National Aeronautics and Space Administration

NASA

Technology & Innovation Committee

NAC Advisory Council

Dr. Bill Ballhaus, Chair
Dr. Matt Mountain

August 1, 2013

Technology & Innovation Committee

“The scope of the Committee includes all NASA programs that could benefit from technology, research and innovation.”

T&I Committee Meeting Participants
July 30, 2013

- Dr. William Ballhaus, Chair
- Dr. Erik Antonsson, Northrop Grumman
- Dr. Randall Correll, Consultant
- Mr. Gordon Eichhorst, Aperios Partners LLC
- Dr. Matt Mountain, Space Telescope Science Institute
- Dr. Dava Newman, MIT
- Mr. David Neyland, Office of Naval Research
- Dr. Mary Ellen Weber, Stellar Strategies, LLC
- Dr. Susan Ying, Consultant

T&I Committee Meeting Presentations

- Space Technology Mission Directorate (STMD) Update
  - Dr. Michael Gazarik, Associate Administrator, STMD
- Science Mission Directorate Technology Overview
  - Dr. Timothy Van Sant, Chief Technologist, SMD
- Technology Demonstration Missions Program Update
  - Dr. Randy Lillard, Program Executive
- Overview of Space Technology Role in Asteroid Retrieval Mission
  - Dr. James Reuther, Deputy AA for Programs, STMD
- Chief Technologist Update and Agency Grand Challenge
  - Dr. Mason Peck, NASA Chief Technologist, OCT
- Update on NASA Commercial Spaceflight Status
  - Mr. Phil Mcalister, Director, Commercial Spaceflight Development, HEOMD
- NASA Aeronautics Program Overview and Update
  - Dr. Robert Pearce, Director for Strategy, ARMD

Why Invest in Space Technology?

- Enables a **new class of NASA missions** beyond low Earth Orbit.
- **Delivers innovative solutions** that dramatically improve technological capabilities for NASA and the Nation.
- Develops technologies and capabilities that make NASA's missions **more affordable and more reliable.**
- Invests in the economy by **creating markets and spurring innovation** for traditional and emerging aerospace business.
- **Engages the brightest minds** from academia in solving NASA's tough technological challenges.

Value to NASA **Value to the Nation**

Addresses National Needs

A generation of studies and reports (40+ since 1980) document the need for regular investment in new, transformative space technologies.

Who:

The NASA Workforce
Academia
Industry & Small Businesses
Other Government Agencies
The Broader Aerospace Enterprise

Challenges for Deep Space Exploration

Communication

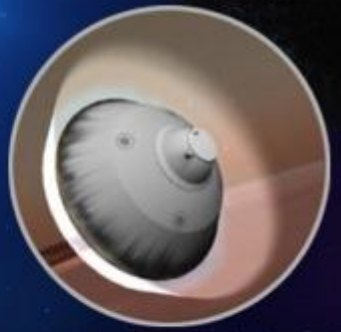
Environment Control & Life Supporting Systems

Power Generation & Storage

Logistics

Navigation

Manufacturing In Space & For Space



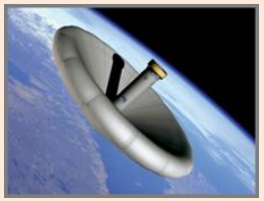
Entry, Descent & Landing

Radiation Mitigation

Propulsion

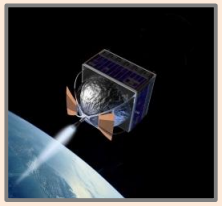
STMD Programs

Transformative & Crosscutting Technology Breakthroughs



Game Changing Development Program

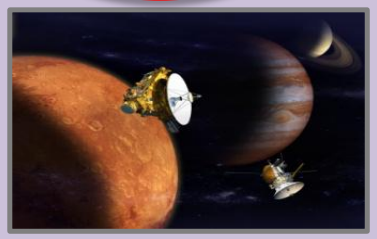
Technology Demonstration Missions Program



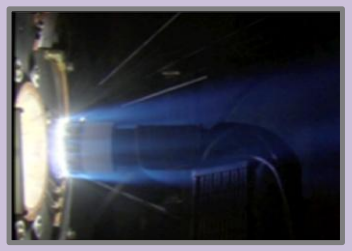
Small Spacecraft Technologies Program

Pioneering Concepts/ Developing Innovation Community

Space Technology Research Grant Program



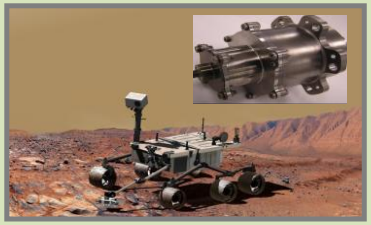
NASA Innovative Advanced Concepts (NIAC) Program



Center Innovation Fund Program

Creating Markets & Growing Innovation Economy

Centennial Challenges Prize Program

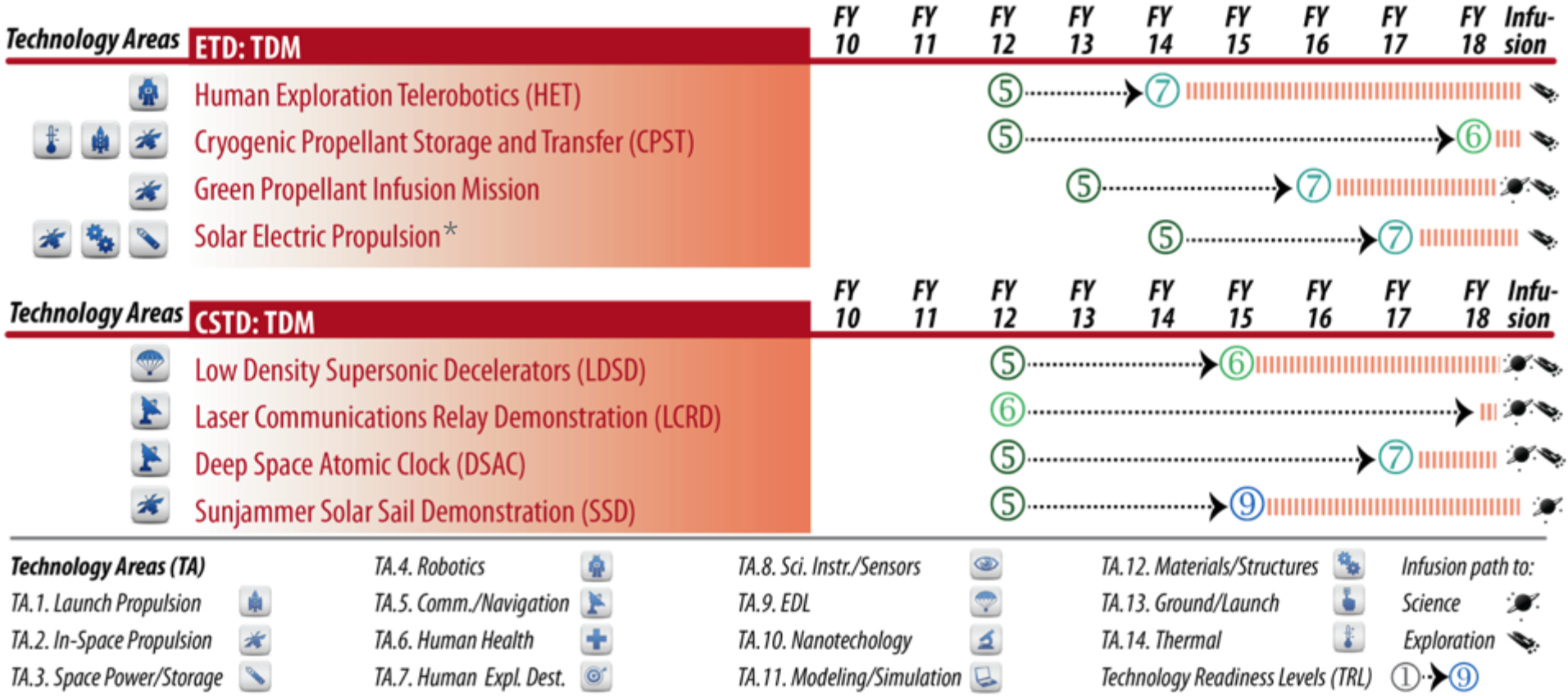


Small Business Innovation Research & Small Business Technology Transfer (SBIR/STTR) Program *

Flight Opportunities Program

*SBIR now consolidated across Agency into a single line in STMD

TDM Portfolio



*SEP does not become a TDM until FY2014

Green Propellant Infusion Mission (GPIM) Overview

Overview: GPIM is a spaceflight demonstration of a complete propulsion system for spacecraft attitude control and primary propulsion using the "Green Propellant" AF-M315E developed by AFRL as a substitute to Hydrazine

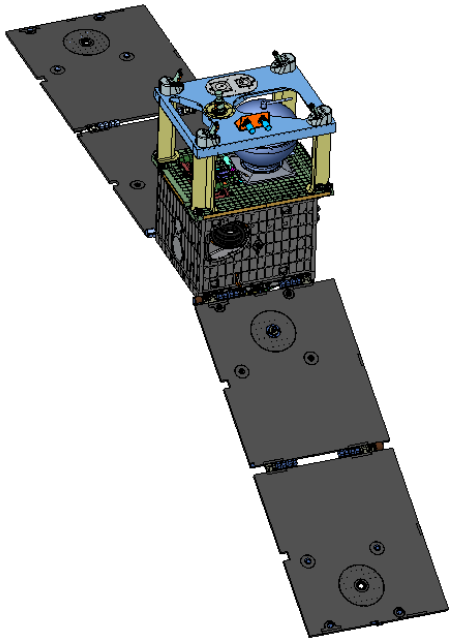
Benefits: Utilizing AFM-315E will significantly reduce the safety restrictions and complexities placed on hydrazine ground operations while substantially increasing performance (50% improvement over hydrazine)

Thrusters: One 22 N and four 1 N thrusters with new high-temperature catalyst technology designed, developed, and tested by Aerojet. Cost comparable to hydrazine thrusters.

Spacecraft bus: Flight-proven Ball Configurable Platform (BCP) 100 bus

Access to space: Secondary payload (ESPA compatible) on DOD Space Test Program launch STP-2 (Falcon Heavy) in Fall 2015

Team members: Ball Aerospace (lead), Aerojet, Air Force Research Laboratory, Space & Missile Systems Center, NASA Glenn Research Center, NASA Kennedy Space Center



GPIM spacecraft

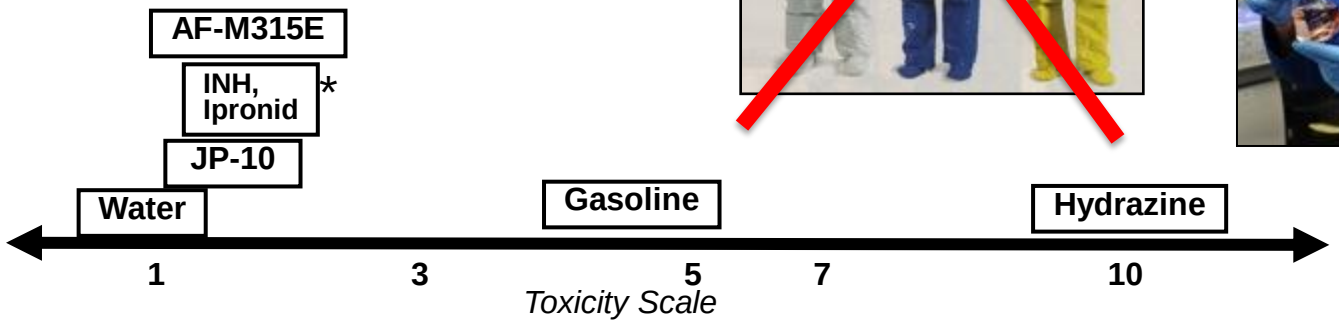
GPIM propulsion system

9

Propellant Characteristics

- AFM-315E was developed by AFRL in 1998 as an alternative to Hydrazine
  - Focus on reducing toxicity and increasing performance
- Propellant is an ionic salt blend of HAN (Hydroxylammonium Nitrate) solid oxidizer with water and a compatible fuel
- >50% improvement in volumetric performance versus hydrazine

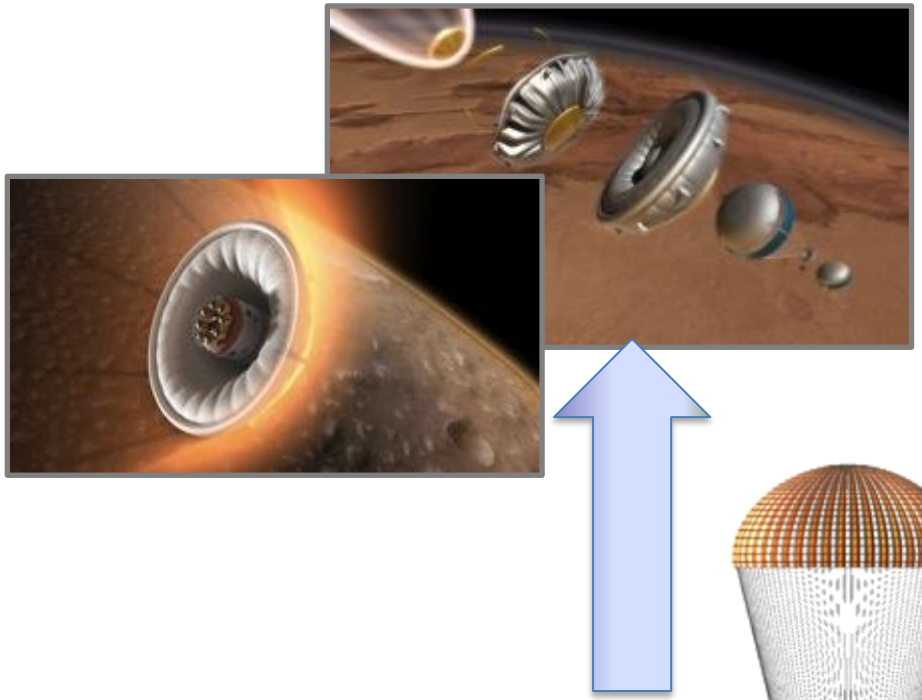
• Less toxic (LD50) than caffeine
• Negligible vapor toxicity allows propellant loading with typical PPE (no SCAPE or monitoring requirement)

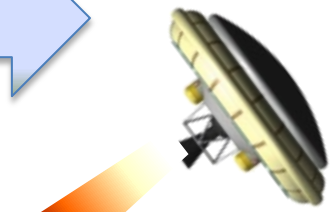


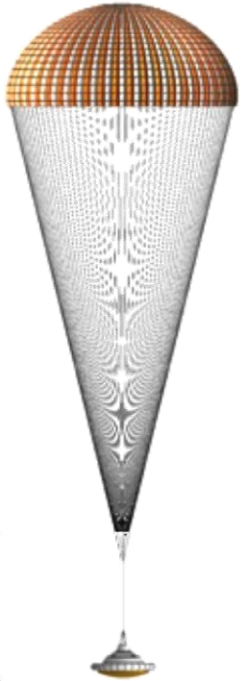
*, INH used in treating tuberculosis; Ipronid is an antidepressant drug

Low Density Supersonic Decelerator

- LDSD is designing and testing EDL systems to enable a new class of planetary entry vehicles
- Improvement over MSL
  - Up to 1mt increase in landed mass
  - 25% increase in elevation
  - 3x reduction in landing ellipse

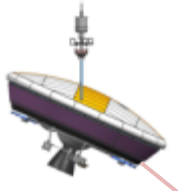




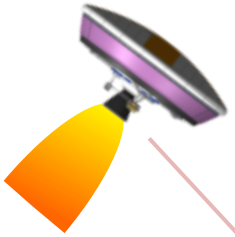


LDSD Supersonic Flight Dynamics Test (SFDT)

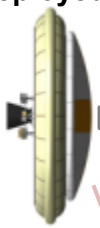
Test Start: Test Vehicle Separates from Balloon



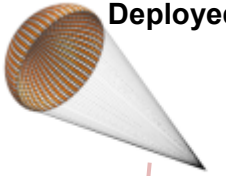
Rocket Powered Flight: aimed NE



Decelerator Deployed

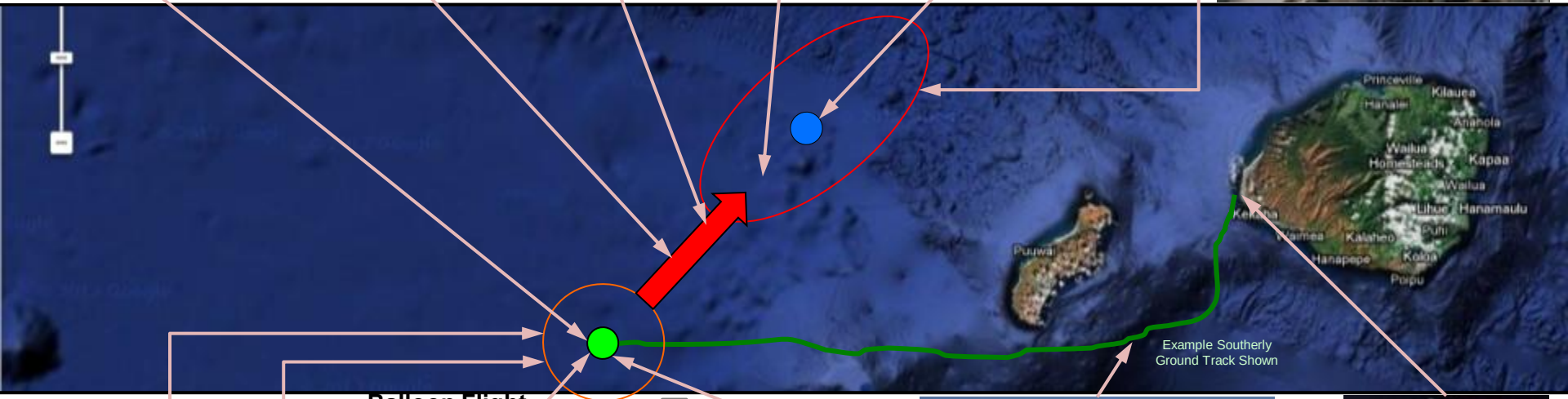


Parachute Deployed



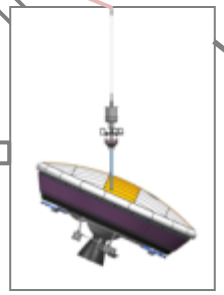
Test Vehicle Splashdown

Test Vehicle Landing & Water Recovery Footprint



Balloon Flight Termination Point

Balloon Water Landing and Recovery Footprint

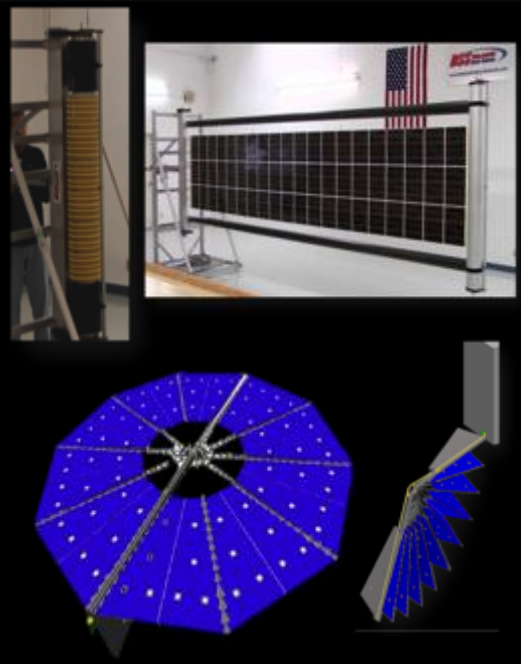


Drop Alt.:120,000 ft

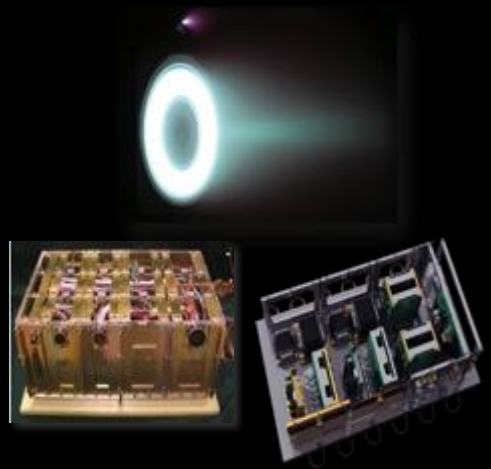
Balloon Climb-out Ground Track

Balloon Launch

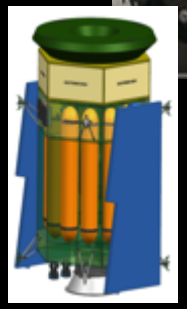
High-Powered Solar Electric Propulsion



Solar Arrays



Thruster and Power Processing Unit



Propellant Feed System and Storage Tanks

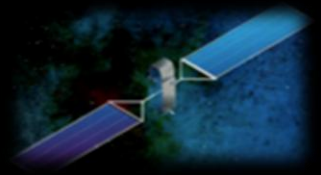
High-powered SEP Enables Multiple Applications

Deep Space Human Exploration

Satellite Servicing

Payload Delivery

Commercial Space Applications



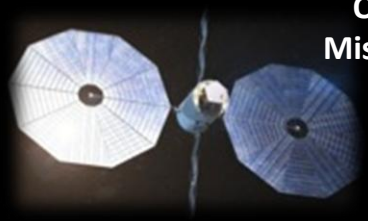
Solar Electric Propulsion

ISS Utilization

Orbital Debris Removal

Space Science Missions

OGA Missions



First Steps Towards Mars

Sequence \ Mission	Asteroid Redirect Mission	Long Stay In Deep Space	Humans to Mars Orbit	Humans to Mars Surface
ISRU & Surface Power				X
Surface Habitat				X
EDL, Human Lander				X
Aero-capture			X	X
Adv. Upper Stage w Cryo-Prop storage & Transfer			X	X
Deep Space Habitat (DSH)		X	X	X
High Reliability ECLSS		X	X	X
Autonomous Assembly		X	X	X
SEP for Cargo / Logistics	X	X	X	X
Deep Space GNC	X	X	X	X
Crew Operations beyond LEO (Orion)	X	X	X	X
Crew Return from Beyond LEO – HS Entry (Orion)	X	X	X	X
Heavy Lift to Beyond LEO (SLS)	X	X	X	X

STMD/ETD Investments

HEOMD/ESD/AES Investments

HEOMD/ESD/AES + STMD/ETD Investments

T&I Committee Recommendation for the NASA Advisory Council

Recommendation:

The Council recommends that NASA continue its commitment to sustain and grow the Agency's space technology programs to enable future NASA missions and to maintain U.S. technical leadership in space.

Major Reasons for the Recommendation:

The missions we want to fly tomorrow will be enabled by technology investments made today. The NASA technology shelf has been depleted over the last decade due to a lack of investment. NASA has begun to correct this over the last three years with the formation of OCT and the STMD. This has been supported by senior government decision-makers in the Agency and within the Administration. We believe sequestration poses a major threat to the vitality of NASA's space technology programs.

Consequences of No Action on the Recommendation:

The combination of the consolidation of the Agency's SBIR activities in STMD, coupled with across the board reductions, could result in a disproportionate cut in the STMD's discretionary technology program. In order to accommodate budget reductions, STMD is forced to reduce its key technology demonstration missions in support of the Agency's priorities.

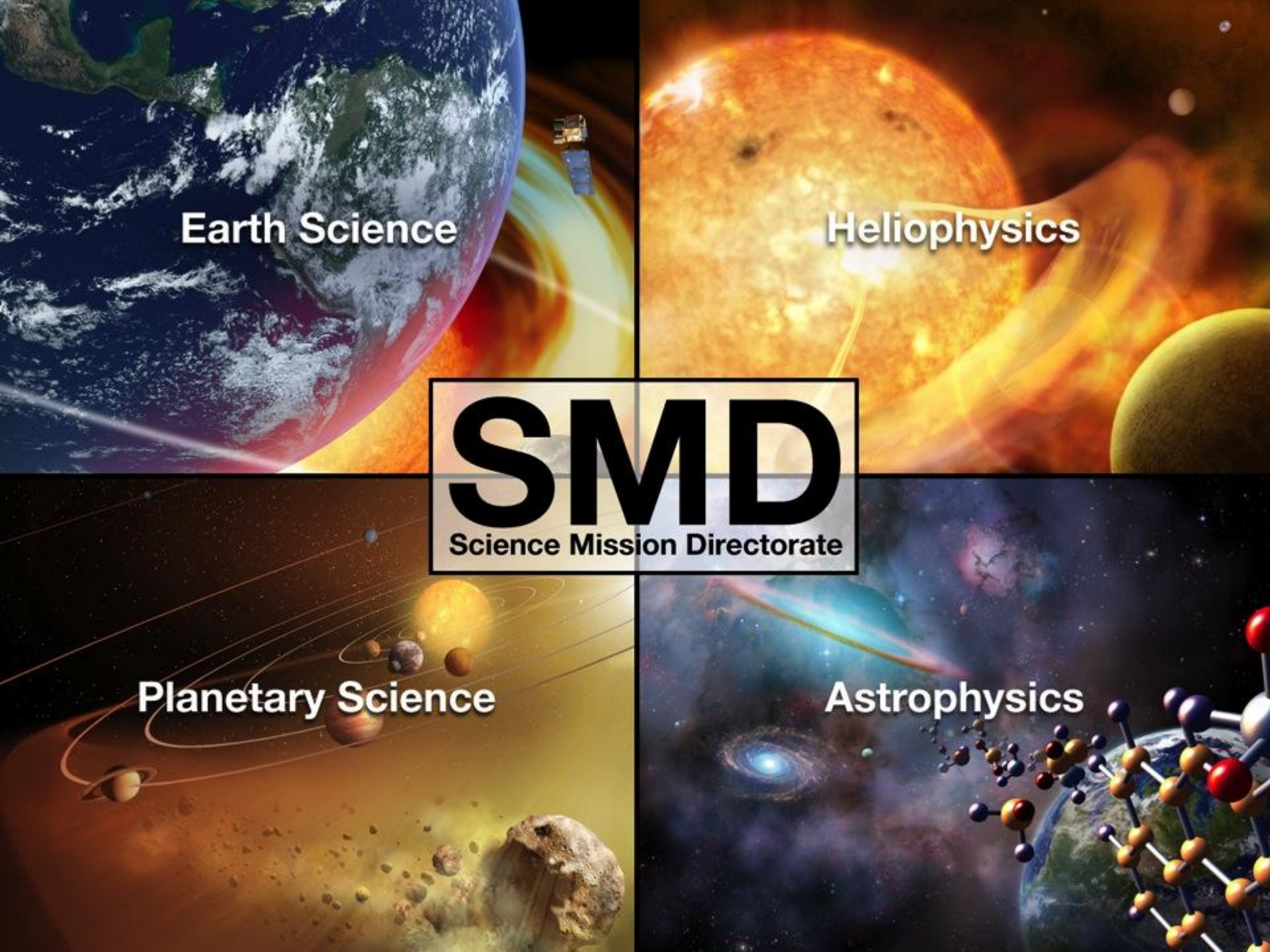
National Aeronautics and Space Administration

SMD Technology Development

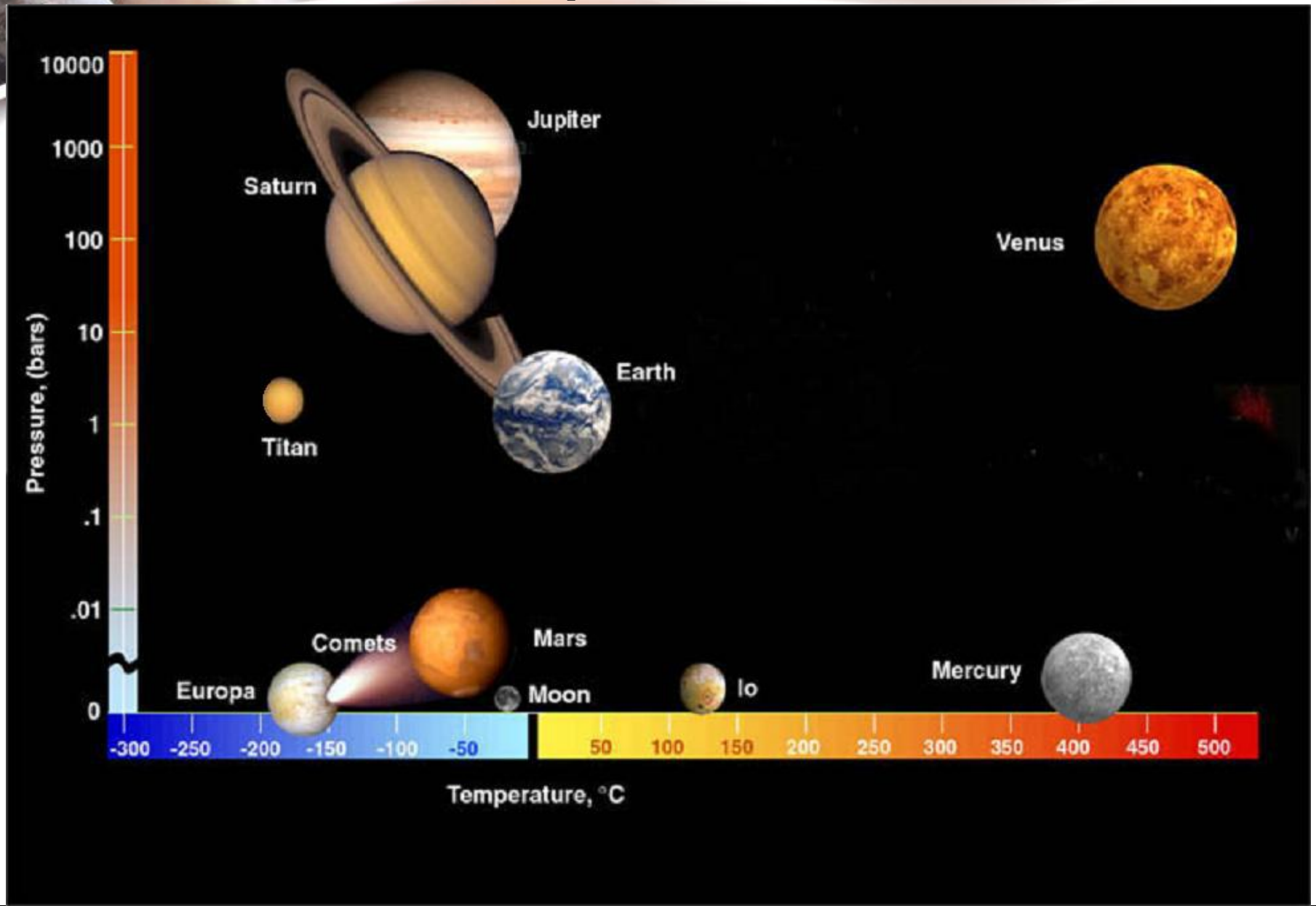
Mr. Timothy Van Sant
Chief Technologist
Science Mission Directorate
NASA

30 July 2013

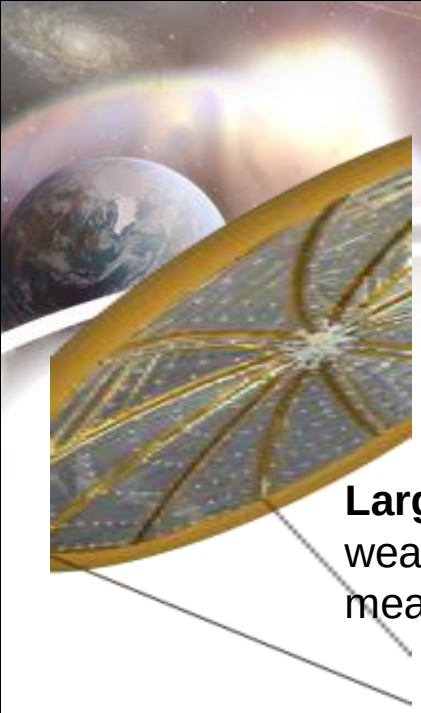
www.nasa.gov


Earth Science
Heliophysics
SMD
Science Mission Directorate
Planetary Science
Astrophysics

Challenge of Planetary Extremes
Pressure-Temperature Environments



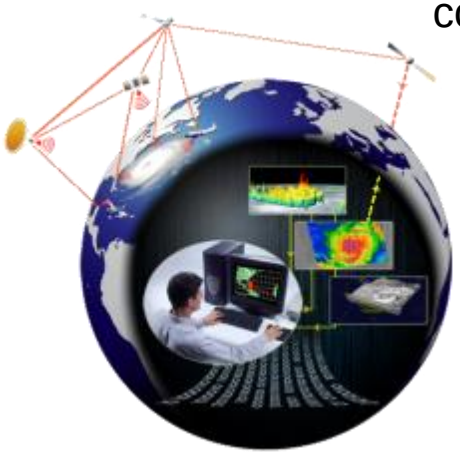
Key Technology Challenges



Active Remote Sensing Technologies to enable atmospheric, cryospheric and earth surface measurements

Large Deployables to enable future weather, climate and natural hazards measurements

Intelligent Distributed Systems using advanced communication, on-board processors, autonomous network control, data compression, and high density storage



Information Knowledge Capture through 3-D visualization, holographic memory and seamlessly linked models.

Mark Clampin (NASA GSFC)
Visible Nulling Coronagraph

Coronagraph Technology Milestone:
Demonstration of ≤ 10^{-8} monochromatic contrast through visible nulling.

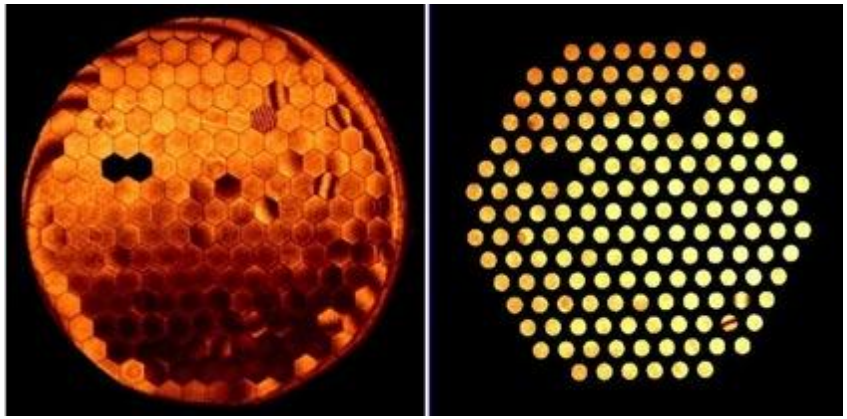
Facility: Visible Nulling Coronagraph Testbed, NASA GSFC.

Current Status: 5.1 x 10^{-9} average @ 2λ/D contrast monochromatic.

Challenges: State of the art in segmented DMs.

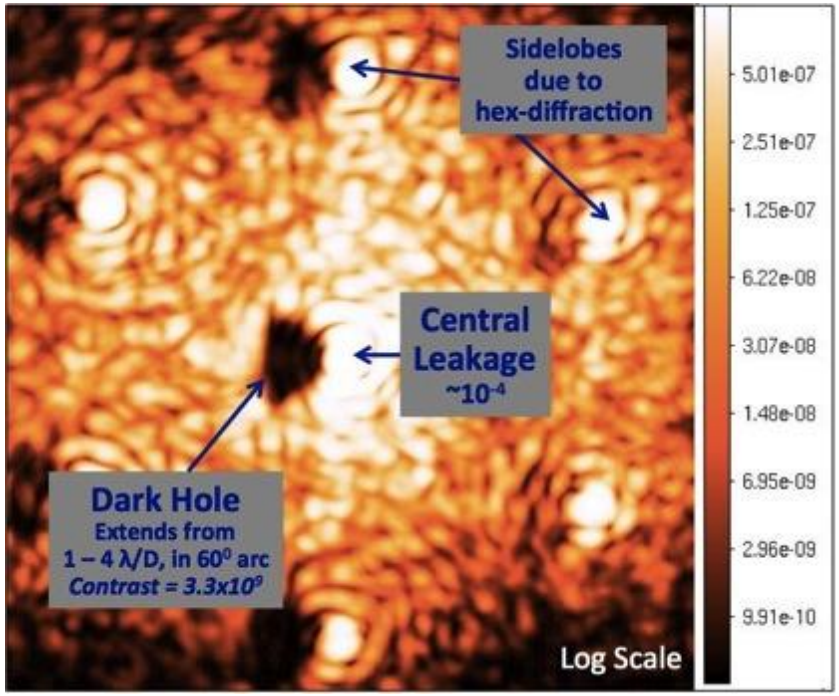
Future Work: Experiments completed, milestone under review. Broadband demonstrations to be undertaken next.

Focal Plane Image thru Spatial Filter Array



Interferometric Bright Image Without Lyot Stop

Interferometric Bright Image With Lyot Stop



TDEM work completed.
Milestone Report pending approval by TAC.

Conclusion

- A focused, science-driven approach
- Peer-reviewed process
- Open, competitive program
- Frequent solicitations ensure current approaches and create regular, multiple opportunities for PI′s
- Technologies selected for eventual infusion by principal investigators and mission managers
- Currently funded technologies are providing state-of-the-art instruments, components, and information systems capabilities for a wide range of science measurements

National Aeronautics and Space Administration

Commercial Cargo and Crew Update

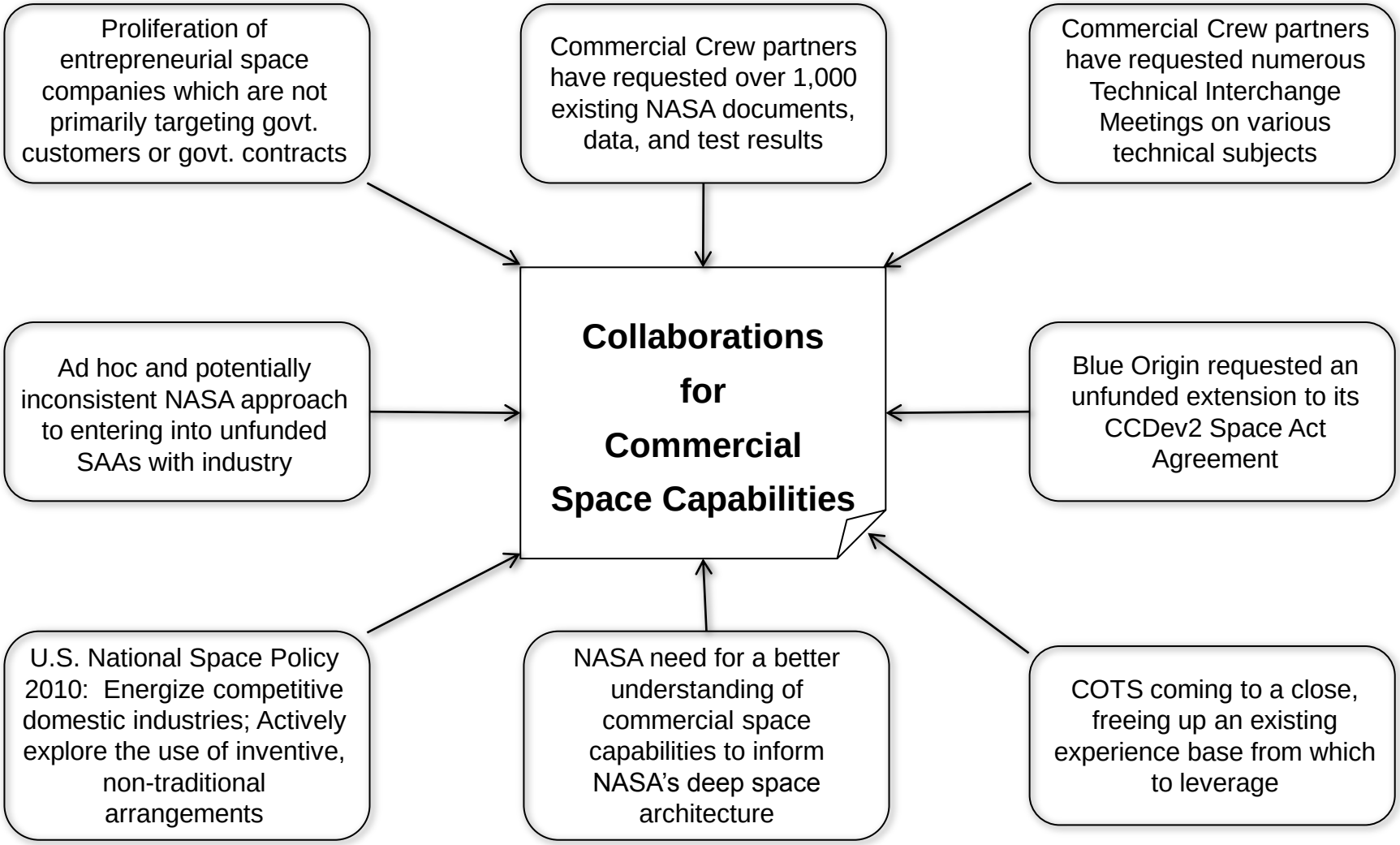
NAC T&I Meeting

July 30, 2013
Philip McAlister
NASA HQ

Technology Needs of our Industry Partners

- For the most part, our Commercial Crew industry partners are deliberately not pursuing advanced technologies.
- Human space transportation to low-Earth orbit is very hard, but it is something the U.S. has done over 150 times for over four decades.
- In addition, the partners are in a competitive environment to develop commercial crew transportation systems as soon as possible with a goal of 2017.
- Innovative designs – yes, cost effective approaches – yes, sound engineering practices – yes. However, our partners have not wanted to overly rely on advanced technology to meet the safety, reliability, and cost effectiveness goals of the program.

Genesis of Collaborations Synopsis



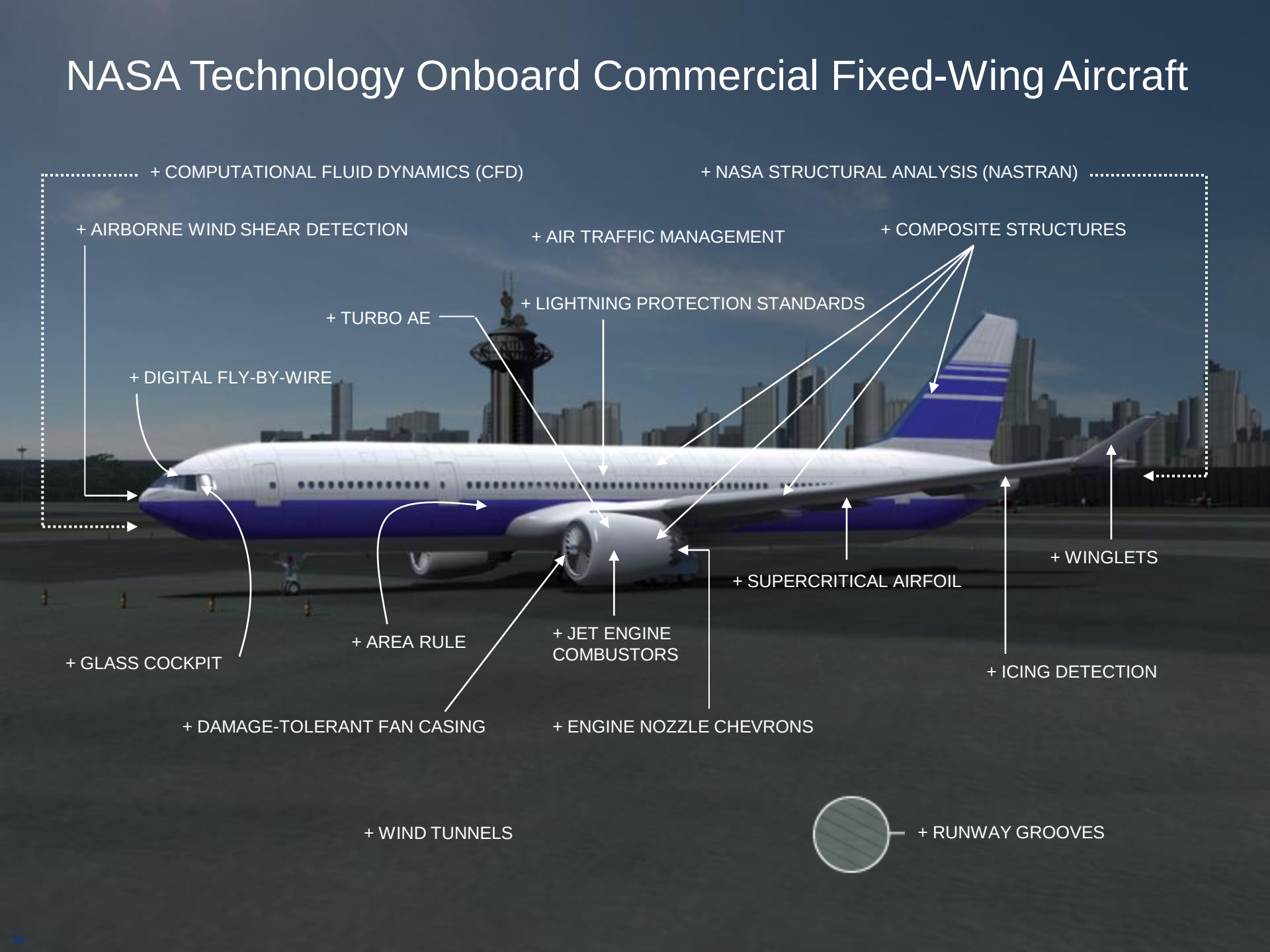
T&I Committee Finding for the NASA Advisory Council

- **Industry may not be pursuing advance technology in its Commercial Crew programs, however, NASA and industry are using innovative partnering and contracting models (Space Act Agreements and streamlined requirements from NASA).**
  - **We encourage NASA to further explore this acquisition approach to streamlining requirements in active dialogue with industry**

NASA's Aeronautics Research Strategy: A Reflection of Research Continuity, Strategic Analysis, and Community Dialogue

Robert Pearce
Director – Strategy, Architecture & Analysis
NASA Aeronautics Research Mission Directorate

NASA Technology Onboard Commercial Fixed-Wing Aircraft



Where do we see NASA's benefits today?

NASA's fundamental research can be traced to ongoing innovation.

Boeing 787

NASA's work on these technologies

- Advanced composite structures
- Chevrons
- Laminar flow aerodynamics
- Advanced CFD and numeric simulation tools
- Advanced ice protection system

Was transferred for use here

824 confirmed orders through August 2012

Boeing 787

Benefits

- 20% more fuel efficient/ reduced CO_2 emissions
- 28% lower NO_x emissions
- 60% smaller noise footprint

Source: Boeing

Boeing 747-8

NASA's work on these technologies

- Advanced composite structures
- Chevrons
- Laminar flow aerodynamics
- Advanced CFD and numeric simulation tools

Was transferred for use here

106 confirmed orders through August 2012

Boeing 747-8

Benefits

- 16% more fuel efficient/ reduced CO_2 emissions
- 30% lower NO_x emissions
- 30% smaller noise footprint than 747-400

Source: Boeing

P&W PurePower 1000G Geared Turbofan

NASA's work on these technologies

- Low NO_x Talon combustor
- Fan Aerodynamic and Acoustic Measurements
- Low noise, high efficiency fan design
- Ultra High Bypass technology
- Acoustics Modeling and Simulation tools

Was transferred for use here

Proposed for Airbus A320NEO, Bombardier C-Series, Mitsubishi Regional Jets

P&W PurePower 1000G Geared Turbofan

Benefits

- 16% reduction in fuel burn/reduced CO_2 emissions
- 50% reduction in No_x
- 20dB noise reduction

Source: Pratt & Whitney

CFM LEAP-1B

NASA's work on these technologies

- Compression system aerodynamic performance advances
- Low NO_x TAPS II combustor
- Low pressure turbine blade materials
- High-pressure turbine shroud material
- Nickel-aluminide bond coat for the high pressure turbine thermal barrier coating

Was transferred for use here

Proposed for Airbus A320NEO, Boeing 737MAX

CFM LEAP-1B

Benefits

- 15% reduction in fuel burn/ reduced CO_2 emissions
- 50% less NO_x
- 15dB noise reduction

Source: CFM

T&I Committee Finding for the NASA Advisory Council

- For more than a decade, NASA Aeronautics program has been under severe budget pressures, shrinking from over $1B to roughly $560M annually.
- U.S. Aviation leadership is a vital to our Nation's future economic future.
- NASA has historically played a leading role in preserving U.S. aviation leadership.
- It appears, NASA Aeronautics no longer significantly investing in several traditional research and technology areas, such as supersonics, hypersonics, flight research, and general aviation.
- T&I Committee wants to hold joint meeting in near future with Aeronautics Committee to assess what Aeronautics Research and Technology investments NASA needs for the Nation's aviation future.

Mason Peck OCT Update

- **Discussion Topics**
  - **Technology across NASA**
    - **Space technology**
    - **SMD**
    - **HEO**
    - **ARMD**
    - **Center Investment Fund within CAS**
    - **Information Technologies**
  - **STMD / OCT scopes**
  - **Next generation roadmapping & STIP**
  - **Agency Grand Challenge**
  - **New initiatives**
    - **Foundational Engineering Science**
    - **Future Grand Challenges**

Overall Grand Challenge Consists of Five Main Segments

Find all asteroid threats to human populations and know what to do about them

Contributors to the Cause

Current Contributors

NASA Contributors

- NEOO (SMD) Program
- NEO Program Office at JPL
- Minor Planet Center (Smithsonian Astrophysical Observatory)
- JRP (HEO) Program
- Asteroid Redirect Mission: Identify, Redirect, and Explore
- STMD (Research Grants, Centennial Challenges)

External Contributors

- Other U.S. Government Agencies
- International Governments (Space Agencies, IWAN, SMPAG)
- European Space Agency (ESA) Space Situational Awareness Initiative NEO element
- Global Coordination Bodies (UN COPUOS)
- Observatories
- Amateur Astronomers
- Universities/Academia
- Non-Profits/Foundations (B612)
- Commercial Space Industry
- Emerging Space Industry
- Space Advocacy

+

Potential Contributors

- Entrepreneurs/Small Businesses
- Investing Community/Venture Capitalists
- Maker Community
- Citizen Science
- Media
- Hollywood

T&I Committee Recommendation for the NASA Advisory Council

Recommendation:

The Council recommends that NASA establish a basic research (engineering science) program relevant to its long-term needs and goals.

- The Council suggests that the Chief Technologist collaborate with the Chief Scientist and the Chief Engineer to establish formal guidance and seek funding for basic research in engineering science. The Council further suggests that NASA begin by managing the agency's basic research portfolio as a pilot activity that is funded separately from the Space Technology Program, similar to how OCT coordinates the agency's technology portfolio.

Major Reasons for the Recommendation:

The Council recognizes that the distinction has been established between basic research and technology. NASA's technology programs now have advocacy and, in the form of the Strategic Space Technology Investment Plan (SSTIP), strategic guidance. However, basic research (or engineering science) that may lead to the development of technology and engineering tools are no longer explicitly part of NASA's technology enterprise.

Consequences of No Action on the Recommendation:

Erosion of NASA's research and technology capabilities

- **Committee reasserts its previous recommendation on the importance of fundamental aerospace engineering science**
- **We look forward to hearing an update from the Agency on this recommendation.**

T&I Committee Finding for the NASA Advisory Council

- T & I Committee management is moving from STMD to OCT beginning next meeting. Katie Gallagher (OCT) will provide support in future.

- Would like to thank Mike Green, Executive Secretary for past three years and Anyah Dembling, executive assistant for all their help and efforts at managing the Committee activities including our meetings.

- Also, want to thank Mike Gazarik for STMD's support as well.