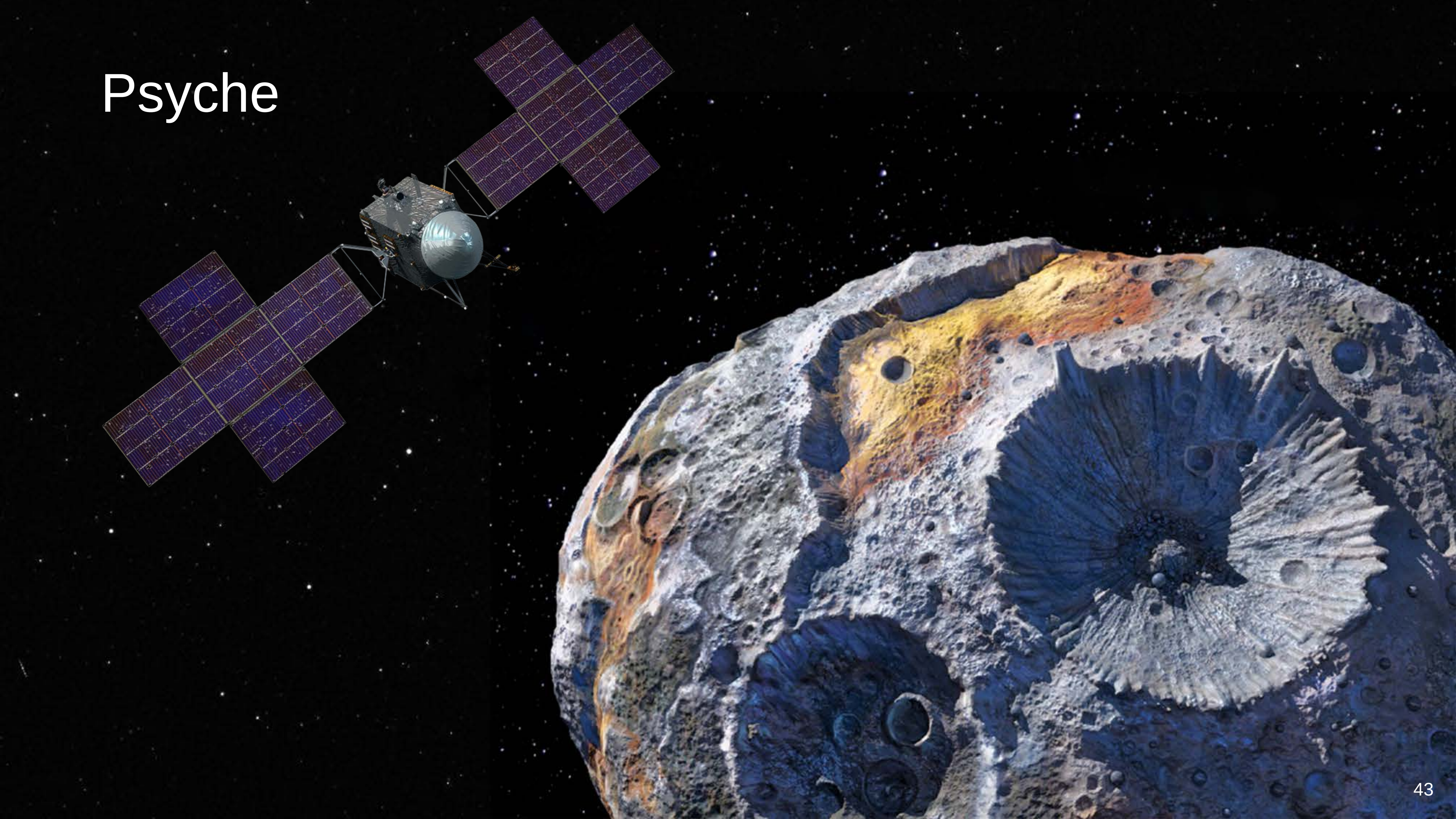
Insufficiency of PI Pool Diversity



Variability of Academic Ages and Gender



Psyche



Key Takeaways on Effective Leadership

- Best predictor of PI’s leadership ability is by how they bring their team together to write a proposal and to make tough decisions; NASA Science notices this during proposal process and Phase A, particularly at site visits
- Team members cannot compensate for significant character weaknesses of PIs, such as arrogance, inability to listen, and inability to make decisions; in Step 2, NASA Science evaluates how teams have evolved
- Proposal writing is a fundamentally innovation-based activity; diversity of PIs and teams will make proposals stronger
- NASA Science is actively discussing how to do a better job developing PIs

EXCELLENT TEAMS

What Makes Excellent Teams?

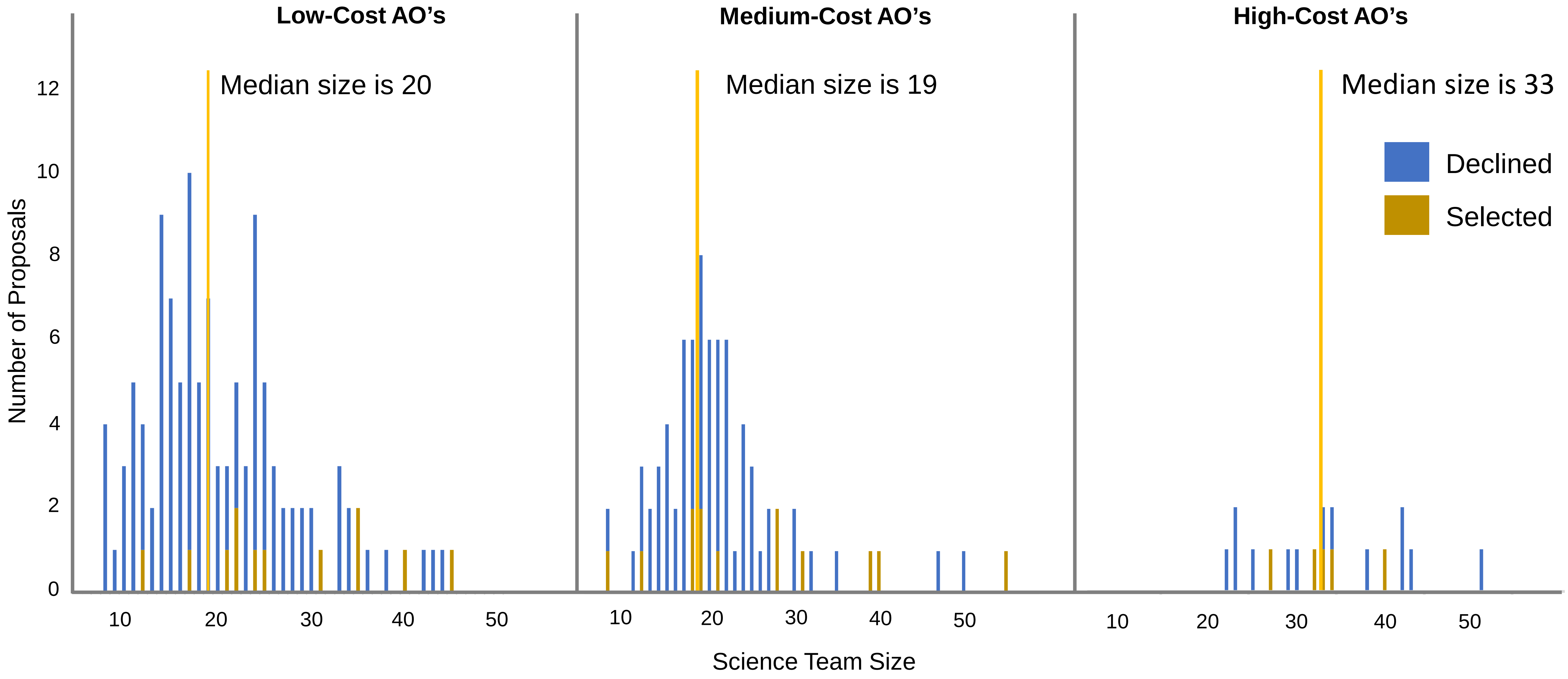
- Industrious individuals exhibiting quality work able to come together with one objective
- Reflect multiple dimensions of diversity to avoid group-think
- Inclusive - team members have a voice and struggle to find best solutions
- Structured for duration of mission - consider succession planning at the start
- Complementary and cross-functional skills
- Right-sized for mission, thinking of all Phases

InSight
Landing Team

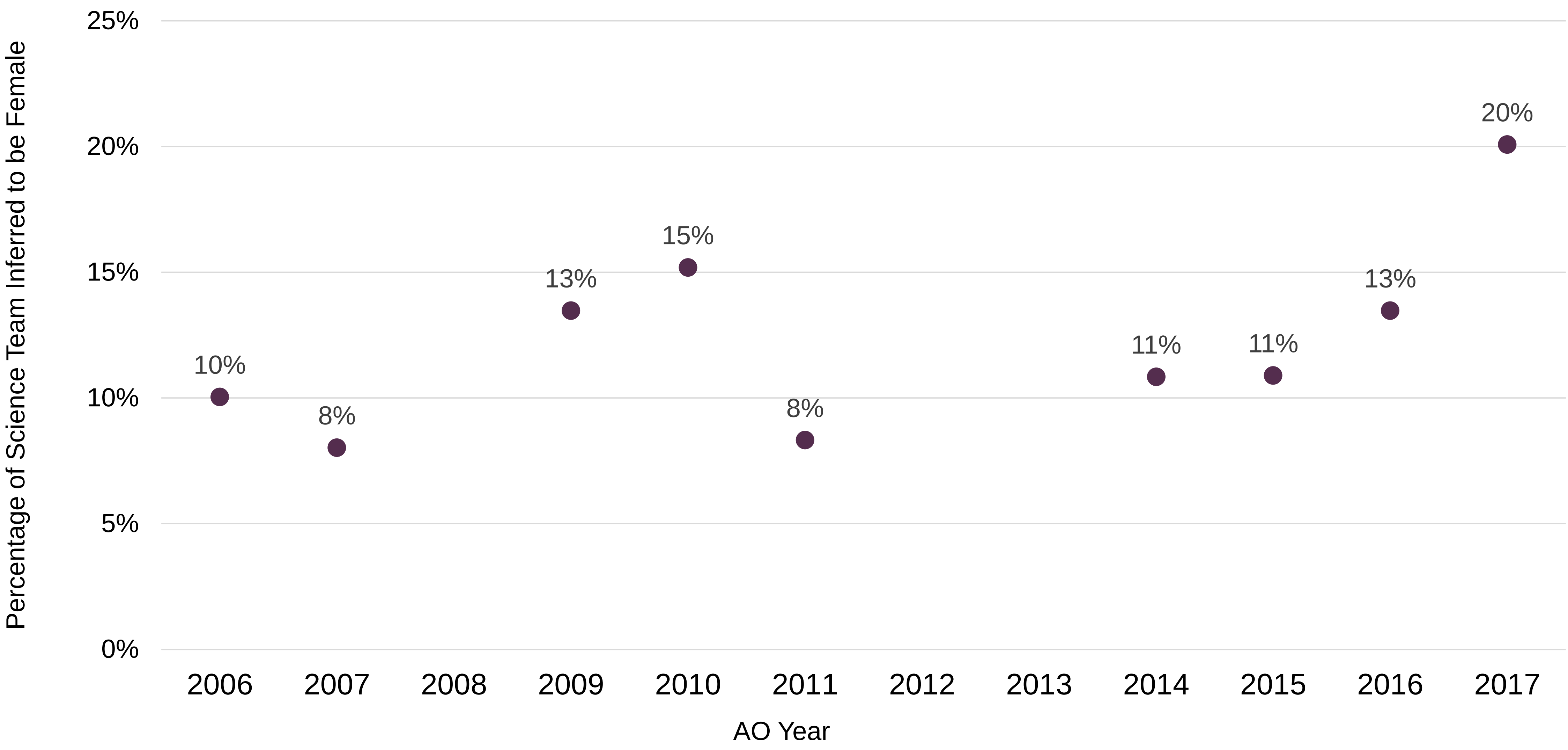
OSIRIS-REx

Journey to asteroid Bennu

Variability of Proposed Science Team Sizes



Fraction of Women on Proposed Science Teams



Key Takeaways on Excellent Teams

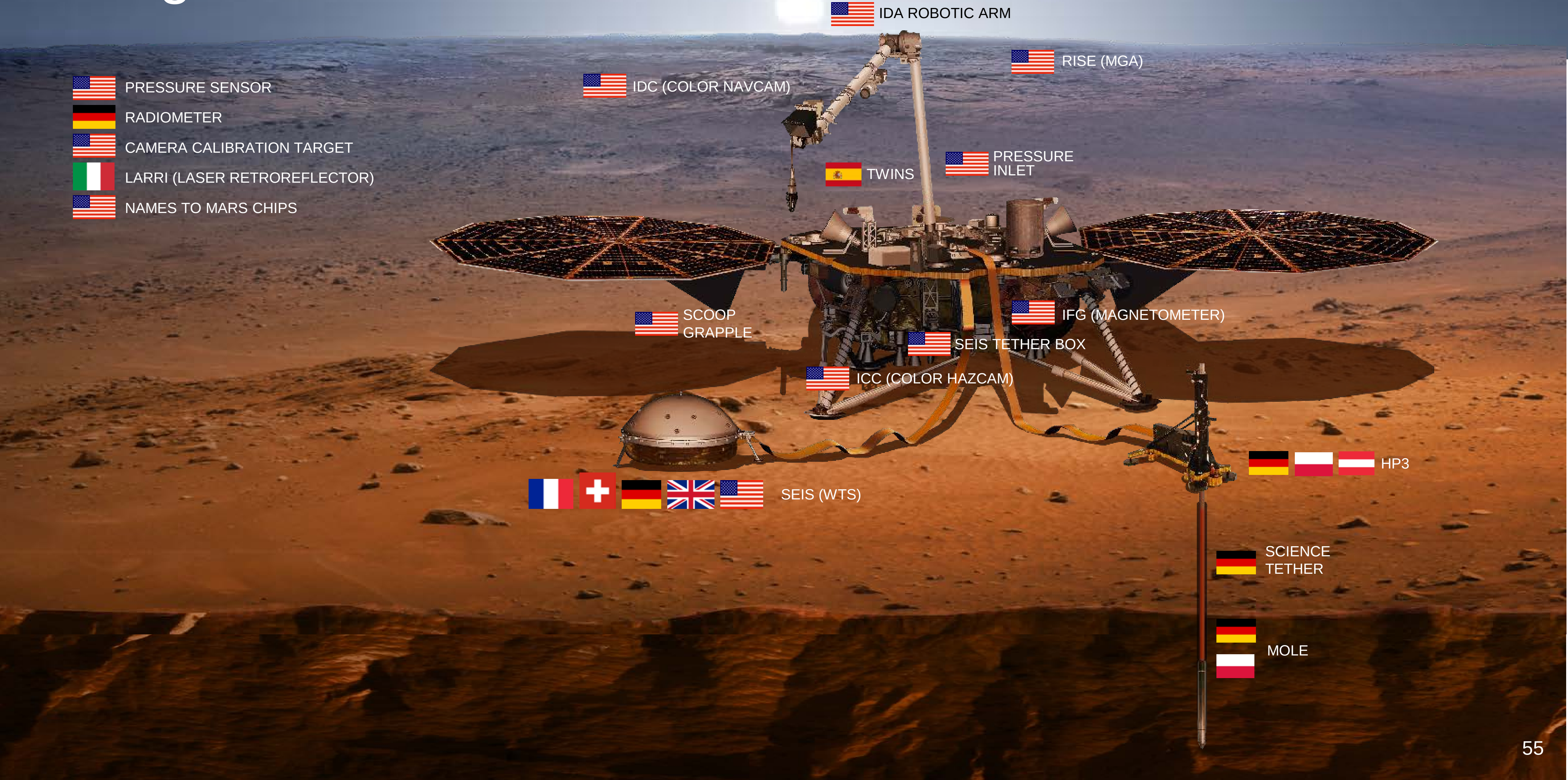
- NASA Science considers team composition from the perspective of excellence and vitality for each proposal received
- Lead and manage your teams – welcome well-motivated changes to team composition
- Selected teams should have a strong code of conduct that prohibits instances of inappropriate behavior; e.g., harassment, suppression of opinions, etc.
- NASA Science welcomes mission teams purposeful about growing talent as part of their mission and is considering new models to include apprenticeship opportunities into mission teams

STRATEGIC PARTNERS

How to Find Strategic Partners

- Recognize partners can make or break a mission – even the best science team does not survive a bad partnership
- Know strengths and weaknesses of potential partners, both for management and industrial partners
- Understand partners' work cultures and how to interact with them
- Communicate how participating aligns with partners' strategies
- Consider past performance and how new partners can meet needs
- International contributions are good, but add complexity that must be managed

InSight Collaboration



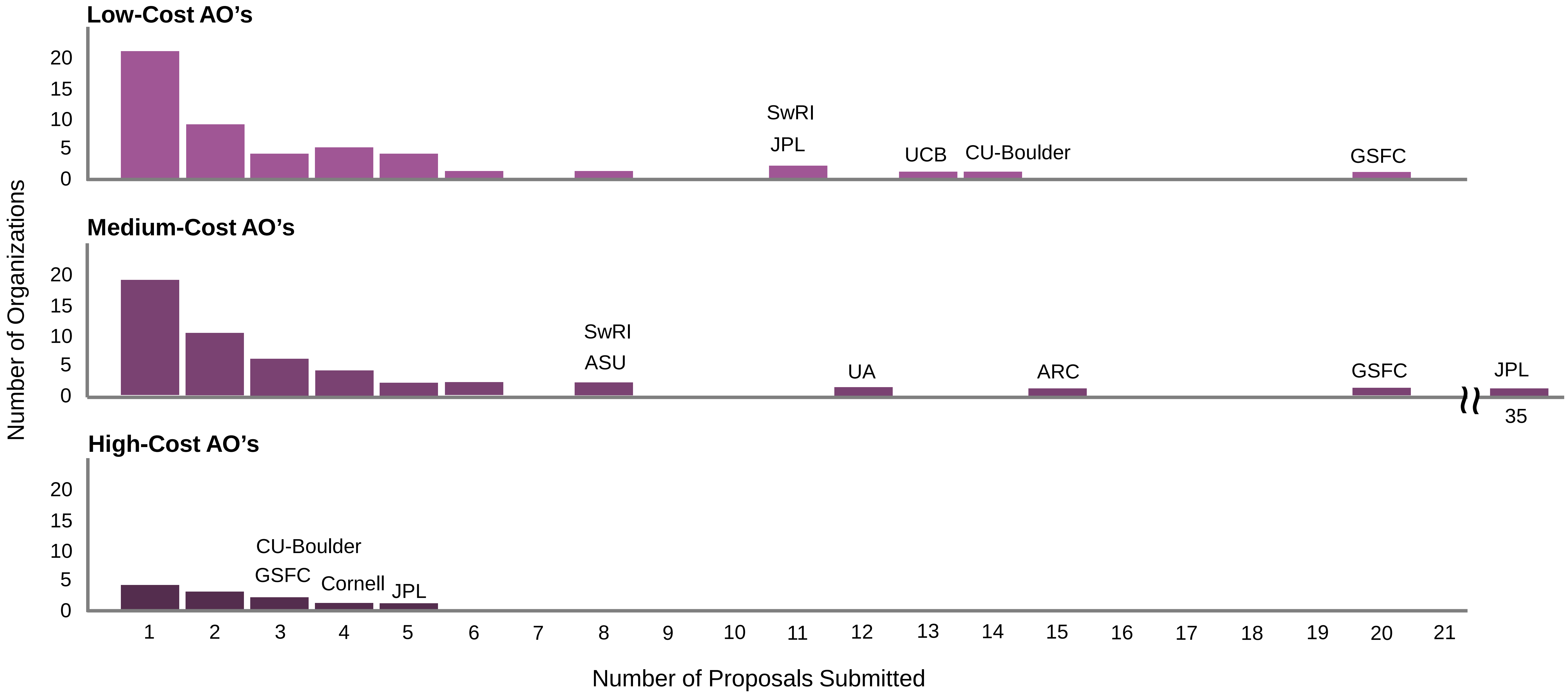
How to Find a Proposal Team

- Find best team members for you to work with, not best team in your zip code or personal network
- Analyze candidate PIs and teams; be sure analysis is performed with rigor, using good data – early stage snap-judgments can lead to substantial loss of talent and diversity
- Avoid impulsive assessments when contemplating industrial partners, particularly in fields of rapid change
- Recognize your management, engineering teams and partners need to gel with your science team; be deliberate about that process – mutual respect is critical

A Word to PI Organizations

- Proposing a PI class mission requires you to be well-equipped to do so; not every institution can submit a billion dollar proposal – benchmark against University of Arizona, University of California – Berkeley, etc.
- Proposing PIs need your commitment through
  - Multi-year support for proposal preparation, including travel, teaching relief, etc.
  - Support staff such as financial personnel, writers, artists, etc.
- If successful, the PI will bring visibility to your institution, but it comes with needs, such as laboratories, management, communications support, etc.
- PI class missions and proposed student collaborations are a huge opportunity for student research – NASA values that!

Proposing PI Organizations



Mission Management Organizations

Of the analyzed proposals, 64% were managed by these 5 organizations

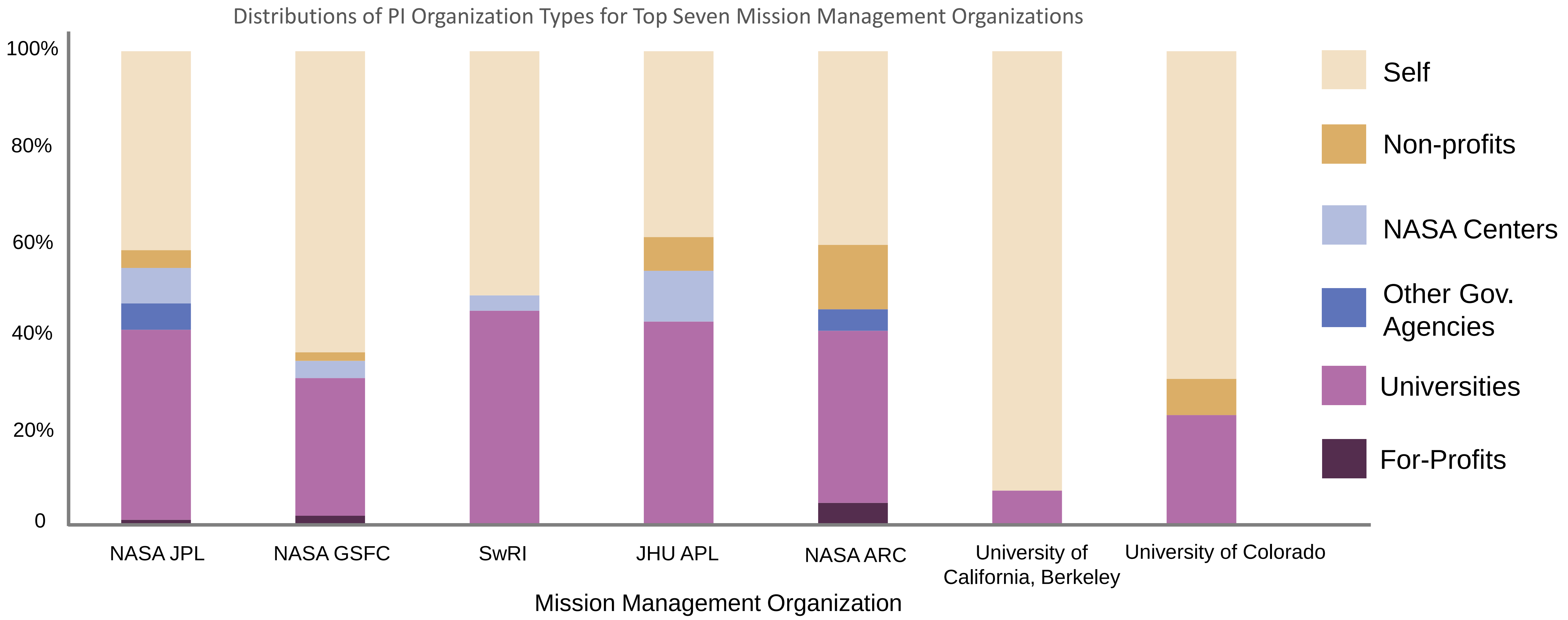
- 28% were managed by NASA JPL
- 22% were managed by NASA GSFC
- 4.5% each were managed by the JHU APL, UC Berkeley, and NASA ARC

Success rates (awards + tech-funding) vary across these organizations though

- NASA JPL's success rate as a management center is 20%
- NASA GSFC's success rate as a management center is 33%
- UC Berkeley's success rate as a management center is 21%
- Both JHU APL and NASA ARC success rate as a management center is 14%

We expect this list to evolve over time, especially for small and medium-size missions

Relationship of PI Organization Type to Proposed Mission Management Organization



Spacecraft Providers

In the 93 proposals where a spacecraft provider could be determined, 78% of proposals partnered with only six organizations

- 18% of proposals partnered with Lockheed Martin
- 17% of proposals partnered with Northrop Grumman or a company that is now a subsidiary
- 15% of proposals partnered with Ball Aerospace
- 12%, 10%, 6% of proposals partnered with JHU APL, Millennium Space Systems, SWRI, respectively

The number of spacecraft providers decreases as the AO Cost Class increases

- There were 12 individual organizations used in proposals to Low-Cost AO's
- There were 10 individual organizations used in proposals to Medium-Cost AO's
- There were 3 individual organizations used in proposals to High-Cost AO's

We expect this list to evolve over time, especially for low and medium-size missions

Key Takeaways on Strategic Partners

- Support from your home organization is critical for success
- NASA Science encourages management and industry partners to be thoughtful and data-driven in their partnership processes; biases introduced here are difficult to recover from as a community
- We encourage organizations to gain experience at lower mission classes and “graduate up” – generally speaking, it is difficult to propose successfully at a class if your organization has not worked on the next lower class within the past 5-10 years
- There is room for experimentation and capacity-building at Missions of Opportunity and Small Explorers levels

SYSTEMS DESIGN

Role of Technical, Management, Cost Analysis

- We are asking a group of experts to come together to understand the proposal and provide a summary of descriptors, issues, and risks
- It is the job of this group to find all issues and risks – it is not their job to decide whether or not we are comfortable with them
- Here is my personal experience
  - There are very few times the analysis is totally wrong
  - There are cases where judgments between proposers and TMC team is different
- **It is NASA HQ's job to accept risks – do not blame TMC for that**
- Note: Expectations keep going up for obvious psychological reasons; we know the problem, but have not found a good response to this

Scores and Categories

- Majority of Category I proposals have Science Implementation Merit of E/VG or E
- Only 1 “high risk” proposal has been Category I

Form B × Category

Form B	I	II	III	IV
E	35	5	1	14
E/VG	31	13	5	18
VG	21	23	7	36
VG/G	2	16	9	34
G		10	6	42
G/F			3	20
F				21
F/P				1
P				1

Risk × Category

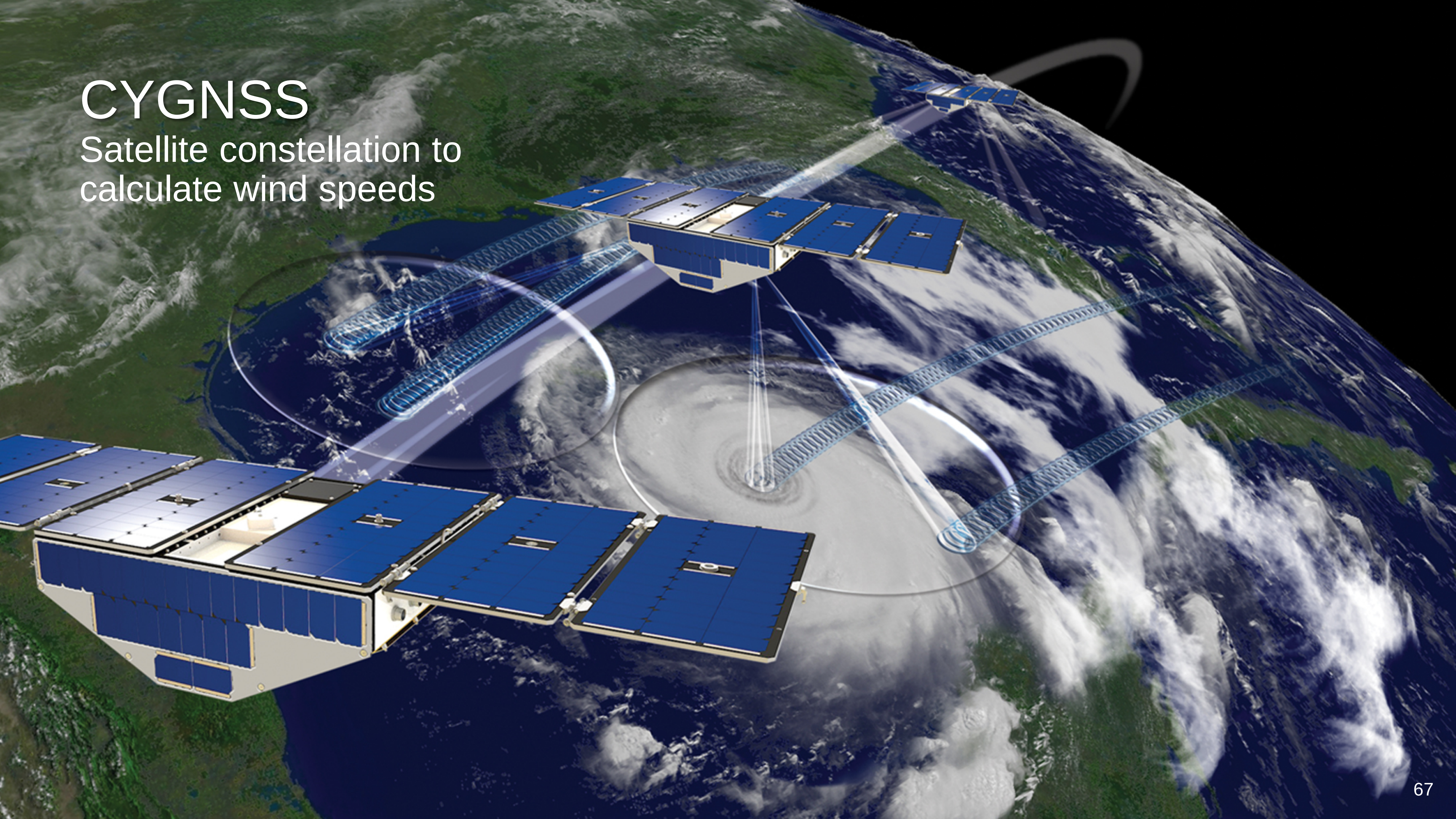
Risk	I	II	III	IV
L	53	22	3	20
M	35	38	7	45
H	1	7	21	122

How Should You Think About Systems Design?

- **Make all decisions flow from overarching science questions to ensure no decisions prevent answering those questions (start with that, then modify)**
- Understand requirements are your friends –they allow to distinguish between what you have to do to achieve your goals from what you might like to do beyond just achieving your goals
- Constraints are also your friends – they help you come up with a lean and focused proposal
- Find a systems engineer you trust and partner with them
- Manage innovation and new technology to produce transformative science

CYGNSS

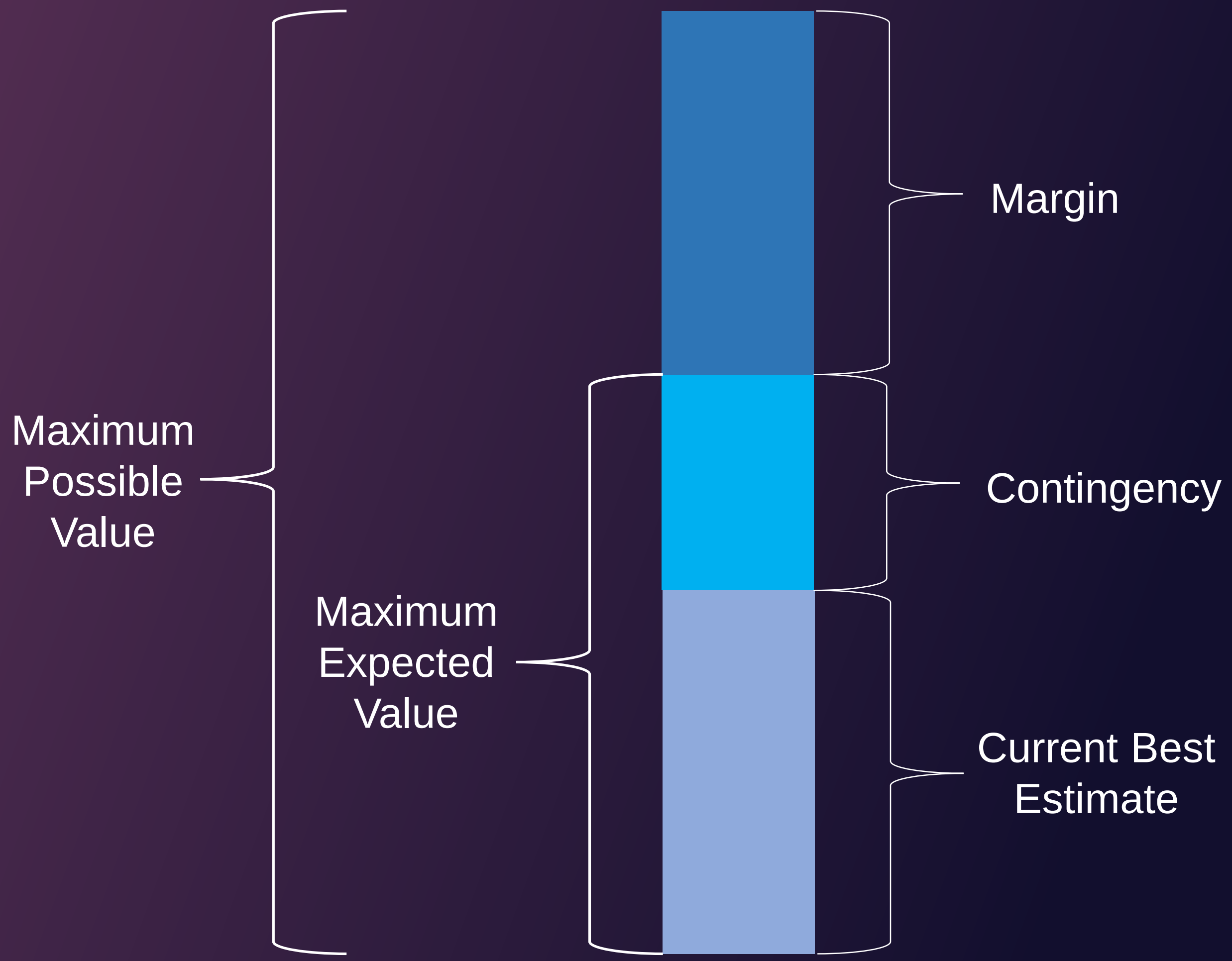
Satellite constellation to calculate wind speeds



Systems Engineering

- TMC concerns about systems engineering plans resulted in major weaknesses in 30% of Step 1 proposals
- Requirements definition and flow-down; consistency between the different project subsystems and mission elements and the proposed mission resources continues to be a common source of major weaknesses
- Other common findings include
  - An incomplete or unconvincing plan for how systems engineering responsibilities will be executed across the entire project with strong project-level oversight of this critical function
  - Whether the implementation plan provides for adequate resources for all participating organizations to successfully accomplish this function

Contingency and Margin



Margin

- The difference between the maximum possible amount of a resource and the expected maximum amount of that resource
- Accounts for unexpected growth - the “unknown unknowns”

Contingency

- The difference between the maximum expected amount of a resource and the current best estimate of that resource
- Accounts for expected growth - the “known unknowns”

Technical Design Margins

- The technical design margins category includes all aspects of the flight system and instrument payload, such as mass, power and energy, data handling and communication links, ΔV impulse budgets and propellant margins
- Of the proposals in the study sample, 40% were judged to have at least one major weakness in this category
  - Of these, mass and power margins were the most prevalent areas of concern, with mass margin issues accounting for about 38% of noted major weaknesses
- TMC review teams look for a comprehensive engineering concept design that includes levels of contingency and margin appropriate for the phase of development, along with suitable rationale for the size of each

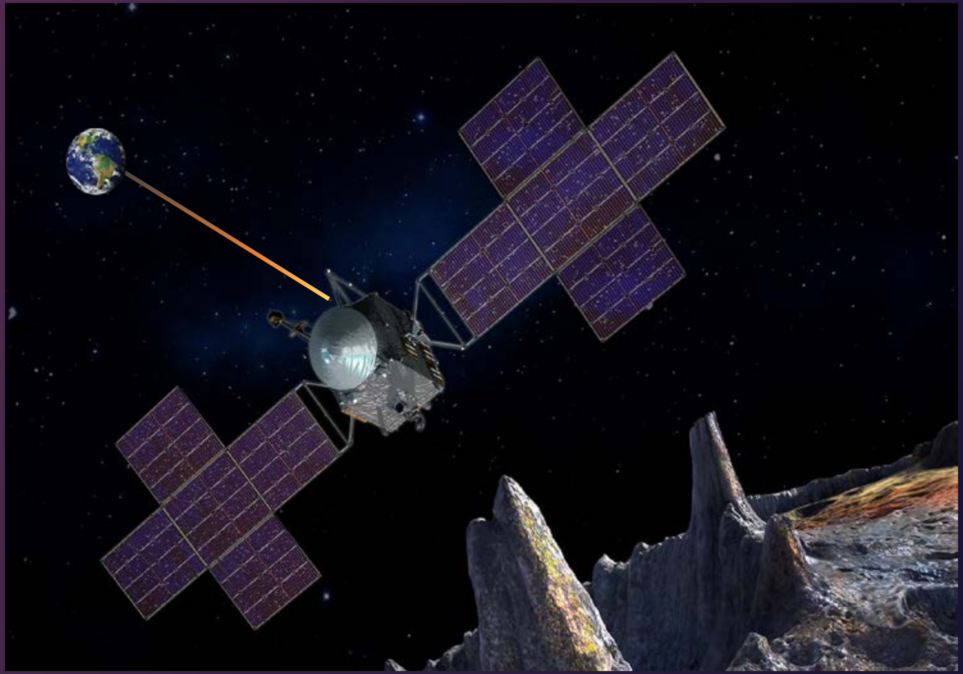
Instrument Implementation

- Major weaknesses in the instrument category appear in 32% of Step 1 proposals
- Areas of concern that produce major weaknesses include
  - Overstated maturity or under-scoped resources for technology development
  - Inadequate or inconsistent definition of performance related requirements
  - Inadequate or inconsistent design concept definition
  - Weak heritage claims
  - Inconsistencies between instrument requirements and the spacecraft instrument accommodation capabilities
  - Insufficient integration and test program including an end-to-end verification test
  - Issues with pointing performance and potential for detector contamination during flight, when appropriate

Approach to Innovative Technology Investments

- Innovative technologies enable transformative science; investments in technology demonstrations, infusions, and new innovations yield better, more affordable science
- Most PI-led missions have innovations, such as first-use technology or innovative operations/target/orbit
- Innovative technology should be matured before beginning mission development; technology needing work to reach TRL-6 can be a major risk that must be mitigated before PDR
- NASA Science offers over $250M of funding through a dozen technology programs competed through ROSES and designed to mature technologies well in advance of a flight mission
- Additionally, Space Technology Mission Directorate supports 10 technology programs to develop low-TRL instruments and space platform technologies

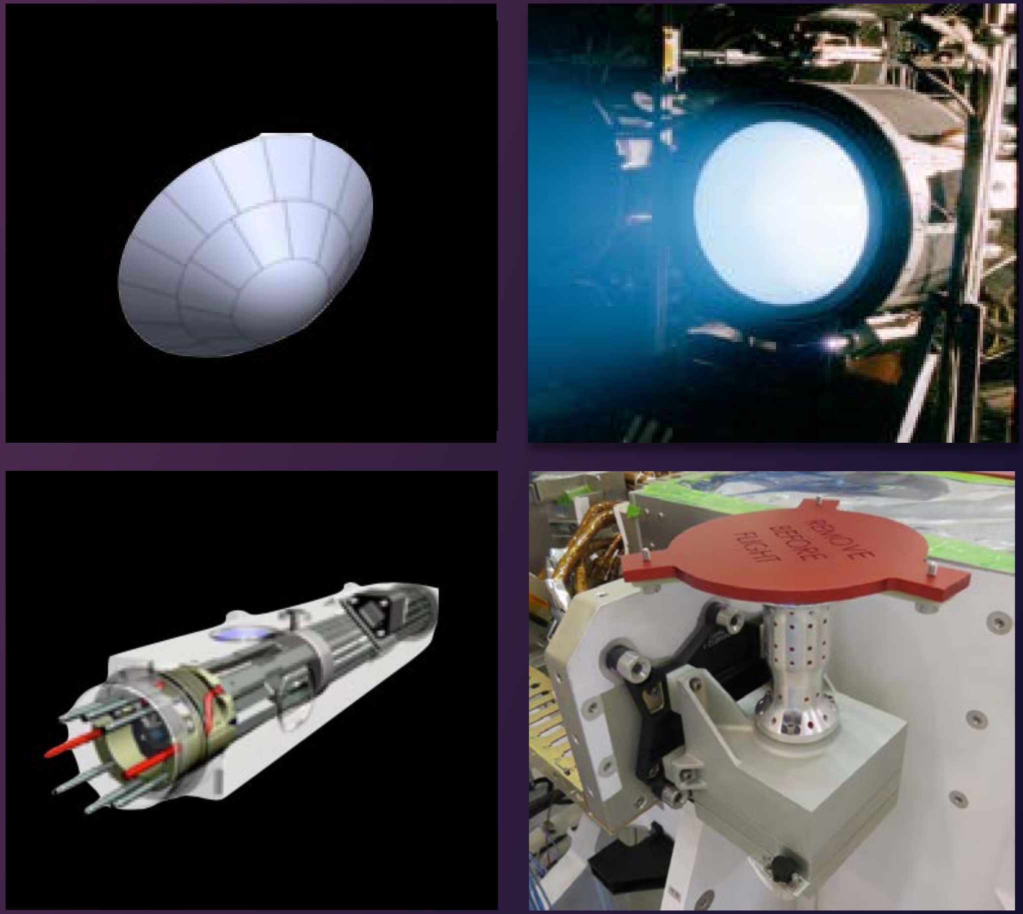
Technology Demonstration Opportunities



Deep Space Optical Comm (DSOC) technology demonstration will be tested on the Psyche mission

- NASA Science encourages the use of new technologies for selected AOs
- “Enhancing Technology Demonstration Opportunities”, or TDOs consist of:
  - Technologies developed either by the PI team or developed by NASA technology programs
  - System-level Technology Readiness Level (TRL) < 6
  - Instruments, hardware, or software
- TDOs enhance, but do not enable, the Baseline or Threshold science mission
- Incentives may be offered to the PI to include TDOs

Technology Infusion Opportunities



Recent Technology Infusion opportunities: NASA Evolutionary Xenon Thruster, Heatshield for Extreme Entry Environment Technology, and Deep Space Atomic Clock

- NASA Science also offers and encourages the use of NASA-developed technologies for mission infusion
- Offered as Government-Furnished Equipment (GFE); NASA is responsible for maturing the technology to TRL 6
- Technology Infusions enable the mission
- Incentives may be offered to the PI to include Technology Infusions

PROJECT MANAGEMENT

How Should You Think About Project Management?

- The main reason PI class management processes are so successful because a single person is empowered to trade mission scope, schedule and cost; proposing teams need to find the right trades, and PIs need to make decisions and take ownership
- Proposing teams should practice that during the proposal and Phase A – communicate, listen, focus, decide
- Balance mission success within cost and schedule constraints over life of mission
- Understand that a single risk is not what kills a mission - accumulation of risk does, or lack of understanding therefore
- We do not blame PIs for risks they do not own

ICON

Cost Issues

- Of all Step 1 proposals reviewed, 33% had at least one major weakness regarding cost
- There are three common reasons why a proposal received a cost major weakness:
  - Cost Reserve is too low. Several common findings may lead to this
    - A reserve level (percent of cost-to-go) below the stated AO requirement
    - Liens already identified against the reserves
    - Reserves too low to cover cost threats identified during evaluation
    - Incorrect phasing of reserves
  - Basis of Estimate is flawed - proposer's explanation of the rationale and methodology used to prepare the cost proposal is found to be incomplete, unconvincing, or deficient in some other significant area
  - The TMC team cannot validate proposer's cost estimate to within the validation error range

Complex Operations

- In 8% proposals, there were major weaknesses identified related to the complexity of the proposed operations
- Included planned observing sequences for instruments, particularly when the payload consisted of several instruments that must be scheduled and operated sequentially to avoid interfering with each other or in cases where many critical events must occur in a short period of time
- Proposed landers present additional operational challenges that may not be adequately planned; takes lots of experience

Management Issues: Management Plans

- Management issues include two separate areas: management plans and project schedules
- Management plans were the source of major weaknesses in 26% of Step 1 proposals
  - Confusing organizational roles and responsibilities for the participating institutions or key individuals
  - Unclear lines of authority within the project, or between the project and the participating institutions
  - Lack of demonstrated organization or individual expertise for the specific role identified
  - Low time commitments for essential members of the core management team
  - Missing letters of commitment or endorsement from partners, as required by AO instruction
- Simple rule: if it is hard to explain a management structure, it is too complicated

Management Issues: Project Schedules

- TMC review of master schedules led to major weaknesses in 17% of the Step 1 proposals reviewed
- Common items of concern are
  - Insufficient detail from which to perform an assessment of whether the proposer understands how the work will be accomplished in time
  - The master schedule shows no margin or inadequate margin to address potential delays
  - The TMC reviewers assess whether the proposed schedule reflects realistic expectations based on recent experiences in flight system and payload development

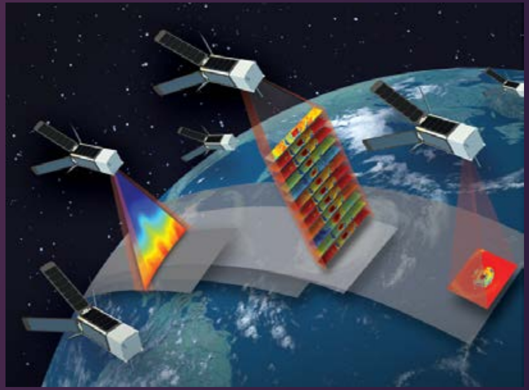
MISSIONS OF OPPORTUNITY

Importance of Small, Innovative Missions

- **Expand** science programs to take advantage of small satellite rapid innovation to achieve breakthrough science
- **Enable** fast access to space with focused science measurements to fill a critical gap between large flight projects
- **Leverage** technology investments to further improve potential of science instruments
- **Partner** with commercial entities to acquire new capabilities of small satellite platforms

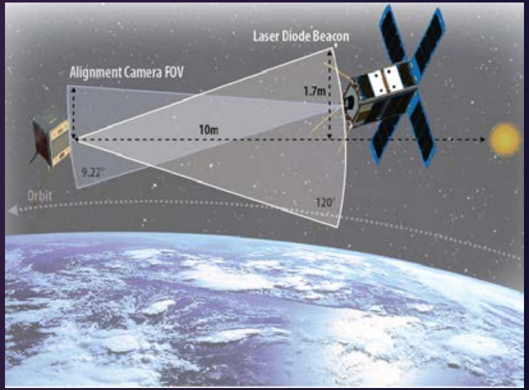
SmallSat Opportunities

Three InVEST-17 Awards Announced July 20, 2018



Earth Venture Missions (EVM) and In-Space Validation of Earth Science Technologies (InVEST)

Investing up to $35M in Astrophysics SmallSat Missions



Astrophysics Explorers SmallSat Missions of Opportunity

Investing up to $65M for ESPA-class Payloads

Heliophysics Technology Demonstration Mission of Opportunity

Investing up to $55M in Deep Space SmallSat Missions

Small Innovative Missions for Planetary Exploration (SIMPLEx)

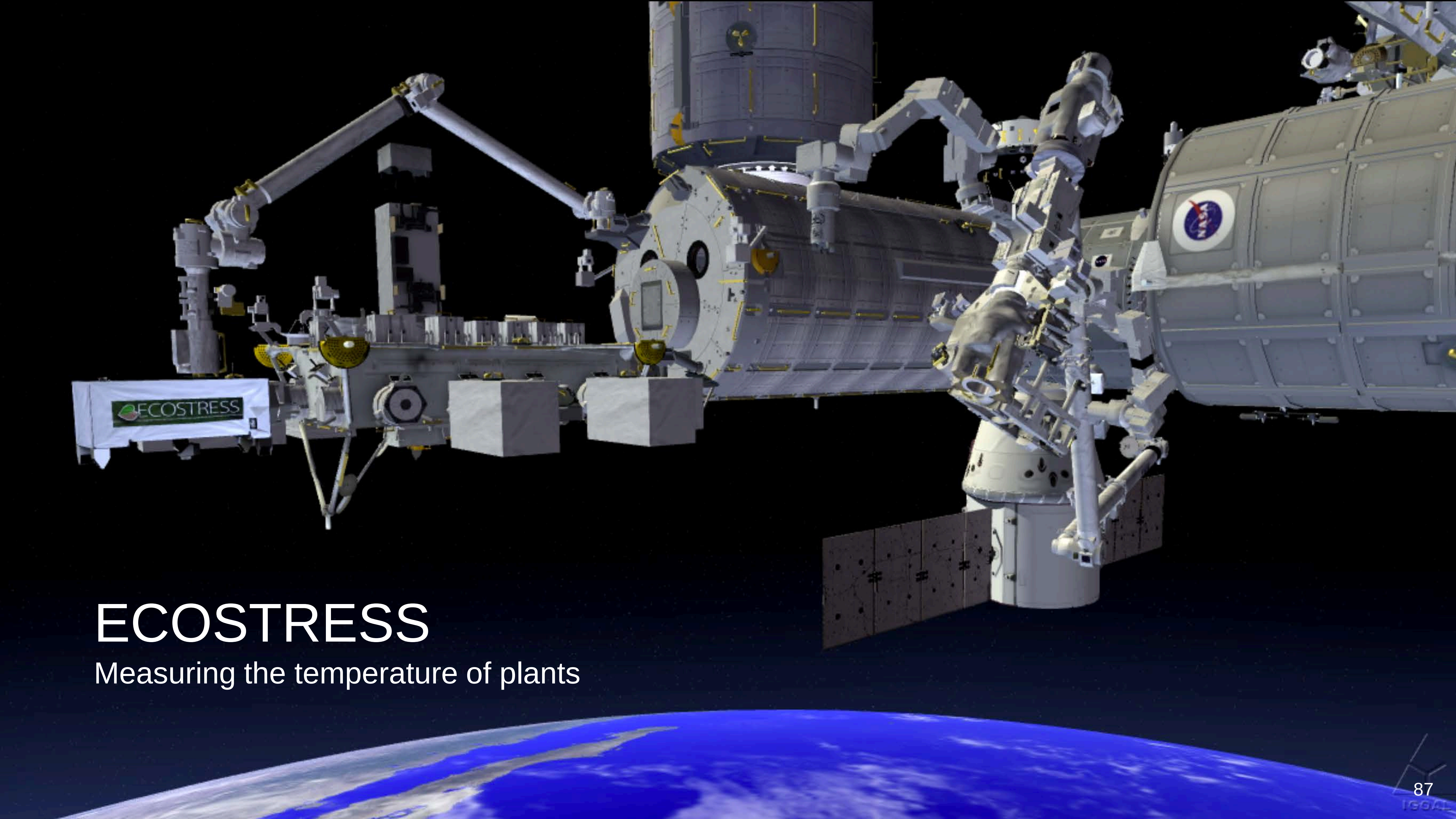
SmallSat/CubeSat commercial engagement opportunities are essential to NASA Science's balanced portfolio, achieving distinct science objectives

Missions of Opportunity, Small Complete Missions

- Solicited by all Divisions through the Stand-alone Mission of Opportunity Notice AO (SALMON)
    - Typically cost-capped at $70M and below
- These are the smallest PI-led spaceflight investigations
    - SmallSats/CubeSats to be co-manifested with other missions or launched on their own on Venture-class launch vehicles
    - Investigations to be mounted on the ISS, Gateway, commercial or non-NASA satellites
- Hardware contributions to international missions
- These are the perfect scope for very targeted investigations
- Many more organizations should be able to manage these than even the smallest full mission
    - BUT: smaller missions are not easier to do - there are often fewer ways to get out of trouble than in a larger mission

Other Ways to Get to Space

- Three divisions offer opportunities for SmallSat or CubeSat missions through “Research Opportunities and Space and Earth Science (ROSES)”
  - Astrophysics solicits science investigations and/or technology development utilizing payloads flown on CubeSats ” through “Astrophysics Research and Analysis (APRA)” program
  - Earth Science solicits for the demonstration of new technologies and/or Earth science measurements from CubeSats through the “In-Space Validation of Earth Science Technologies (InVEST)” program
  - Heliophysics solicits technology and associated science investigations with instruments flown on SmallSats or payloads on the International Space Station (ISS), or other rideshare opportunities through the “Heliophysics Flight Opportunities for Research and Technology (H-FORT)” program

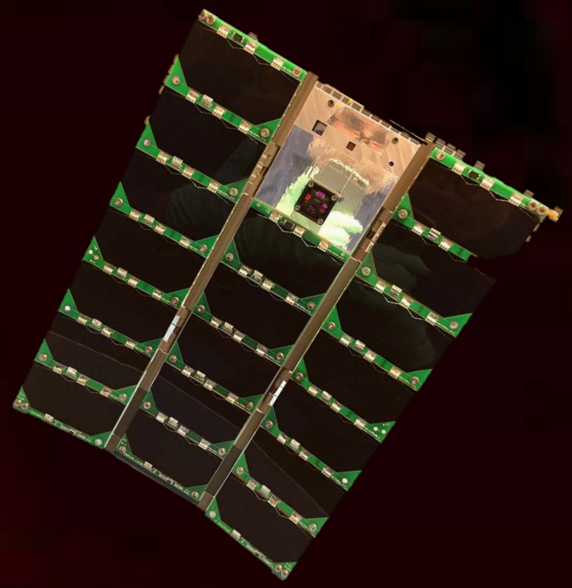


ECOSTRESS

Measuring the temperature of plants

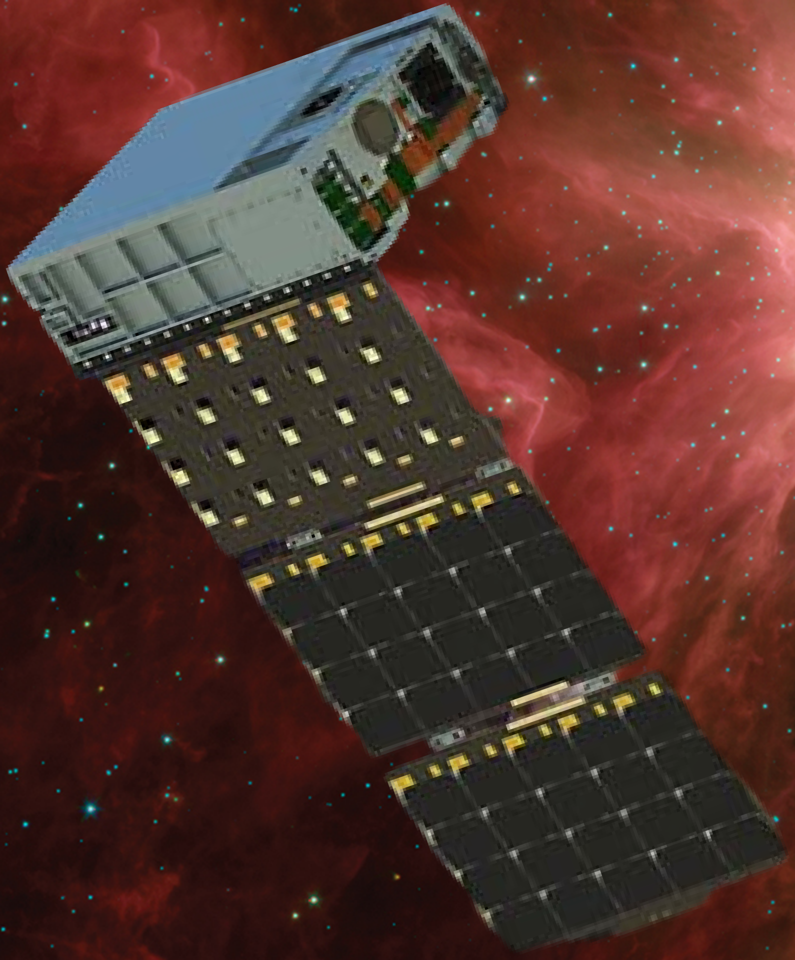
Miniature X-ray Solar Spectrometer (MinXSS)

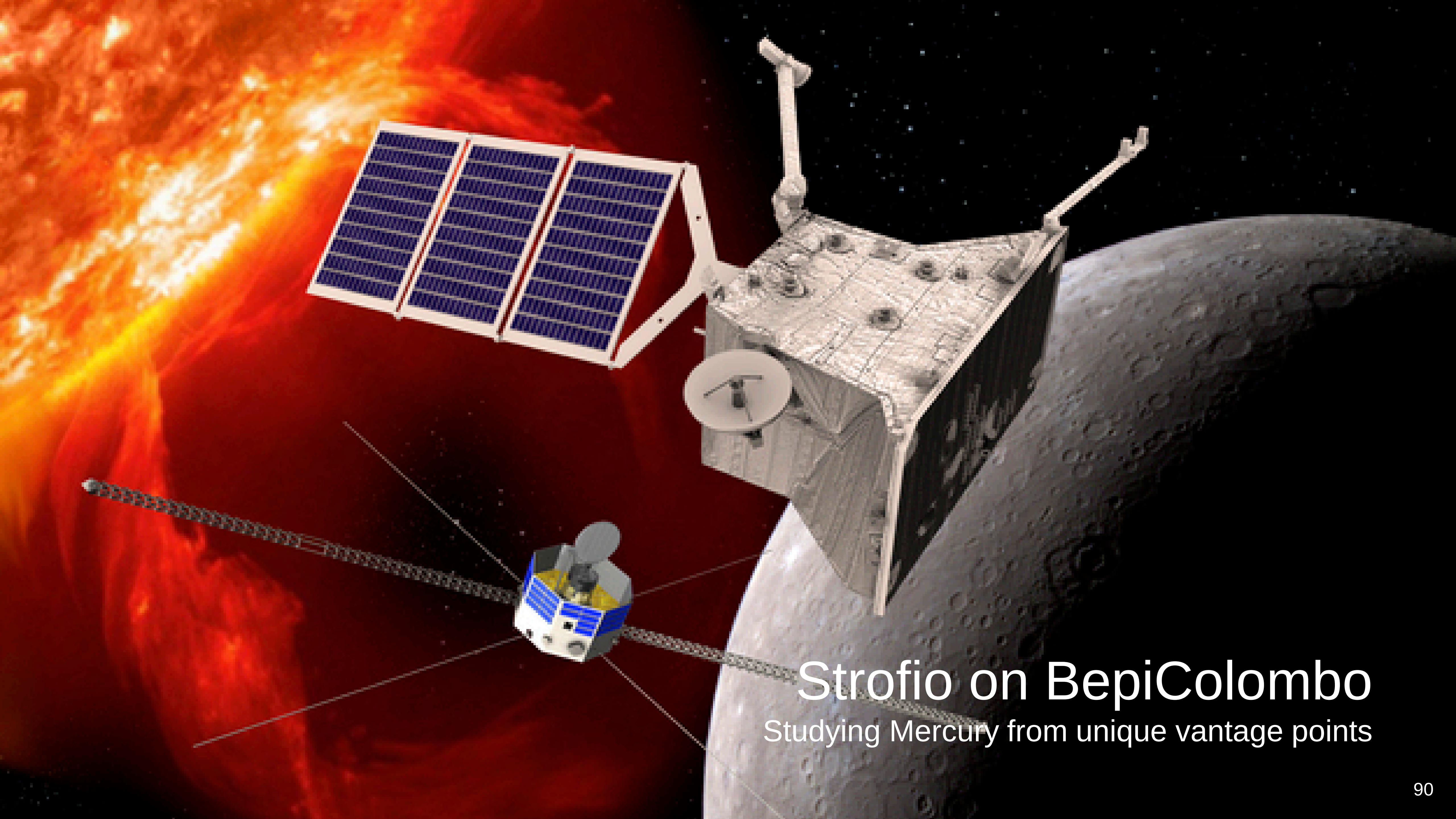
Studying solar flares



HaloSat

X-ray detection of
galactic hot gas halo





Strofio on BepiColombo

Studying Mercury from unique vantage points


GOLD
Instrument
Onboard SES-14

Missions of Opportunity Often Tailored Class D

- NASA Science has put in place a policy mandating that all missions costing less than $150M should be managed as Tailored Class D
- SMD wants to manage these missions differently: there are fewer high-level reviews, smaller number of reviewers, fewer management requirements
- The goal is for SMD to take more risks and move faster for these types of missions
- NASA Science manages risk through cancellations when needed, and the threshold for these projects is lower

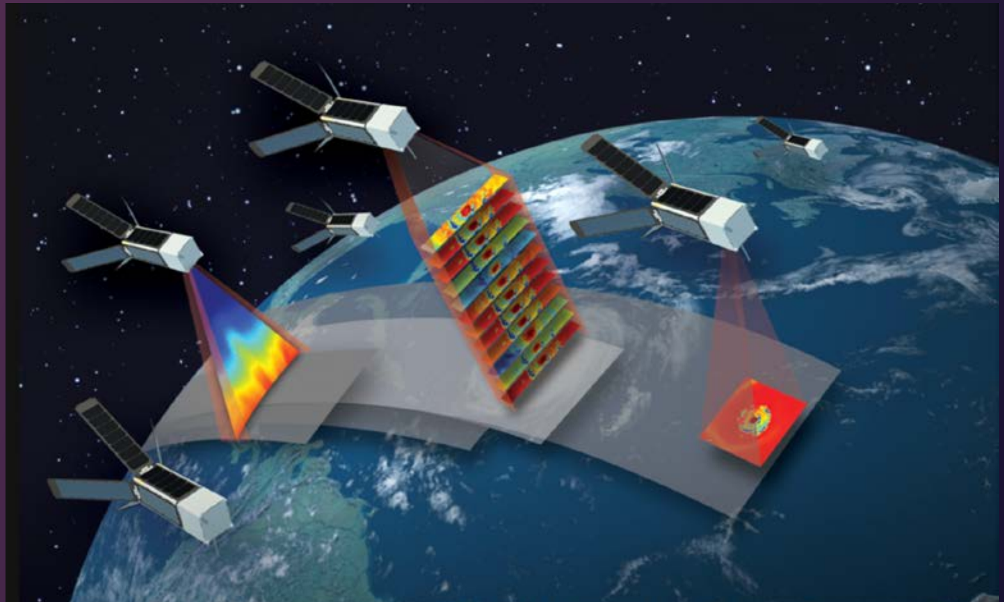
Class D Streamlined Implementation

Accepting higher risk for scientific gain by implementing a tailored classification approach

Comments on Missions of Opportunity

- We believe that policy is not yet working as intended
- Recently, a Tailored Class D Mission of Opportunity came to confirmation with over 50 configuration-controlled documents - we need buy-in from all stakeholders in the community to succeed!
- Current Mission of Opportunity proposals are almost as complex as full mission proposals
- Discussing simplifying the Missions of Opportunity process to significantly reduce what is needed for the Step-1 proposal

Rideshare Enables Small Mission Science


A constellation of identical 3U CubeSats provide sounding (left CubeSat has a temperature profile of a simulated Tropical Cyclone (TC) from a numerical weather prediction (NWP) model) and 12-channel radiometric imagery (center CubeSat has simulated radiances from NWP model and radiative transfer model and the near right CubeSat has a single-channel radiance image of a TC) with a median revisit rate approaching 30 minutes to meet most PATH requirements.

- Enables low cost access-to-space by leveraging excess capability on NASA launches
- Decouples mission decision from access-to-space decision
- Enhances opportunities to define and answer new science questions and sustain continuity measurements
- Opportunity to infuse technology
- Significant international growth presents additional opportunity

5.5 million

6.9 million

4.7 million

NASA Awards Venture Class Launch Services Contracts

- Three companies selected to provide new commercial launch capabilities for SmallSats/CubeSats
  - Firefly Space Systems Inc.
  - Rocket Lab USA Inc.
  - Virgin Galactic LLC
- Increases frequency NASA can utilize SmallSats/CubeSats for scientific research
- Opens doors for commercial launch services dedicated to transporting smaller payloads

CAUTIONARY TALE

(YOU STILL MAY NOT BE SUCCESSFUL)

- Even perfectly written proposals do not always win
- I personally led and participated in five Category I proposals that did not win
- There are issues related to programmatic balance, availability of workforce, etc. that can come into play at the end
- Our commitment: We are not perfect, but we run a fair and strict process
- My personal commitment: After Step 2, I will personally break the good and the bad news. I tend to meet personally with those who do not win

Open Questions We Are Considering

- How can the proposal process be simplified without losing essential ingredients for success?
- How should proposal requirements adapt to opportunities of different cost/complexity?
- How do we solicit MOs to right-size proposal process and to gain speed?
- How do we not stand in the way of new ways of doing business?
- How do we use MOs, especially CubeSat/SmallSats, to effectively train future mission leaders?
- How do we ensure teams remain healthy and aligned with NASA's values? Should NASA intervene when it does not work? If so, how?

Mission Principal Investigator Development

- NASA Science has been exploring barriers to participation
- Workshop in November 2018 explored issues and provided valuable feedback for forward work
  - Developed a consolidated PI resources webpage at https://science.nasa.gov/researchers/new-pi-resources
  - Introduced a pre-reviews of mission peer review panels to ensure diversity and reduce conflicts of interest
  - Added a code of conduct requirement for SMD-funded conferences to ROSES 2019
  - Restarted proposal writing workshops at major science conferences
  - Included career development positions and associated evaluation criteria as part Discovery and New Frontiers AOs
- Upcoming activities include
  - Information sessions at science conferences and stand-alone workshops to support those developing first proposal
  - First workshop will be held October 16-18, 2019 in Tucson, AZ and information on how to register will be forthcoming
  - Sign up to learn more at https://lists.hq.nasa.gov/mailman/listinfo/hq-smdpi-workshop-outreach

Final Thoughts

- We know this is difficult, but it is worthwhile
- This is an iterative process, do not conclude anything about yourself from losing
- We are routinely making changes to AOs and the peer review process
  - Standard AO Template
  - Implicit Bias Training
  - Classified Appendices
  - Handling of co-manifested payloads and ride-alongs, etc.
- Leverage advances in the commercial and government sector to achieve excellent science
- Class D and other lower-cost / higher-risk opportunities (rideshare, hosted payloads, CubeSats, Venture Class, etc.) are expanding ways to become a PI

National Aeronautics and Space Administration

EXPLORE SCIENCE

Writing Successful Proposals: OBSERVATIONS FROM NASA

Dr. Thomas H. Zurbuchen
Associate Administrator
Science Mission Directorate

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