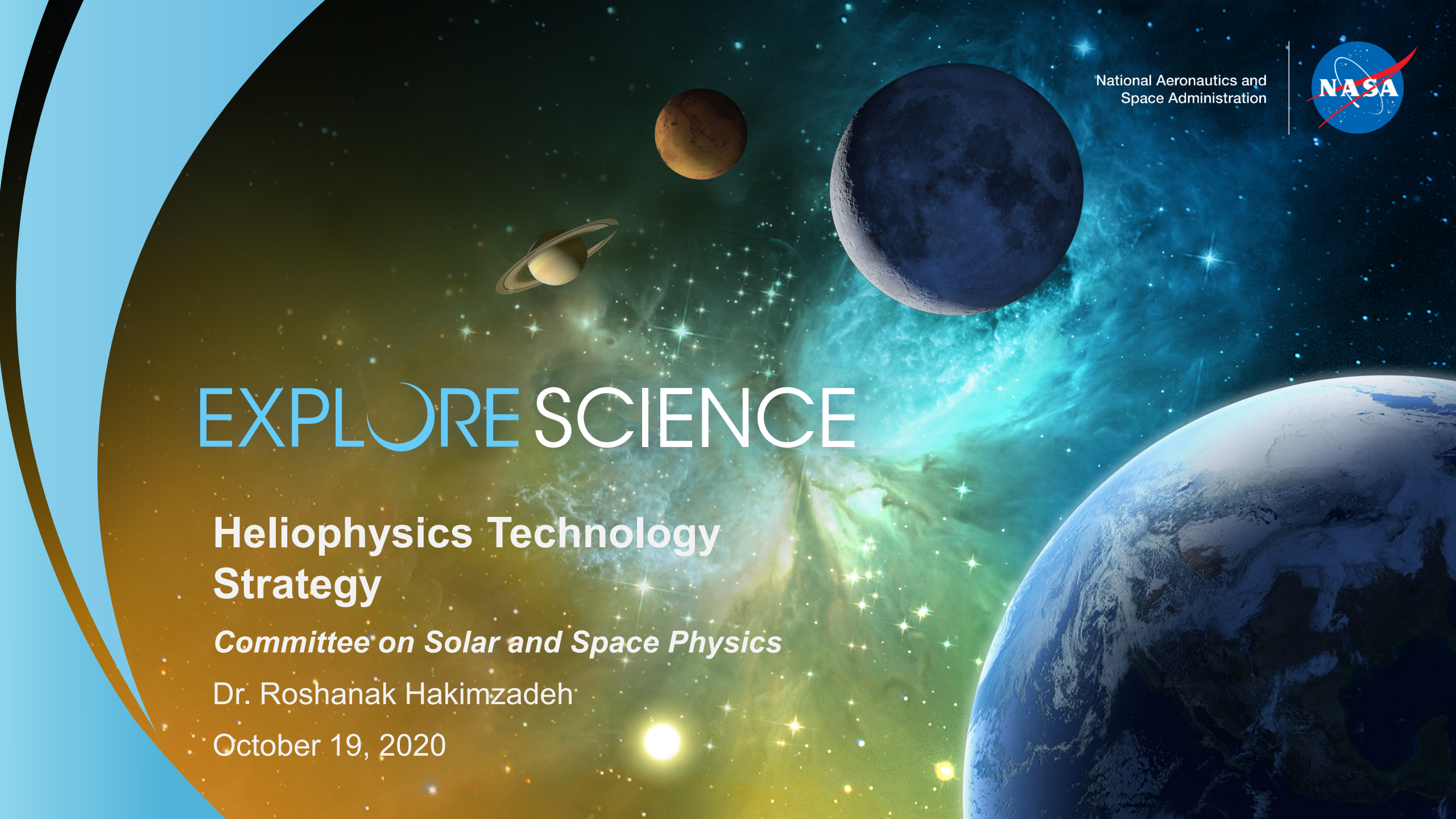


Heliophysics Technology Strategy

Committee on Solar and Space Physics

Dr. Roshanak Hakimzadeh

October 19, 2020

Heliophysics Technology Strategy:
Preparing for Heliophysics 2023 Decadal Recommendations

To drive innovation for the upcoming Decadal Survey (DS) process, NASA's Heliophysics Division (HPD) formed nine strategic working groups (SWG) to generate momentum on key topic areas.

The next DS is scheduled to be developed in 2023. The Technology SWG seeks to ensure that the next DS makes maximum use of achievable technologies and that technology developments lead to impactful science outcomes.

The Technology strategic initiative seeks to:

- Demonstrate capacity to develop technologies to expand the scope of the next DS science objectives,
- Utilize a strategy to develop and mature technologies over full range of Heliophysics Science, and
- Develop technologies now to enable both smaller and strategic missions in the next decade and beyond.

Developing the Heliophysics Technology Strategy

Goal: Develop a strategic plan for HPD's technology program to make the technology investments more focused, impactful, and innovative, enabling Heliophysics Science Missions

- Developed a structured methodology for how to proceed toward developing a strategic plan
- Team was assembled
- Key questions were identified
- Constraints were identified
- Charter, expectations, and timeframe were developed

Technology Strategy: Some Key Questions

- How might we become more strategic about funding technology development that would support key decadal missions?
- How might we increase the number of proposals? Increase the quality of proposals?
- How might we invest more wisely, increasing the chances that our investment in technology have a higher chance of being infused in future missions?
- How might we identify, standardize, and track data of value throughout the technology maturation process?
- How might we better advance technology through maturation and demonstration in flight?
- How might we expand our reach to the community? How do we better inform the community about what we are looking for?
- How might we infuse people and ideas from outside of HPD to drive innovation?
- Should we capture and maximize the utility of the intellectual property that results from technology funding? If so, how?

Explore the possibility of a formal HPD Technology Office.

Rationale for a Heliophysics Technology Office

The focus on a Heliophysics Technology Office fulfills the directives from both Congress and the Decadal Survey:

➢Congressional Justification

➢Department of Commerce and Justice, Science, and Related Agencies 2020 Appropriations Bill, Sept. 2019

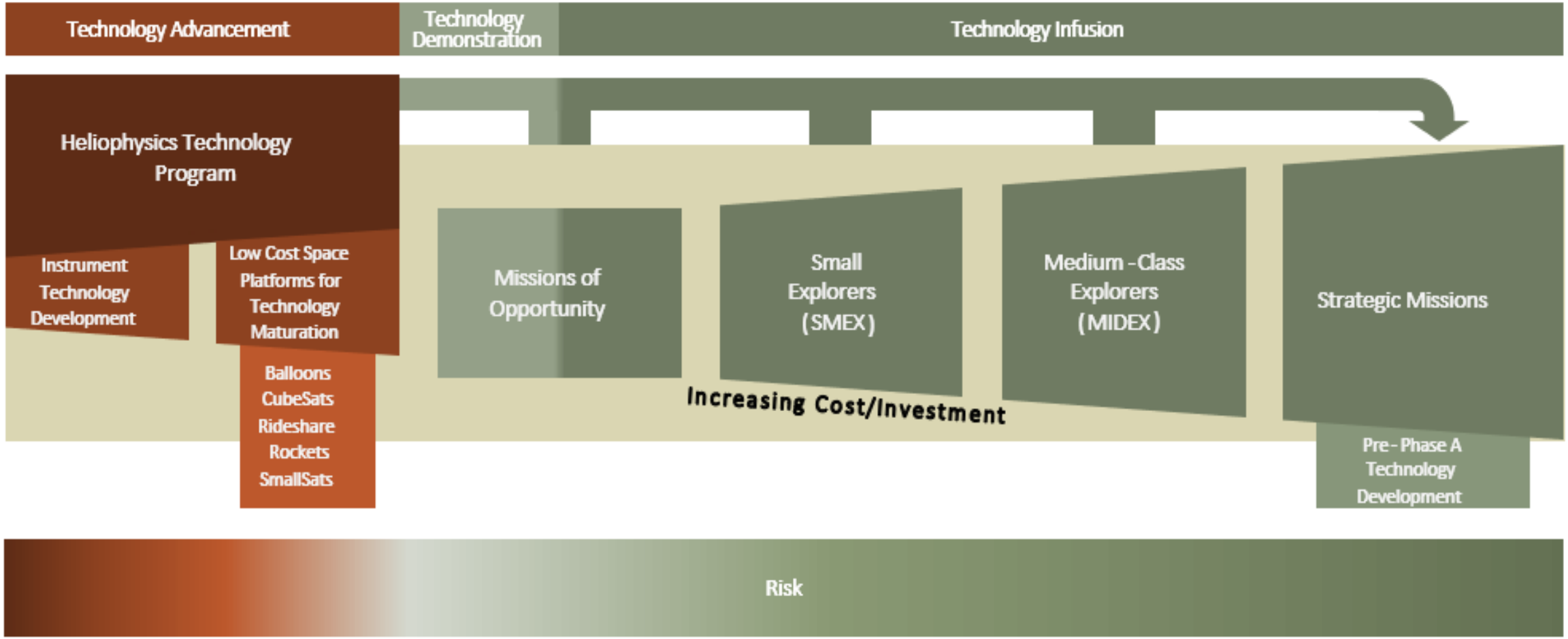
- *"The Congressional Committee recognizes the critical role that technology development programs play in enabling novel and transformative capabilities and mission concepts and notes the contributions of these programs in the other Divisions within SMD. The Committee directs the administration to formally include such a program as a standalone account line in future budget proposals to Congress."*

The 2013 Decadal Survey (DS)

DRIVE Framework, 2013

- *"The future of solar and space physics depends on the ability to **Venture** into transformative technologies and capabilities. Development of new and innovative means of pursuing grand challenge science is also critical, taking full advantage of the progress that comes from collaborations between theorists, modelers, computer scientists, and observers. In fact, new mechanisms are required to facilitate development at the frontiers of science and technology."*

Current Heliophysics Division Technology Activities



Heliophysics Technology Strategy:

Vision

To enable New Realms of Heliophysics Knowledge and Capability

Mission

Enable novel and transformative capabilities and mission concepts. Advance science by expanding the limits of what is measurable, observable and achievable in Heliophysics. Set the tone for the future of the field, enabling science and missions that are not conceivable or achievable today.

Technology Strategic Plan
To fulfill our Mission and Vision, we have identified three Strategic Goals:

1. Advance

- ***Advance*** technology to expand heliophysics science

2. Improve

- ***Improve*** likelihood of technological and scientific success

3. Optimize

- ***Optimize*** the return of technology investment

NASA Heliophysics Technology Strategy

Strategic Goal	Strategic Objectives
1. Advance technology to expand heliophysics science	1.1 Assess: Conduct periodic assessment of existing technologies and technology gaps to identify opportunities for strategic investment a. Perform periodic gap analyses b. Perform mission and concept studies c. Track trends in technology development/advancement d. Identify technologies to fill technology gaps and mission needs e. Periodically assess the progress made and advancement in technologies
	1.2 Catalyse: Catalyse the novel and transformative technologies for Heliophysics Science (push) a. Evolutionary b. Transformational (high risk/high reward)
	1.3 Cultivate: Work with Strategic Mission leads to cultivate technologies to meet Heliophysics mission needs (pull) a. Mission Enhancing (e.g. MMS Hot Plasma Composition Analyzer) b. Mission Critical (e.g. heat shields for Parker Solar Probe)
	1.4 Expand: Tap into the technologists from outside the Heliophysics community to infuse cross-disciplinary technology perspectives a. Alternative Initiation of Technology Exploration (AITE)

NASA Heliophysics Technology Strategy

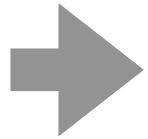
2. Improve Likelihood of Technological and Scientific Success	2.1 Incubate: Technology and Instrument Incubator Project a. Establish an incubator process for promising technologies to proactively nurture and advance such technologies
	2.2 Advance: Shepard technologies through maturation and demonstration to enable infusion into missions a. Mature transformational technologies from early stage concept to flight demonstrations (TRL 3 to 6) b. Demonstrate technologies in flight to effectively transition them for NASA missions and for use by other government agencies and industries
	2.3 Infuse a. Create deliberate access of matured technologies and databases to future PIs b. Work with mission leads to bolster infusion of advanced technologies into Heliophysics missions c. Promote infusion into other NASA missions d. Evaluate opportunities for infusion with external NASA partners

NASA Heliophysics Technology Strategy

3. Optimize the Return of Technology Investment	3.1 Leverage: Facilitate the use of NASA-developed heliophysics technology for broader usability
	3.2. Partner a. Collaborate internally with other NASA stakeholders b. Collaborate with external domestic stakeholders (Gov, Nonprofit, Non-Gov) c. Collaborate with international organizations and foreign researchers
	3.3. Transfer a. Expand publication of results of technology investments b. Increase patents for technologies developed/funded by NASA c. License technologies developed/funded by NASA to external stakeholders

Strategic Plan: Goals & Objectives

Theme	Strategic Goals	Strategic Objectives
Advance	1. *Advance* Technology to Expand Heliophysics Science	1.1 Assess 1.2 Catalyze 1.2 Cultivate 1.3 Expand
Improve	2. *Improve* Likelihood of Technological and Scientific Success	2.1 Incubate 2.2 Advance 2.3 Infuse
Optimize	3. *Optimize* the Return of Technology Investment	3.1 Leverage 3.2 Partner 3.3 Transfer



Heliophysics Strategic Technology Office (HESTO) Implementation Plan

- ➢ Actions
- ➢ Results
- ➢ Metrics

Next Steps…

A Path toward Implementation

Heliophysics Strategic Technology Office (HESTO) Implementation Plan

- ➢ Actions
- ➢ Results
- ➢ Metrics

The Technology SWG has initiated development of the technology Implementation Plan, including actions, results and Metrics

Current Heliophysics Technology Portfolio:

➢**Technology Investment**

- **Solicited Instrument Technology Development via R&A (ROSES Elements):**
  - Heliophysics Technology and Instrument Development for Science (HTIDeS) - A balanced program for ground-based technology and instrument development: ITD & LNAPP
- **Targeted Instrument Technology Development/Advancement:**
  - Example 1: CHIMERA/MAGIC
    - Technology was advanced through HTIDeS
    - Targeted funding to advance technology through the demonstration "*Valley of Death*"
    - Flight demonstration planned on TRACERS Ride Share
  - Example 2: SPICES:
    - Originally proposed as technology demonstration instrument that could be included in the STP-5/Interstellar Mapping and Acceleration Probe mission"
    - Following HPD review, targeted funding provided to advance technology to PDR (TRL-6)

Technology Demonstration Missions of Opportunity

- Demonstration of technologies through rideshare opportunity on IMAP
  - Two phase A investigations selected (SETH, Solar Cruiser)

In addition, the current HPD portfolio leverages several partnerships within NASA to enable key technology development. For example, partnerships with STMD enabled CubeSats/SmallSats and associated technologies, Solar sail technology, and laser communications technology.

Steps Toward growing the Technology Portfolio

- Increase HTIDeS investment which includes Instrument and Technology Development (ITD), and Laboratory Nuclear, Atomic, and Plasma Physics (LNAPP) (ROSES)
- Maturation and Demonstration:
  - Provide opportunity for further development and maturation of technologies through orbital and sub-orbital flight: Sounding Rockets, Balloons, SmallSats/CubeSats, Rideshare, and ISS (ROSES element)
  - Demonstrate technologies in flight to effectively transition them to NASA missions and for use by other government agencies and industries
- Increase Targeted technology investments (Ex. MAGIC, SPICES)
- H-FOS (Flight Opportunities Studies) is a new element in ROSES-20
  - Technology Analysis & Mission Design
- Expand: Tap into the technologists from outside the Heliophysics community to infuse cross-disciplinary technology perspectives (ROSES?)

Backup

Technology Highlight: University of Iowa Fluxgate Magnetometers

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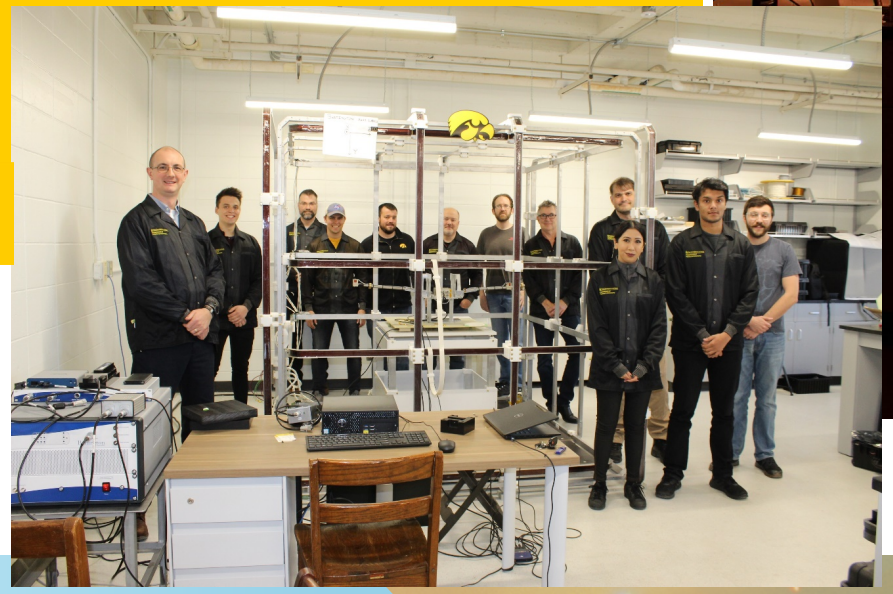


Technology Highlight: Fluxgate Magnetometers

- **Problem: The United States risks losing its capability to produce the world-class fluxgate magnetometers that are used routinely by NASA, NOAA Space weather, and the Defense agencies.**
- **Fluxgate magnetometers are a widely used instrument that provides measurements of the DC and low-frequency AC magnetic field.**
- **Fluxgates have flown on a large percentage of all space science missions. However, reliance on legacy Infinetics S1000 fluxgate ring-cores (out of production since 1996) for the sensors has stagnated the size and performance of sensor designs. More critically, the stockpiles of these legacy ring-cores, maintained by individual institutions, have been depleted with some providers now exploring destroying flight-spares and hardware from previous missions to recover and refurbish the cores to produce new spaceflight instruments.**
- **Potential Solution: The University of Iowa funded effort is to address this unsustainable problem.**

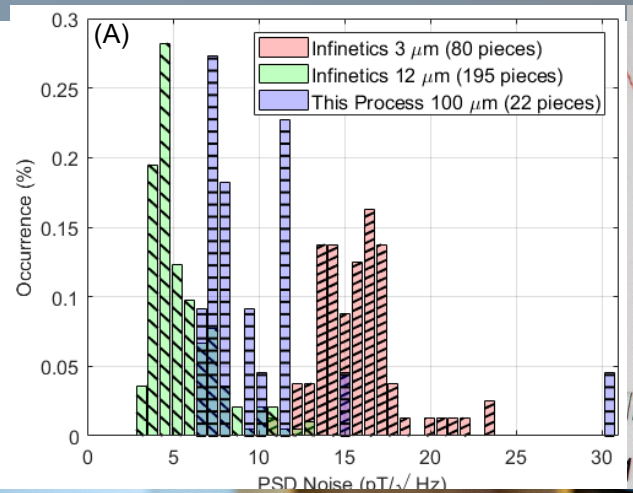
University of Iowa Fluxgate Magnetometers

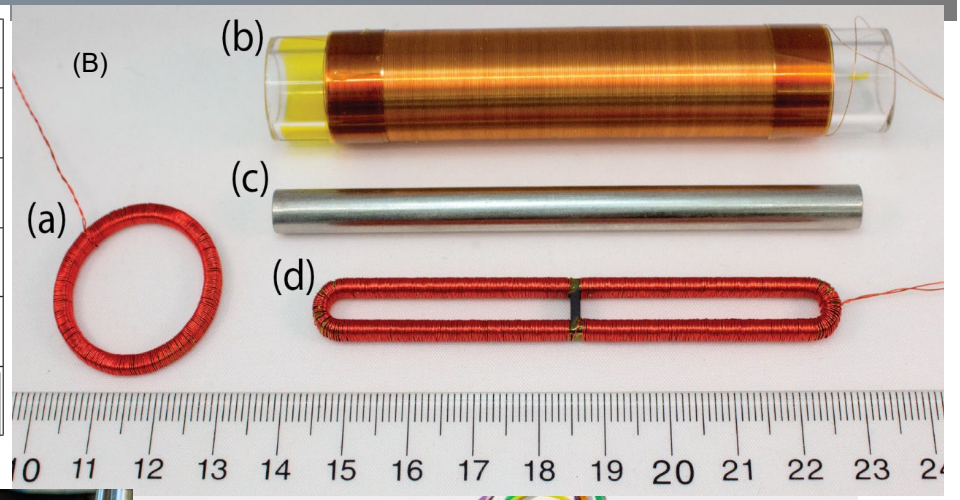
- UI appointed Assistant Professor David Miles, in 2017 as part of a targeted hiring sequence in space instrumentation
- Dr. Miles focuses on next-generation magnetic field instruments and has experience with spacecraft (e-POP/Swarm-ECHO MGF), CubeSats (Ex-Alta 1), and suborbital sounding rockets (ICI-4, Maxidusty-1b, ICI-5)
- UI commissioned a purpose-built process furnace and magnetometer laboratory including a two-meter Merritt coil system as part of an $860 k startup renovation

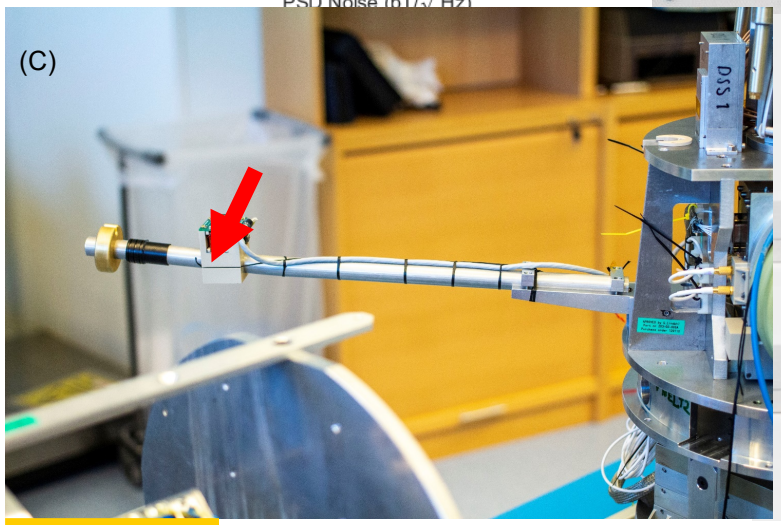
Technology Evolution

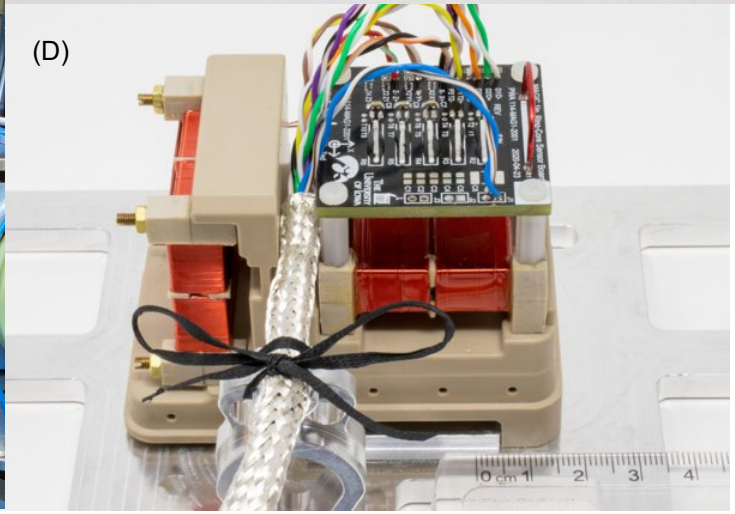
Lab Technology Evolution: Lab → Chimera → MAGIC

- Magnetometer core work originated in Canada (CSA funded) at U. British Columbia and U. Alberta (A).
- New magnetometer lab created at U. Iowa under Faculty Startup for PI Miles.
- NASA Chimera Instrument Technology Development (ITD) funding made advances in low-noise magnetometer cores (B).
- First U. Iowa built magnetometer demonstrated on ICI-5 sounding rocket in Nov 2019 (C).
- MAGIC will demonstrate two magnetometers on the TRACERS satellites (D).





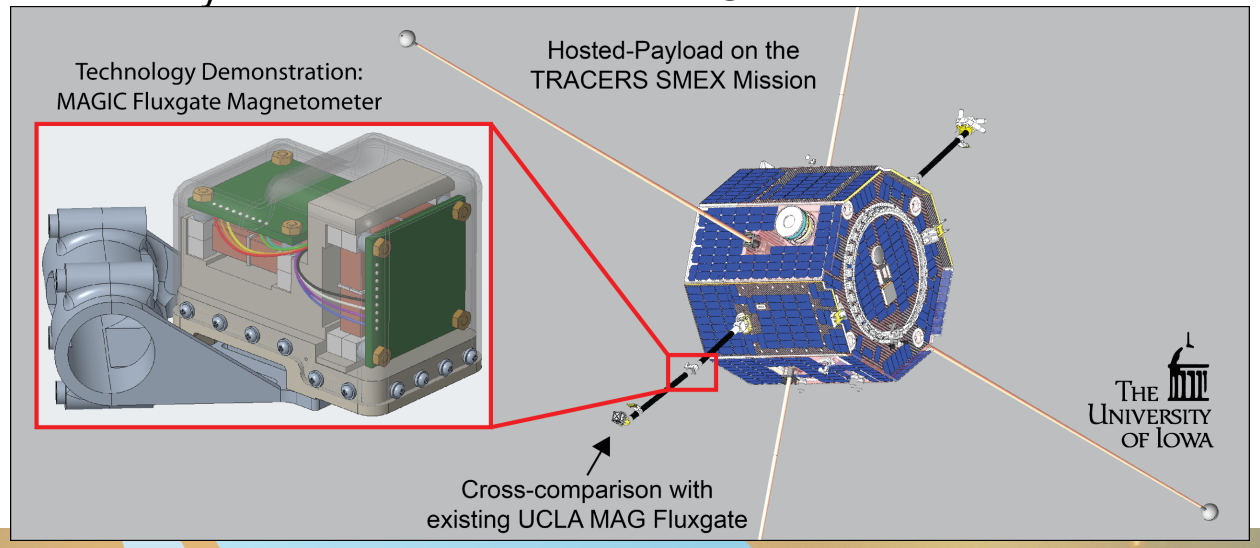




IOWA **Department of Physics and Astronomy**

MAGIC Technology Demonstration

- Initiated as a Strategic Initiative for NASA
- No formal contribution to TRACERS science
- Focus on interface safety
- Do No Harm to TRACERS
- NPR 7120.8A rather than NPR 7120.5E
- New modern fluxgate magnetometer
- New high-stability sensor variant
- New early-career instrument team at U. Iowa



IOWA **Department of Physics and Astronomy**

MAGIC Objectives:

Objective 1: Technical Demonstration on TRACERS Establishing Flight-Heritage
Objective 2: New National Capability to Provide Spaceflight Magnetometers

- Proposed five years of work to design, build, and test MAGIC, a next-generation University of Iowa built spaceflight fluxgate magnetometer
- Establish an early-career instrument team that can provide spaceflight magnetic field instruments
- Establish flight-heritage through a do-no-harm Technical Demonstration as a hosted-payload on the UI-lead TRACERS SMEX mission that complements the existing UCLA magnetometer (enabling spacecraft field mitigation)
- MAGIC is built from scratch at the University of Iowa by PI Miles
- MAGIC delivers world-class magnetic measurements without relying on the legacy ring-cores used by most other providers and can be scaled and tuned for other applications
- TRACERS was proposed prior to PI Miles joining UI so MAGIC could not have been included in the original TRACERS proposal
- This Technical Demonstration flight offers an opportunity to prove the UI built magnetometer through on-orbit cross-comparison with existing UCLA instrument and having two magnetometers allows additional mitigation of the spacecraft field