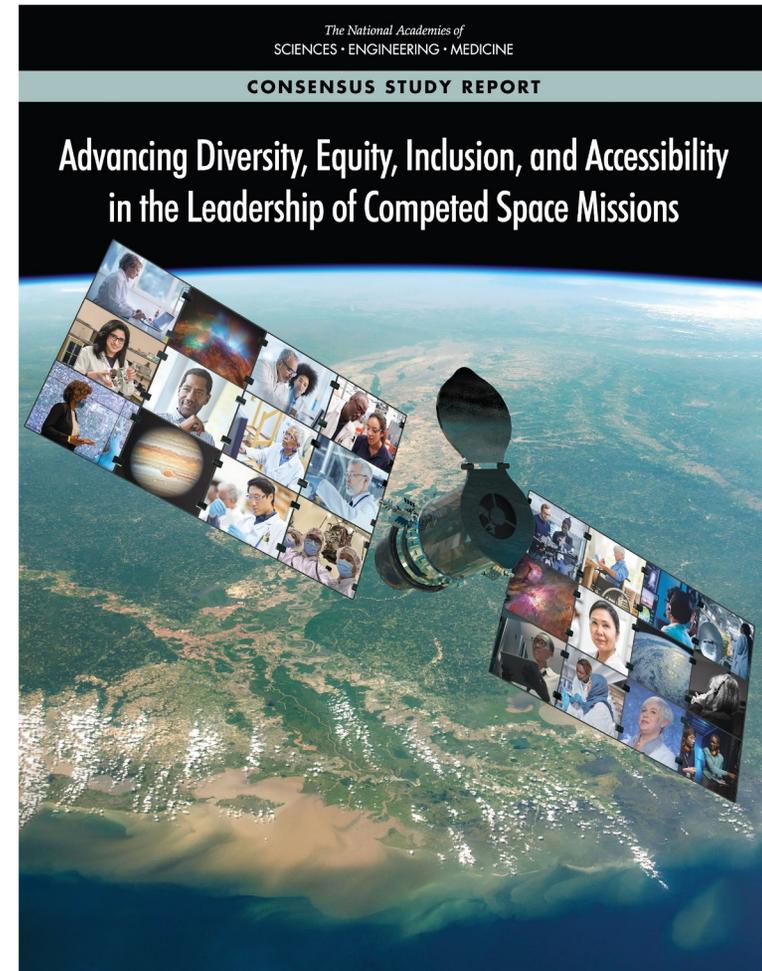


Outline

- **Context and charge**
- **Study process**
- **Actionable near-term & long-term recommendations**
- **Q&A**



Context

The Principal Investigator (PI) leads a mission team

NASA's Science Divisions: **Astrophysics, Earth Science, Heliophysics, Planetary Science** solicit space mission investigations via Announcements of Opportunity (AO)

- **Strategic Assigned Missions** – large; instruments often competed
- **Competed Missions** – Three sizes: small (cubesats, balloons, rockets, instruments), medium, large (\$35M-\$1B)

Context

- **Diverse perspectives, experiences, and backgrounds are beneficial to the creativity, innovation, and impact of science teams**
- ***“NASA believes in the importance of diverse and inclusive teams to tackle strategic problems and maximize scientific return.”*** (NASA’s Science Plan 2020-2024)
- **Currently, mission teams lack demographic diversity: principal investigators and teams are largely white and male**

Study Charge

Recommend actions to increase DEIA in the leadership of space mission proposals submitted to NASA SMD:

- requisite tasks, organizational processes, and human networks necessary to navigate mission proposal process
- barriers and bottlenecks to potential proposers
- social and behavioral elements presenting impediments (e.g., bias, discrimination, harassment, work/life balance considerations, tenure requirements, lack of inclusion & accommodations for disabilities)
- differences in pool of mission leaders across SMD divisions and compared to pool of potential proposers
- best practices from other federal agencies

Committee Members

FRAN BAGENAL (NAS) (Co-Chair)

University of Colorado, Boulder

* **WANDA E. WARD** (Co-Chair)

University of Illinois, Urbana-Champaign

CLAUDE R. CANIZARES (NAS)

Massachusetts Institute of Technology

* **ERIN CECH**

University of Michigan

ANNMARIE ELDERING

Jet Propulsion Laboratory

* **ELENA A. EROSHEVA**

University of Washington

ORLANDO FIGUEROA

Orlando Leadership, LLC

ALLISON N. JAYNES

University of Iowa

* **LINDSEY MALCOM-PIQUEUX**

California Institute of Technology

DAVID J. MCCOMAS

Princeton University

* **CHRISTOPHER B. NEWMAN**

Azusa Pacific University

KUNIO M. SAYANAGI

Hampton University

KEIVAN G. STASSUN

Vanderbilt University

LOUIS-GREGORY STROLGER

Space Telescope Science Institute

- physical sciences

* - social sciences

The Study Process

- **8 public fact-finding meetings**
- **Engaged with numerous experts**
 - NASA personnel (past and present)
 - Research institutions, universities, professional societies
 - Social Science scholars
 - Representatives from other federal agencies
- **Evidence**
 - Documentation provided by NASA, other federal agencies, space sciences professional societies, universities, industry, and research institutes
 - Peer-reviewed research in the social sciences
 - Collective expertise of committee members with mission experience
 - Pilot, qualitative study involving semi-structured interviews with a sample of mission proposal PIs

Committee Focus

Domestic science workforce

- Provide opportunities to every U.S.-born person, especially those from underrepresented communities, to pursue a career in the space sciences
- Supply of foreign talent in flux, unclear how it will change

Full career pathway in the space sciences

- Identify opportunities earlier in education-to-career STEM pathways

Minority Serving Institutions (MSIs)

- Produces significant % of STEM graduates (e.g., physics degrees) from underrepresented groups
- More likely to employ physics faculty who are from underrepresented groups

Report Recommendations

15 total: Oversight & 4 Themes

Near-Term

- 1 • Proposal Process & Review — Enhancing Opportunities, Mitigating Barriers
- 2 • Data System — Collection, Analysis, Reporting of Data on Proposal Teams, Proposal Pools, and Workforce
- 3 • Training and Mentoring Potential PIs
- 4 • Investment in Career Pathways for Underrepresented Groups

Long -Term

Oversight of Implementation of DEIA Efforts

Oversight of Implementation of DEIA Efforts

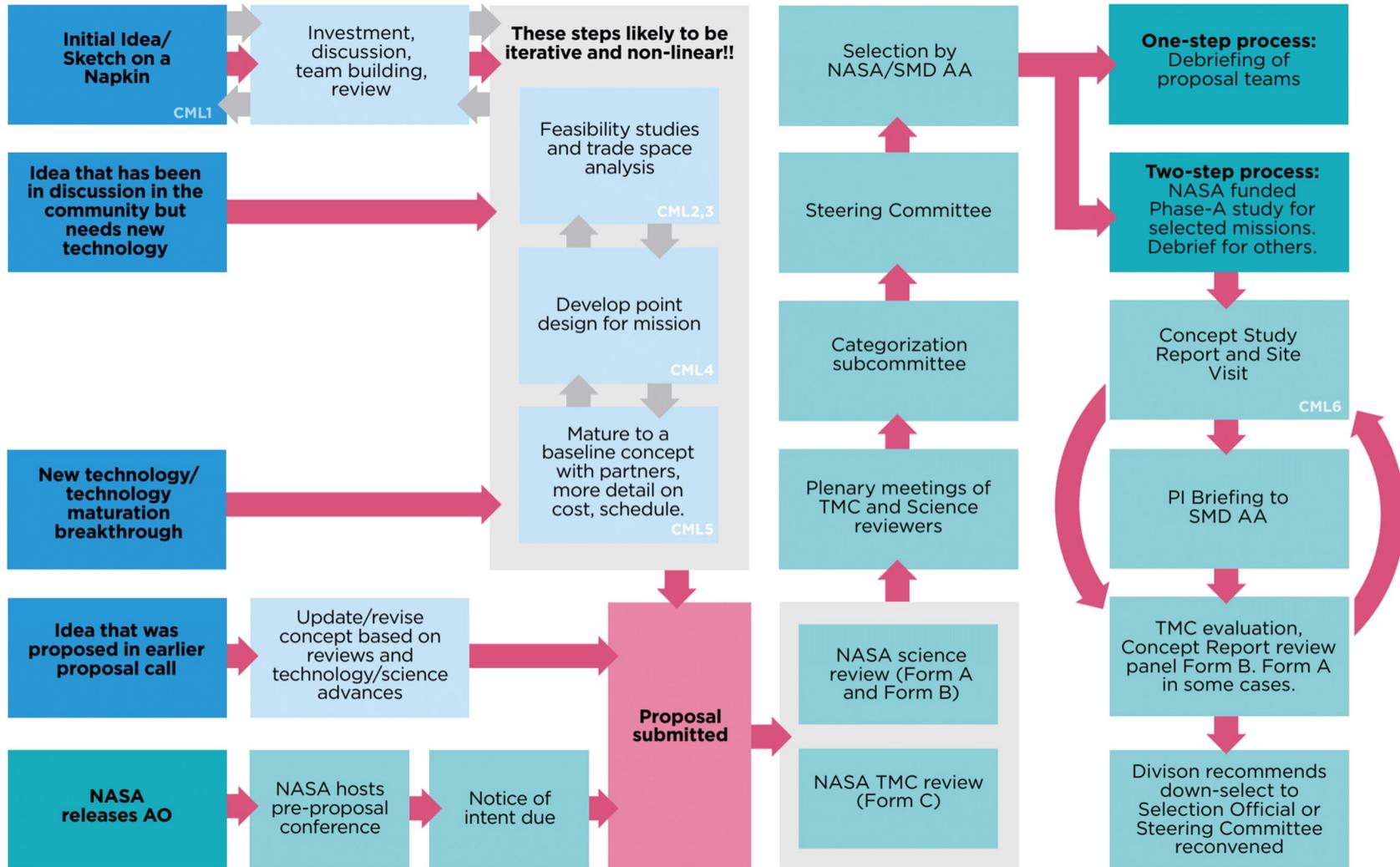
CONCLUSION: Lack of NAC committee focused on DEIA with Chair serving on NAC itself, misses unique opportunity to help set the tone at top of Agency & ensure ongoing critical focus on shaping NASA SMD's broadening participation efforts.

RECOMMENDATION 1:

NASA should empanel an ongoing NASA Advisory Council specifically focused on DEIA, whose committee Chair serves on the NAC. This Committee should have a broad charter and external world-class membership in this area to directly advise top NASA leadership and ensure an ongoing strong focus on NASA's broadening DEIA efforts.

THEME 1: Proposal Process and Review—Enhancing Opportunities, Mitigating Barriers

Proposal Process and Review



It's complicated!

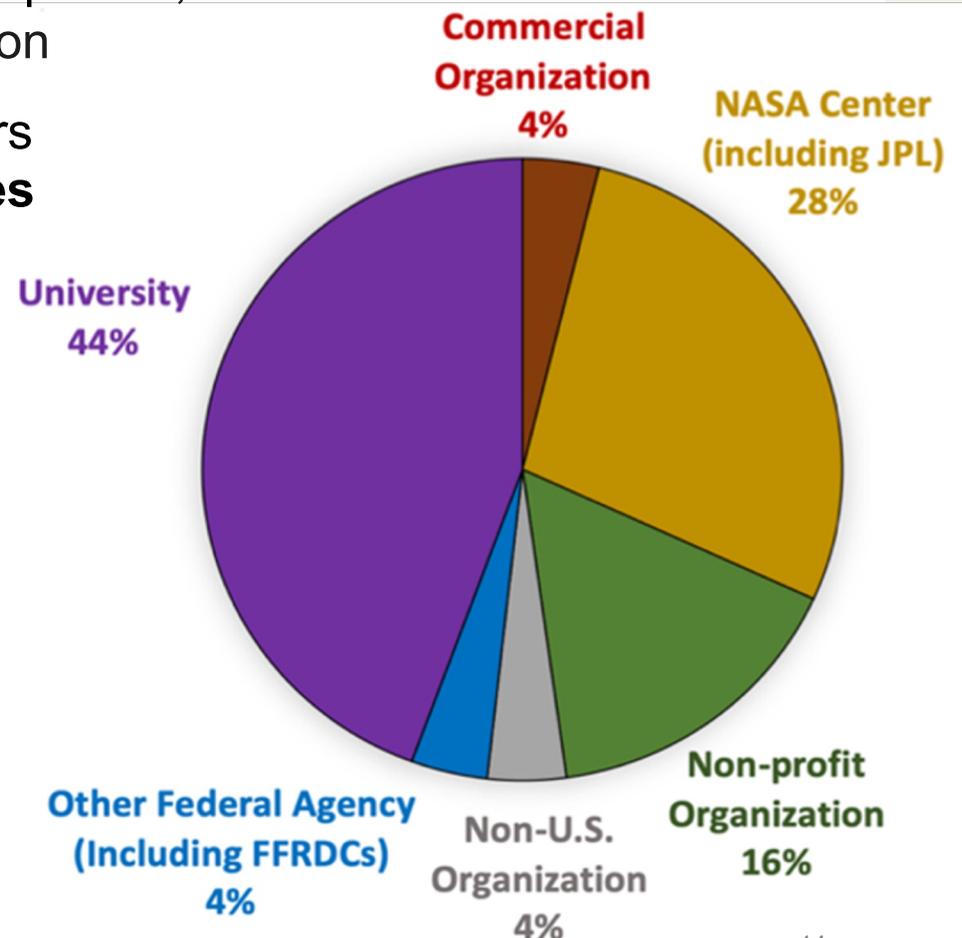
Proposal Process and Review: Findings

“The Competition before the Competition”

- Team formation, concept development, proposal preparation can be: **informal, idiosyncratic, organic, opaque and often personality-driven**
- **Resource-intensive:** time, money, expertise, often years before proposal submission
- Proposing institutions decision-makers **control investments & opportunities** to become PI.

Impacts diversity of PI candidate pool

Disadvantages prospective PIs from underrepresented populations & less-resourced institutions.



Recommendation 2

NASA should work to make the pre-proposal “competition before the competition” process transparent and accessible.

Additionally, NASA should use its own resources to expand support of pre-proposal and proposal efforts of diverse, external PIs through its field centers and encourage other involved institutions to do the same.

Proposal Process and Review: Findings

Proposal PIs report in interviews:

- **Multiple forms of bias** throughout proposal process
- **Experiencing discrimination** even after assuming leadership position for successful competed mission.
- Interpersonal interactions with others **undermined their sense of belonging**
- **Mismatch in the messaging** about “what it takes” to be a PI versus their self-perceptions

These are all potential barriers to diversity along pathway to competed space mission leadership positions.

Recommendation 4

NASA SMD should develop and make public a systematic and transparent process to assess how the review of proposals submitted for research support is conducted.

- Moreover, NASA SMD should **collaborate with experts to develop and employ an assessment of its mission proposal review process** as well as involve **experts on disparities in research funding** experienced by historically marginalized groups. Such an assessment should also include gathering feedback from proposers.
- In the longer term, NASA Headquarters should **develop a comprehensive assessment of its proposal review processes**, not only with the PI-led missions, but **to be employed agency-wide**.
- This analysis and assessment should include **consideration of emergent bias-reducing practices** (such as Dual-Anonymous Peer Review) and **methods to track, identify, and reduce bias in the review and evaluation process**.

Recommendation 5

In keeping step with its core values of diversity, equity, inclusion, and accessibility, NASA SMD should:

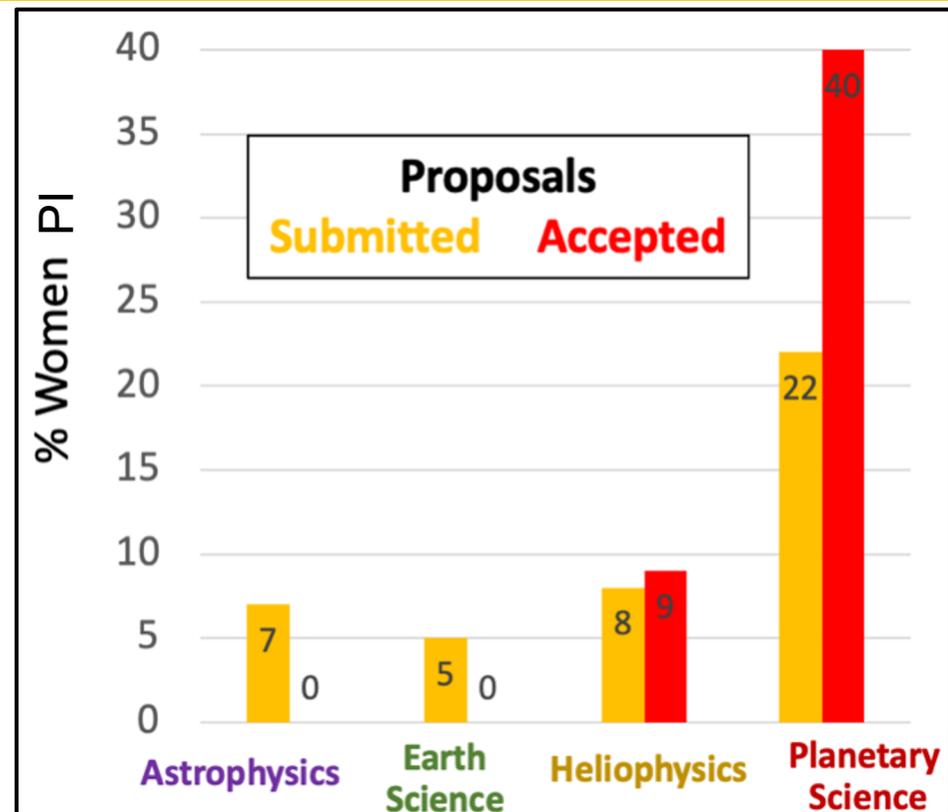
- **Require AOs to include a description of how the dimensions of DEIA, including talent development and workforce diversity, are critical to NASA, and require proposals to include a plan for DEIA in the proposed missions describing how the proposed DEIA activities are key for mission success**
- **Establish a separate, scorable evaluation criterion of the proposed DEIA plans as part of mission proposal review and provide training for reviewers to better equip them to appropriately evaluate proposals concerning DEIA dimensions**
- **Engage with DEIA experts to implement the new requirements for mission proposals in ways that advance the overarching goal of broadening participation of underrepresented groups in missions**
- **Establish monitoring and assessment processes to continually measure the impact of the new DEIA plan requirement on progress toward NASA's stated DEIA goals.**

THEME 2: Data System Collection, Analysis, and Reporting of Data on Proposal Teams, Proposal Pools, and Workforce

Data Collection, Analysis, and Reporting: Findings

2010-2019
Submitted to 4 SMD Divisions
524 Mission Proposals

101 Astrophysics
108 Earth Science
96 Heliophysics
219 Planetary Science

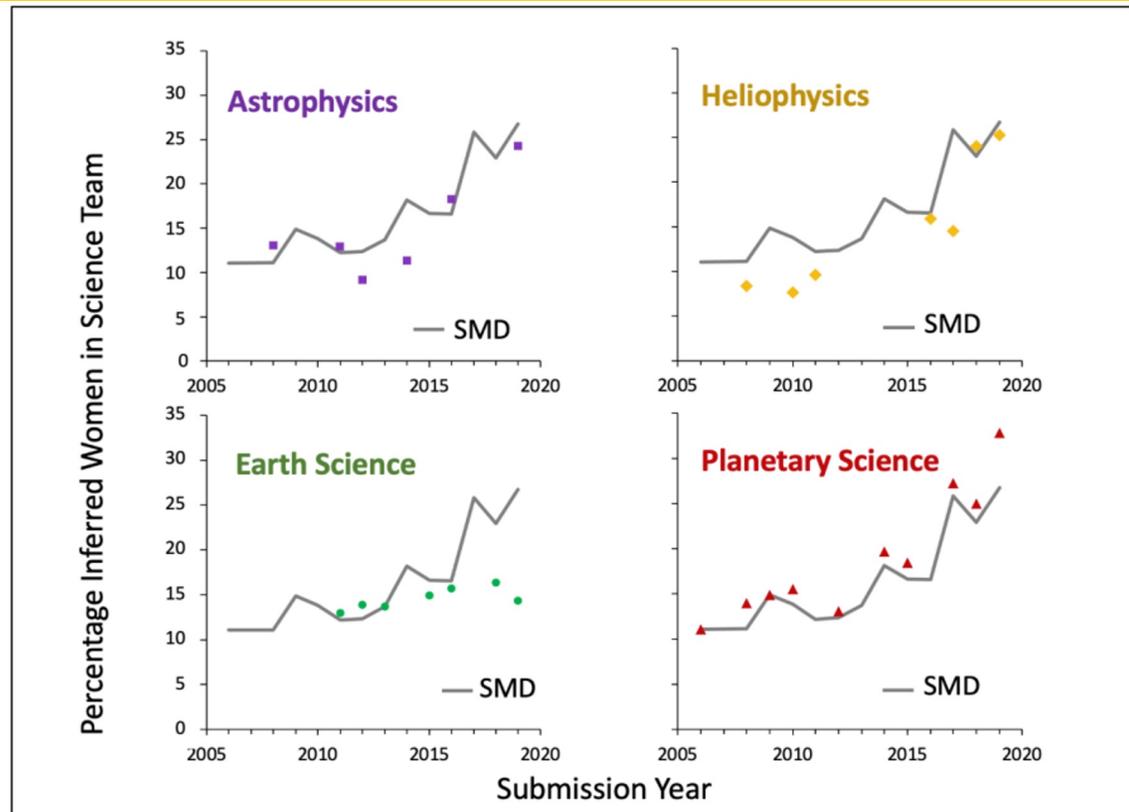


SOURCE: NASA SMD Data Analytics Team

- **Stark variation in award by gender across Divisions**
- **<10% of mission proposals submitted by women PIs** – except in Planetary
- **No women PIs selected in Astrophysics and Earth Science** for almost 10 yrs
- No data provided on race/ethnicity of PIs

Data Collection, Analysis, and Reporting: Findings

Participation by Women in Mission Teams 2006-present



SOURCE: NASA SMD Data Analytics Team

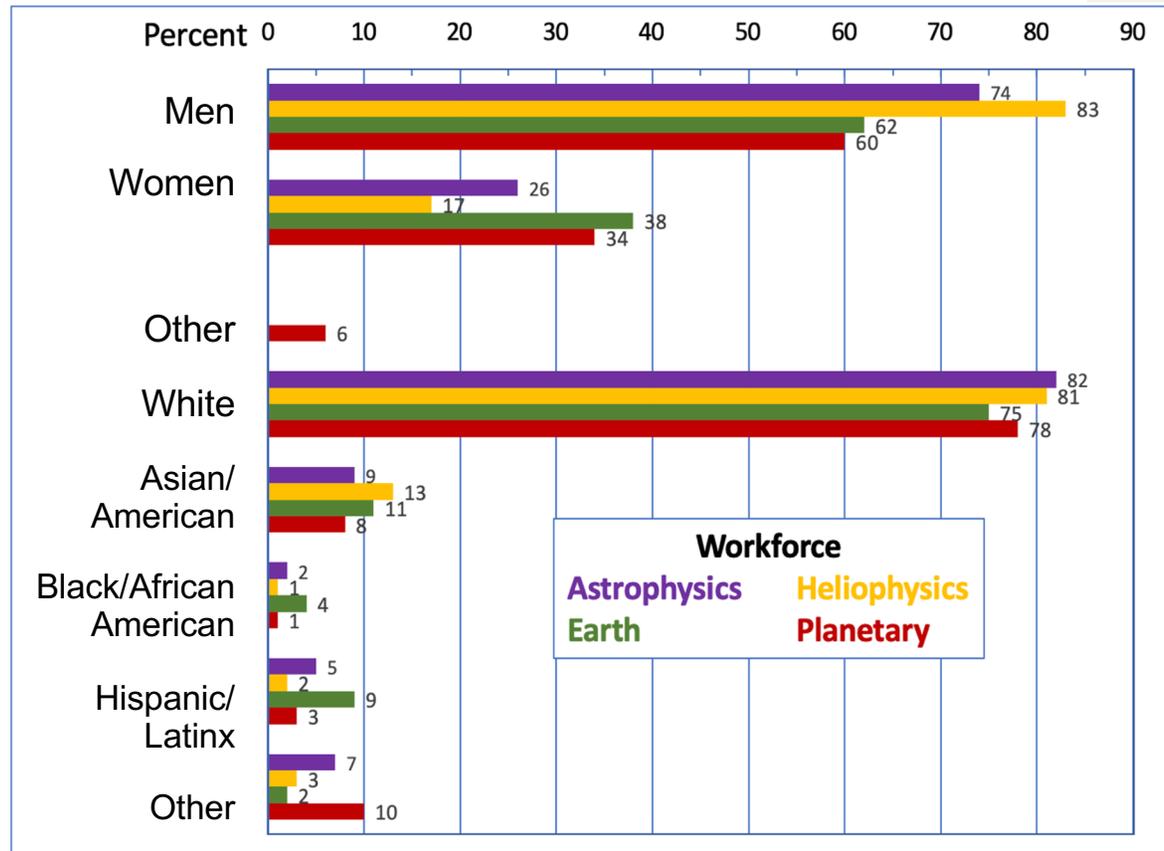
- Across 4 Divisions: **participation of women increased 10% to 25%**
- Earth Science: participation of women has remained quite flat
- Planetary Science: participation of women is above average
- No data provided on **race/ethnicity** of mission science teams

Data Collection, Analysis, and Reporting: Findings

Demographics of Space Sciences Workforce

- Women: 17-38%
- Men: 60-83%
- White: 75-82%
- Asian: 8-13%
- Black/African American, Latinx/Hispanic, Other: 1-10% severely under-represented

Participation in NASA-funded Research (i.e., R&A Grants) shows similar demographics



SOURCE: AIP & NSF

Total size and demographics of U.S. post-PhD workforce in each Division of SMD – plus overlap between Divisions – poorly quantified

Recommendation 7

NASA HQ should develop a systematic and transparent process that employs **routine monitoring and tracking of proposal submissions and selections, and submit an annual report of these data to the NAC DEIA committee as well as make the report public.**

Include data on dimensions such as funding rates, diversity in team participation in PI-led missions and R&A grants; could include data on other important dimensions of interest to the Agency.

NASA HQ should seek professional statistical expertise for the infrastructure to support robust data collection, monitoring, and reporting including, but not limited to, adequate staffing, data collection standards of practice, monitoring and analytic systems, annual reporting capability, and external partnerships, to overcome the challenges of tracking participation in NASA's earth and space science activities.

Recommendation 9

To regularly assess the state of the profession:

NASA SMD should provide funding for professional organizations (e.g. AIP, AAS, AGU, APS, etc.) to employ the necessary professional expertise in survey methodology and statistical analysis to systematically carry out surveys of the workforce, within and across the four science divisions with competed missions, that informs NASA of the participation of different demographic groups as well as the barriers and opportunities for advancement along entire career pathways in the earth and space sciences.



THEME 3: Training and Mentoring

Training and Mentoring: Findings

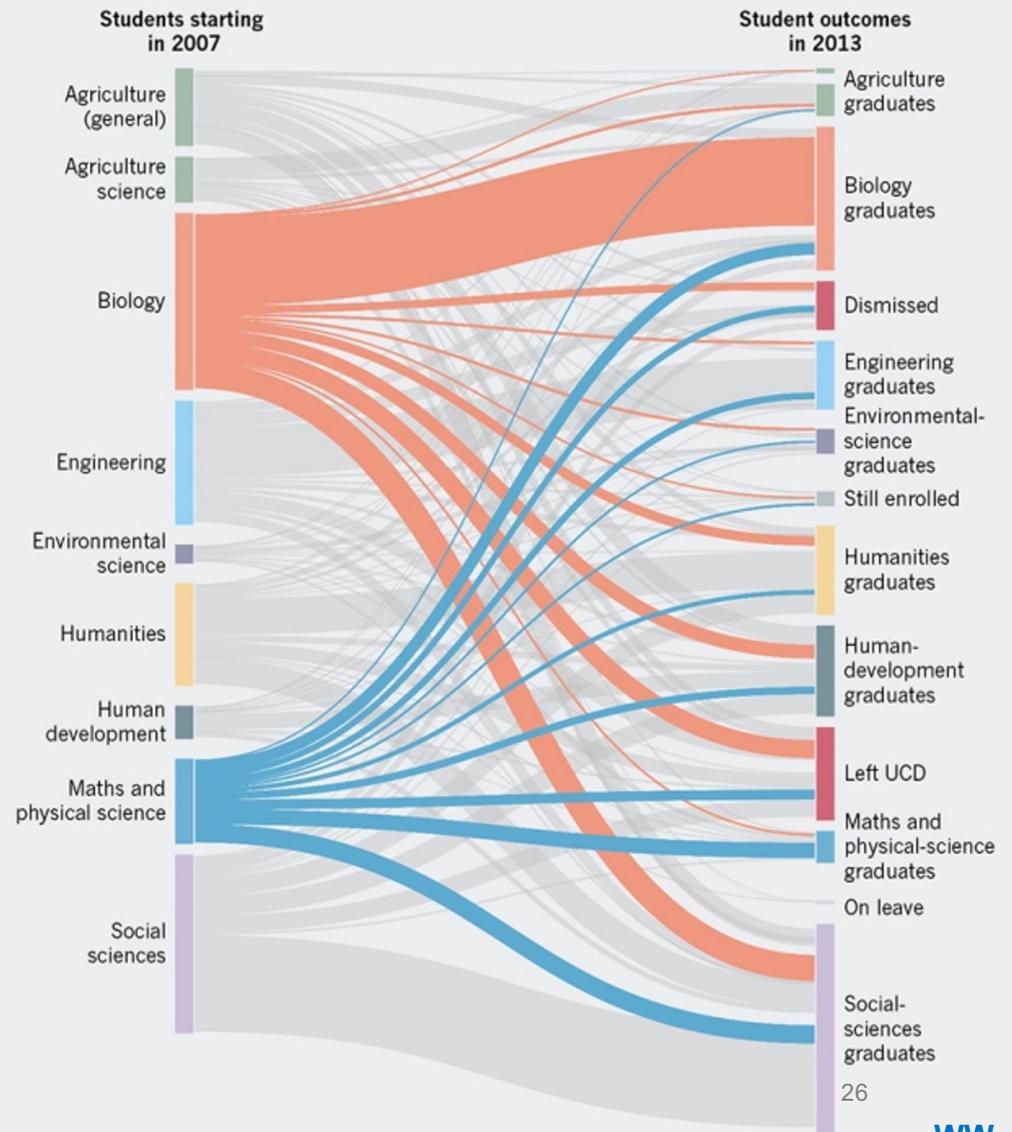
Physical Sciences: Undergraduate Training

- main disciplinary pathways to future NASA mission leadership
- 2% of incoming college students
- lose ~90% of students to other fields before graduation
- retention lowest (4%) for underrepresented populations

Major “pinch point” to size & diversity of pool for future NASA mission leadership.

CHARTING A PATH

Visualizing students' educational journeys has informed recruitment and retention efforts at the University of California Davis (UCD). The tool was developed by the iAMSTEM HUB in Undergraduate Education.



Training and Mentoring: Findings

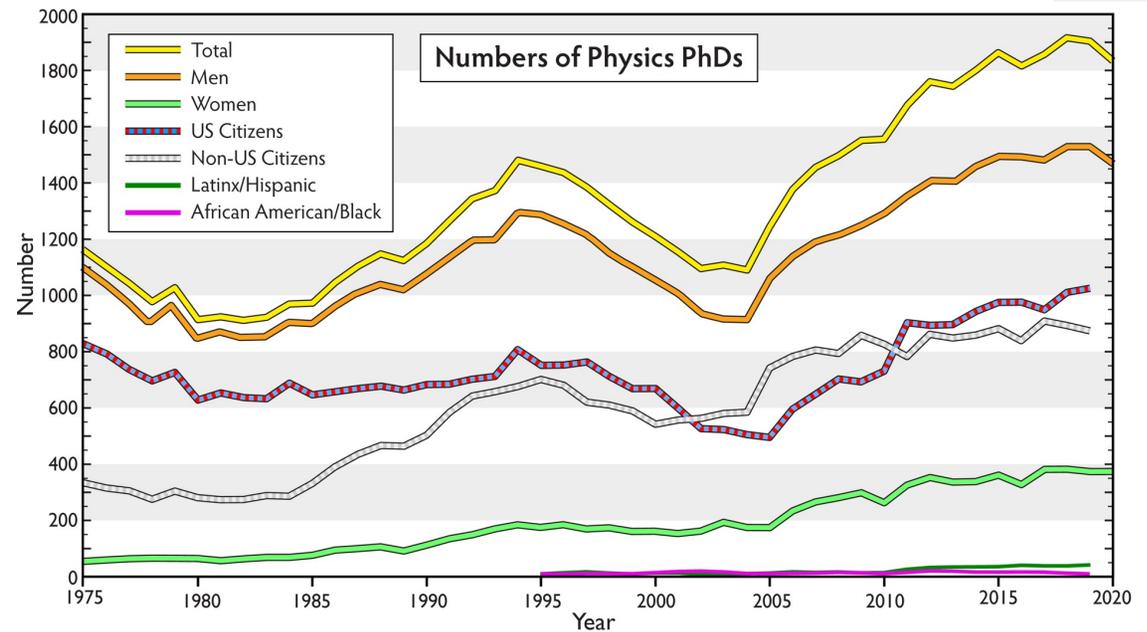
Physics & Astronomy: Graduate Training

Percent of Physics PhDs:

- Women: **19%**
- Latinx/Hispanic Americans: **2%**
- Black/African Americans: **<1%**

Trends in Astronomy PhDs:

- Women: **40%**
- Latinx/Hispanic Americans:
single digits PhDs/yr
- Black/African Americans:
~1 PhD/yr
- Native Hawaiians:
3 total PhDs (in 50+ yrs)



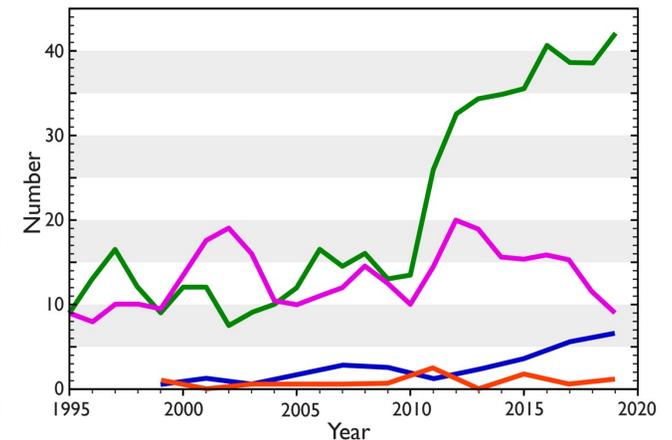
Number of PhDs to URMs

Physics

- Latinx/Hispanic (green)
- Black/African American (magenta)

Astronomy

- Latinx/Hispanic (blue)
- Black/African American (red)



Training and Mentoring: Findings

Some Explanations for Low Retention in STEM (including physical sciences):

- Lack of opportunity & resources
- Lack of authentic research experiences
- Exclusive STEM cultures & environments
- Structural racism, sexism, implicit bias
- Mismatch between STEM careers & personal identities

Non-PhD granting academic institutions, Historically Black Colleges and Universities, & other MSIs:

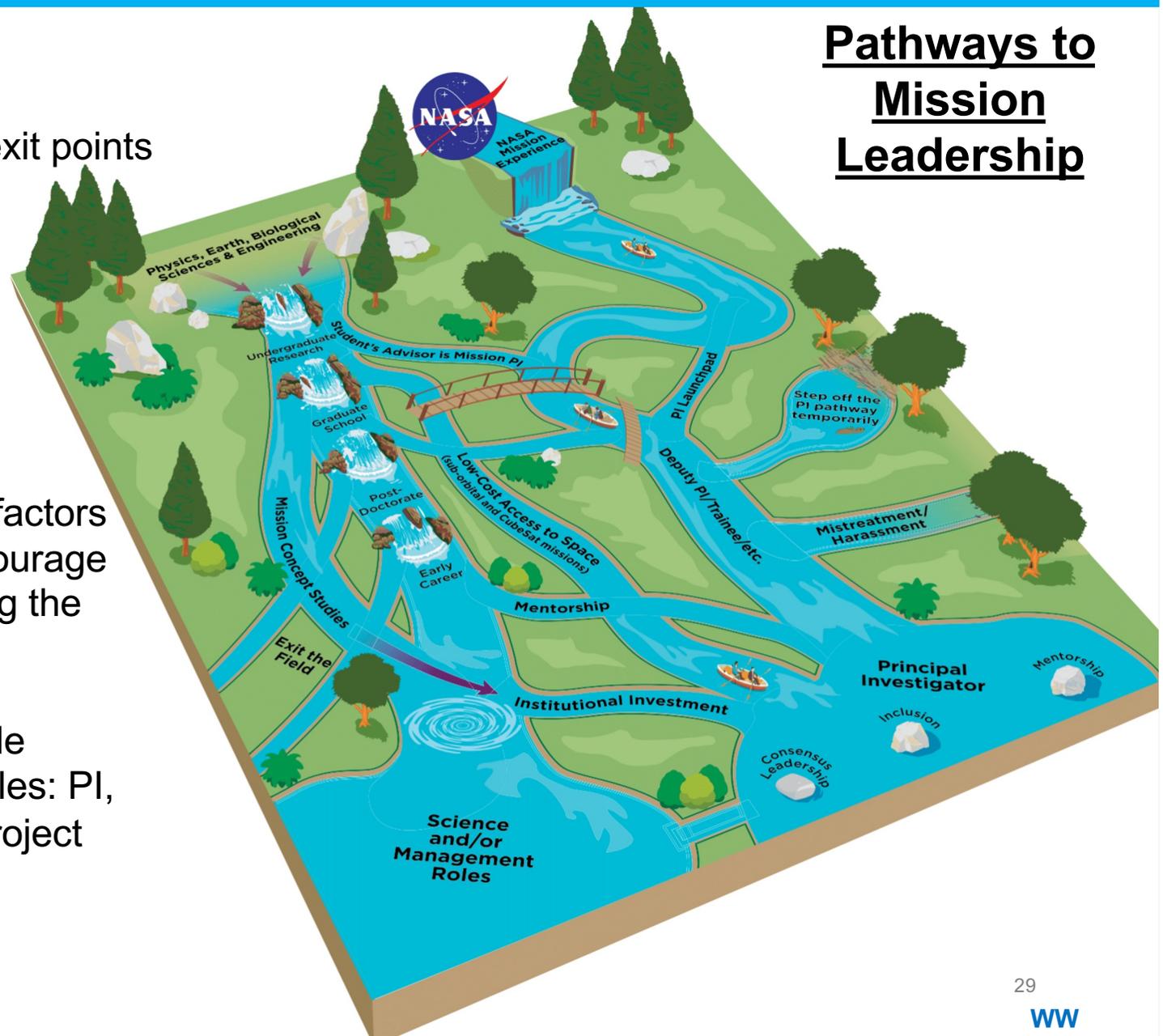
- High concentration of students of color educated & women faculty and/or of color employed in physical sciences
- Experience inequitable access to mission experiences

Significant concerted efforts needed to ensure currently small pool of physical scientists of color have opportunity to engage in NASA missions.

Training and Mentoring: Findings

Pathways to Mission Leadership

- Different entry & exit points
- Opportunities, barriers along pathway
- Structural/cultural factors encourage or discourage advancement along the pathways
- Pathway to multiple mission-related roles: PI, deputy PI, Co-I, project scientist, etc.



Recommendations

RECOMMENDATION 10:

NASA should expand and increase the frequency of training programs aimed at encouraging women and historically minoritized communities to become more involved in mission leadership.

RECOMMENDATION 11:

To engage and train diverse teams at all stages of professional talent development, NASA should offer mission-related research, mentorship, and training opportunities – ideally, integrated into actual NASA missions – through colleges/universities as well as NASA Centers, that should start as early as first-year undergraduates and graduate students (e.g., internships), and extend to the ranks of postdocs (e.g., fellowships), and established scientists (e.g., Participating Scientists).

Training and Mentoring: Findings

Expectations for aspiring PIs:

- Flight missions/instrument development experience
- Networking & management skills
- Familiarization with potential partner organizations
- Access to professional & social networks

Mission-related training, experience, and mentorship:

- Limited opportunities on existing missions
- Limited small mission opportunities
- Women & underrepresented groups:
 less access to mentors & networks; lower quality mentorship

Expectations for aspiring PIs do not match current opportunities available to gain needed experience.

Recommendation 12

PI-led missions present opportunities for aspiring PIs to gain invaluable experiences. **NASA should expand resources (e.g., instructional materials, seminars, workshops) for aspiring PIs** to gain leadership experience and connect with individuals with mission experience for mentorship opportunities.

This may include:

- **Integrating aspiring PIs as mentees in roles on mission teams, including the higher leadership positions.** This could be achieved by including developmental positions in all missions (i.e., competed, non-competed, and instrument investigations), which may require increasing the PI Managed Costs
- **Encouraging aspiring PIs to pursue entry points to mission leadership,** such as proposing to smaller, low-cost mission opportunities, (e.g., suborbital, smallsats and cubesats, instrument development, and hosted payloads)
- **Expanding structured networking opportunities at relevant disciplinary conferences** such as meet-and-greets where aspiring PIs can connect with collaborators and meet existing PIs, and participate in presentations and question and answer sessions led by NASA personnel about the proposal process

THEME 4: Investments in Pathways for Groups Underrepresented in STEM

Investments in Groups Underrepresented in STEM

Guiding Principles for STEM Pathway Investments

Promote the Development of STEM Identities

- Support meaningful engagement in the practice of STEM disciplines
- Allow for transfer STEM knowledge into action on issues of interest
- Authentic and culturally relevant

Establish Flexible and Relevant STEM Education-to-Career Pathways

- Support gains in the ability to think and work like a STEM professional
- Connect education and workforce opportunities
- Accommodate students' diverse interests and backgrounds

Intentionally Recruit from Historically Underrepresented Groups

- Facilitate targeted recruitment from historically underrepresented groups at all levels
- Actively engage institutions that intentionally educate and serve the professional needs of underrepresented groups (e.g., through investments, partnership and collaboration)

Investments in Groups Underrepresented in STEM

Guiding Principles for STEM Pathway Investments

Provide Access to Diverse Mentorship

- Various forms: formal or informal, sponsorship, peer mentorship, tiered mentorship
- Offer the potential to see oneself through the eyes of an influential role model
- Inclusive and support the development of a sense of belonging in STEM contexts

Foster Career-Life Balance

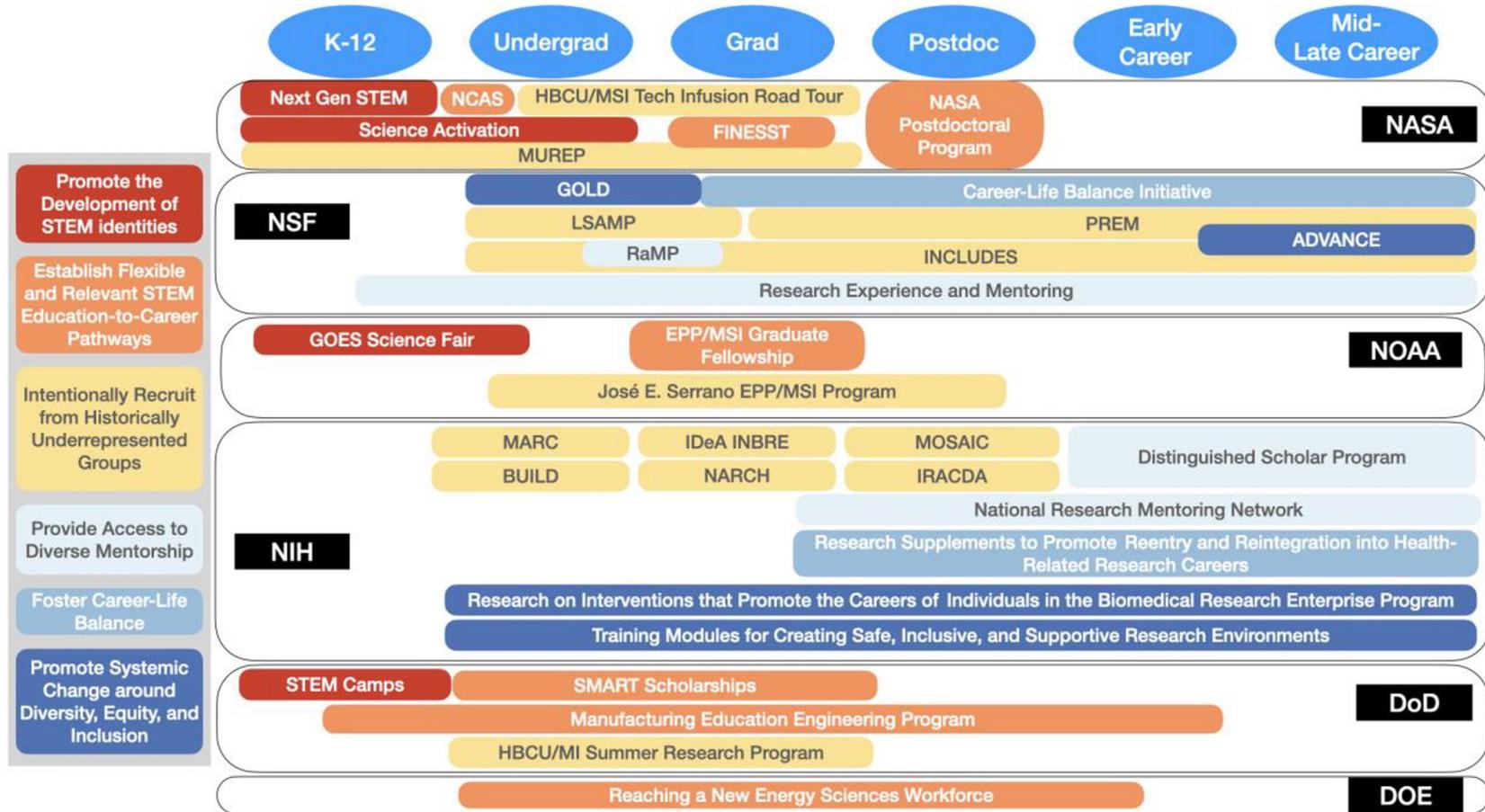
- Focus on minimizing institutional barriers that can undermine performance and promotion due to parental status and other family responsibilities
- Intentional focus on increasing the advancement and retention of women in STEM who are more negatively impacted by work-life imbalance

Promote Systemic Change around Diversity, Equity, and Inclusion

- Focus on transforming institutional and organizational cultures of STEM fields
- Focus on building capacity for broadening participation in STEM fields.
- Focus on addressing the impacts of structural racism, discrimination, and harassment on career advancement

Investments in Groups Underrepresented in STEM

Select Federal Agencies Investments along STEM Pathways



NASA
 Many investments: K-graduate years
 Fewer investments: post-PhD years

Investments in Groups Underrepresented in STEM

Two different parts of NASA lead STEM engagement efforts:

NASA's Office of STEM Engagement (OSTEM)

- provides opportunities for STEM engagement and the development of research capacity and infrastructure of MSIs (e.g., via MUREP and MIRO)

NASA SMD's Science Activation Program (SciAct)

- provides opportunities for meaningful engagement in science through the efforts of a cooperative network of awardees and by leveraging NASA's infrastructure activities

Further partnership among NASA SMD, OSTEM & MSIs, plus leveraging NASA's unique assets, would strengthen participation of underrepresented groups in missions.

Recommendation 14

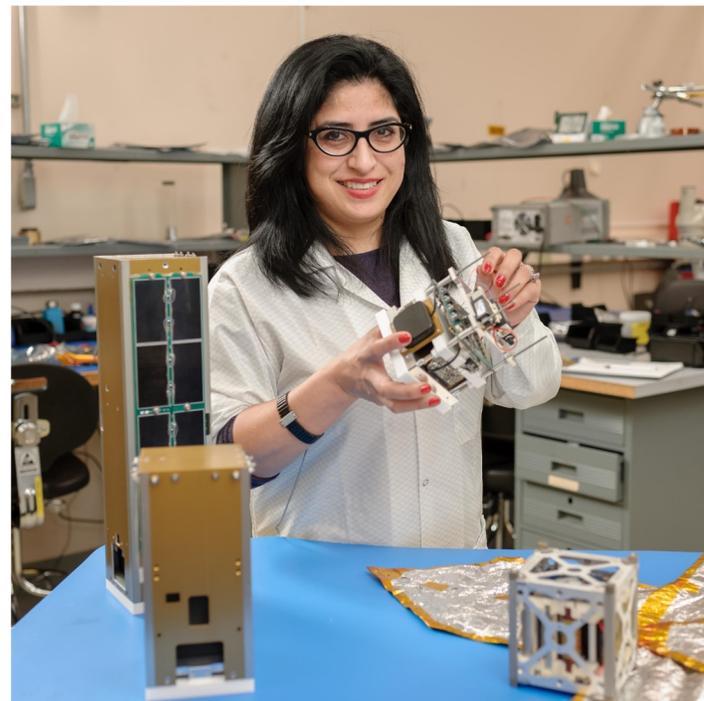
In order to ensure a vibrant, next generation pool of excellent and diverse talent for leadership in competed space missions:

NASA SMD, in collaboration with the Office of STEM Engagement, should provide consistent and adequate funding for STEM initiatives that are explicitly centered on DEIA, address recruitment and retention challenges in the earth and space sciences, and support and expand opportunities for individuals from underrepresented groups.

These investments should reflect a pathways approach spanning the academic and career continuum from post-secondary through post-PhD years in order to establish flexible and robust education-to-career trajectories into the earth and space sciences workforce, and ultimately into PI-led missions. A systematic process should also be in place to document measurable impacts of these investments.

Recommendation 15

NASA leadership, specifically the SMD and OSTEM Associate Administrators, should charter a joint team to examine and strengthen the historic and current relationship between the two organizations with respect to investments in MSIs. NASA's investments should also redress the historical inequities in NASA supported research and training at these institutions.



Recommendation 15 continued

NASA should:

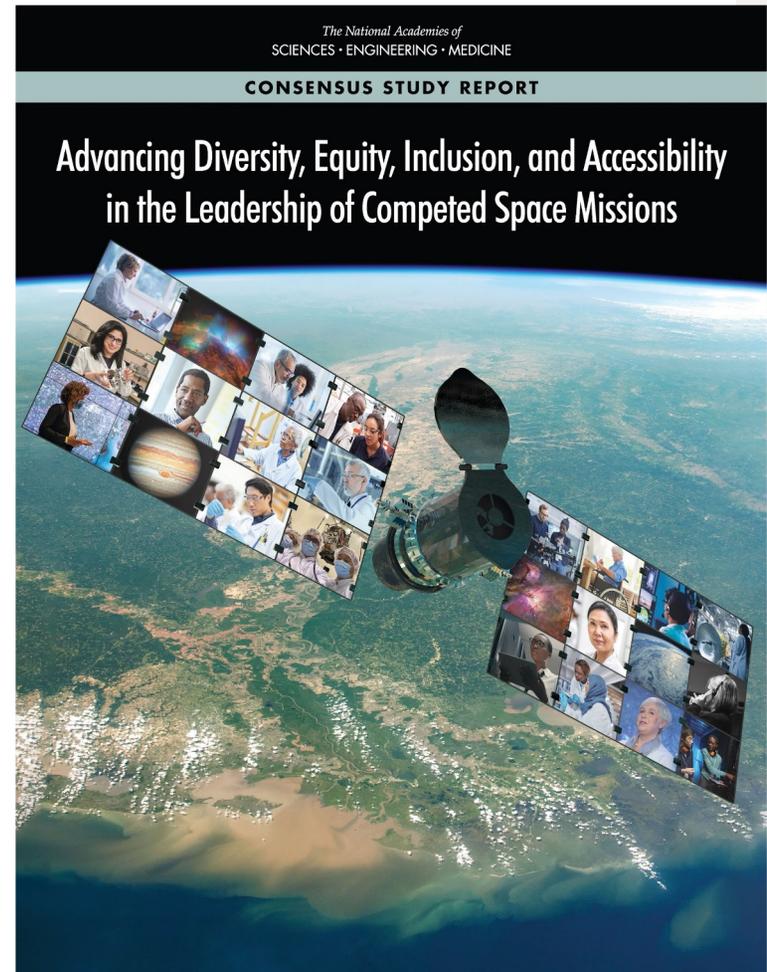
- **Reinvest in talent development programs in partnership with MSIs specifically related to NASA missions**, such as the undergraduate-to-graduate “bridge” type programs previously supported by NASA SMD’s MUCERPI program.
- **Further leverage NASA programmatic assets such as MUREP, MIRO and SciAct** to advance broad access to all of its missions, and further enhance early preparation and research engagement of students and early-career researchers, including underrepresented communities.
- **Provide funding to support mission-related work and activities** (e.g., building and designing instruments for space flight, hosting science team meetings, etc.) **as a means of enhancing research capacity at HBCUs, HSIs, and other MSIs.**

Major Takeaways

Report is snapshot of current status at NASA, which continues to evolve.

Report recommendations are actionable steps for the Agency -

- **Near-term:** advance existing talent & DEIA efforts
- **Longer-term:** build robust infrastructure needed to produce next generation of diverse space science talent



Thank you for your engagement!

Free copy of the report (PDF): nap.edu/26385