National Aeronautics and
Space Administration

Space Technology Mission Directorate Briefing

NAC T&I Committee

Presented by:
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Space Technology Mission Directorate

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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**

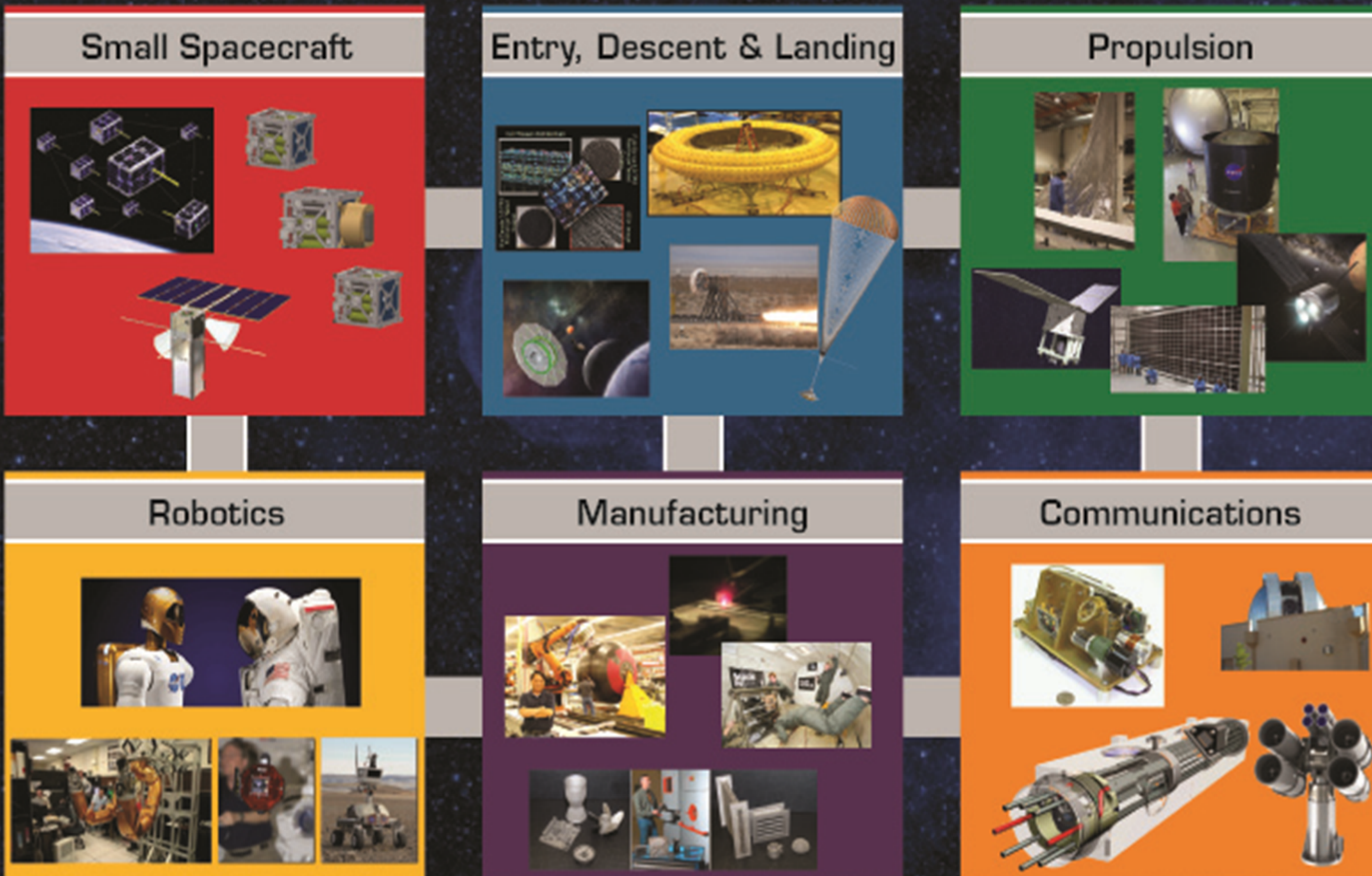
Addresses National Needs

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

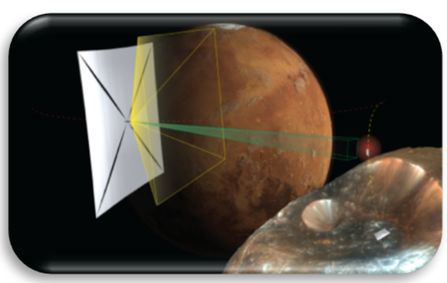
Trends in Space Technology

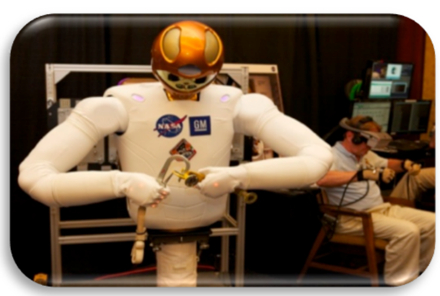


Guiding Principles of the Space Technology Programs

Space Technology Programs

- **Adheres to a Stakeholder Based Investment Strategy:** NASA Strategic Plan, NASA Space Technology Roadmaps / NRC Report and Strategic Space Technology Investment Plan
- **Invests in a Comprehensive Portfolio:** Covers low to high TRL, student fellowships, grants, prize competitions, prototype developments, and technology demonstrations
- **Advances Transformative and Crosscutting Technologies:** Enabling or broadly applicable technologies with direct infusion into future missions
- **Selects Using Merit Based Competition:** Research, innovation and technology maturation open to academia, industry, NASA centers and other government agencies
- **Executes with Structured Projects:** Clear start and end dates, defined budgets and schedules, established milestones, and project authority and accountability.
- **Infuses Rapidly or Fails Fast:** Rapid cadence of technology maturation and infusion, informed risk tolerance to infuse as quickly as possible
- **Positions NASA at the cutting edge of technology:** Results in new inventions, enables new capabilities and creates a pipeline of innovators for National needs



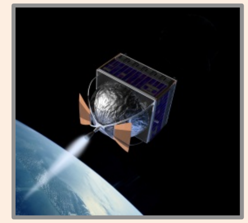


Space Technology Portfolio

Transformative & Crosscutting Technology Breakthroughs

Game Changing Development (ETD/CSTD)

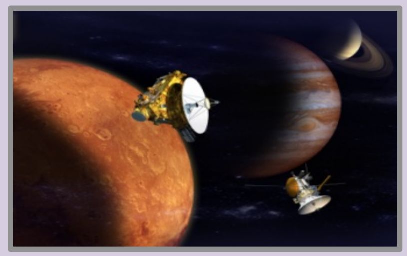
Technology Demonstration Missions (ETD/CSTD)



Small Spacecraft Technologies (CSTD)

Pioneering Concepts/ Developing Innovation Community

Space Technology Research Grant (CSTD)



NASA Innovative Advanced Concepts (NIAC) (CSTD)

Center Innovation Fund (CSTD)

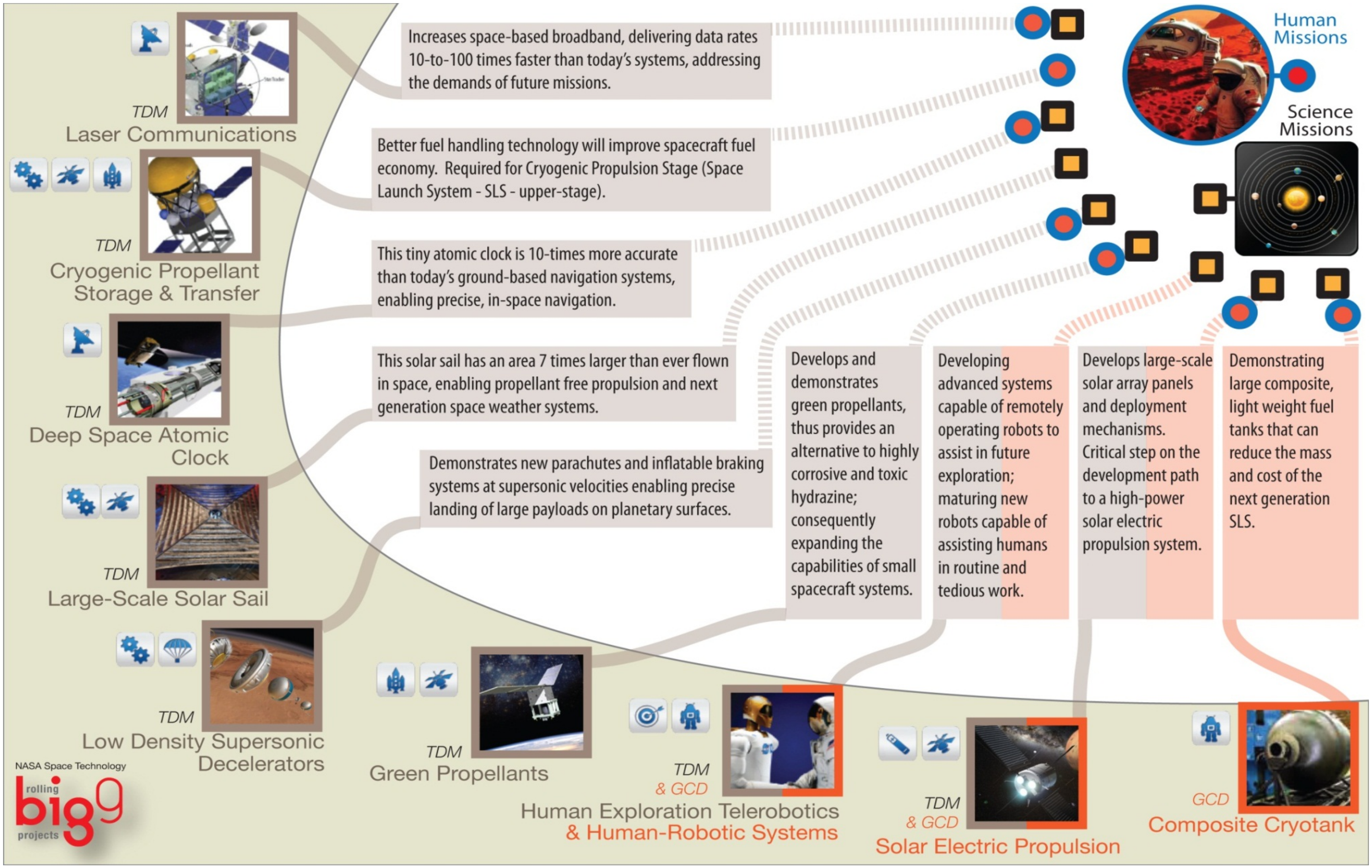
Creating Markets & Growing Innovation Economy

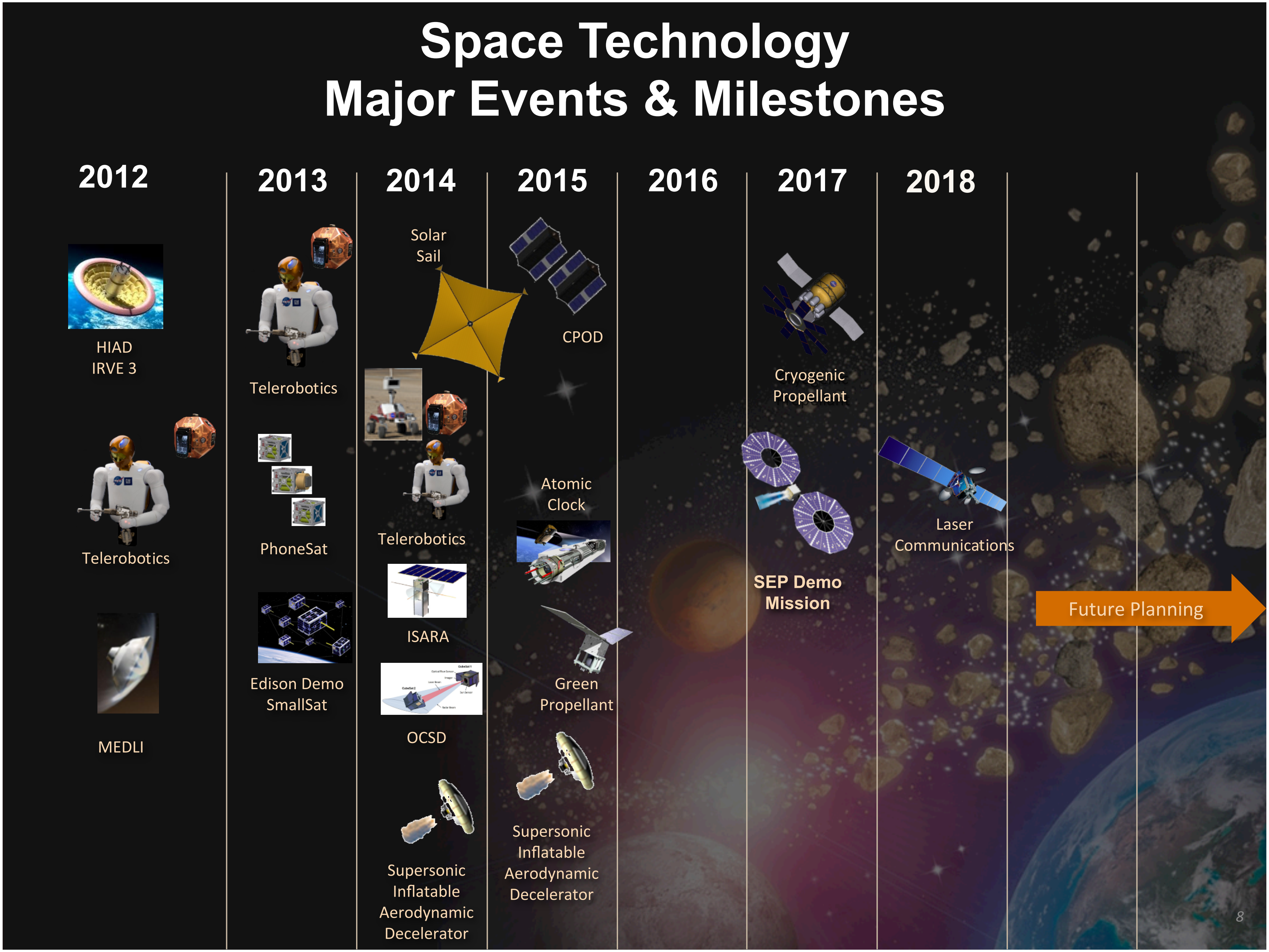
Centennial Challenges (CSTD)

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

Flight Opportunities Program (CSTD)

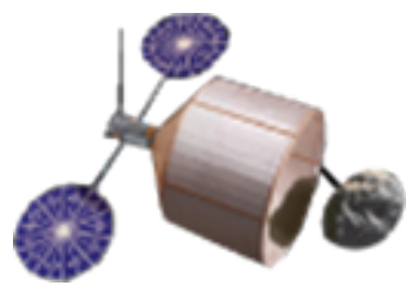
FY2014 Big Nine



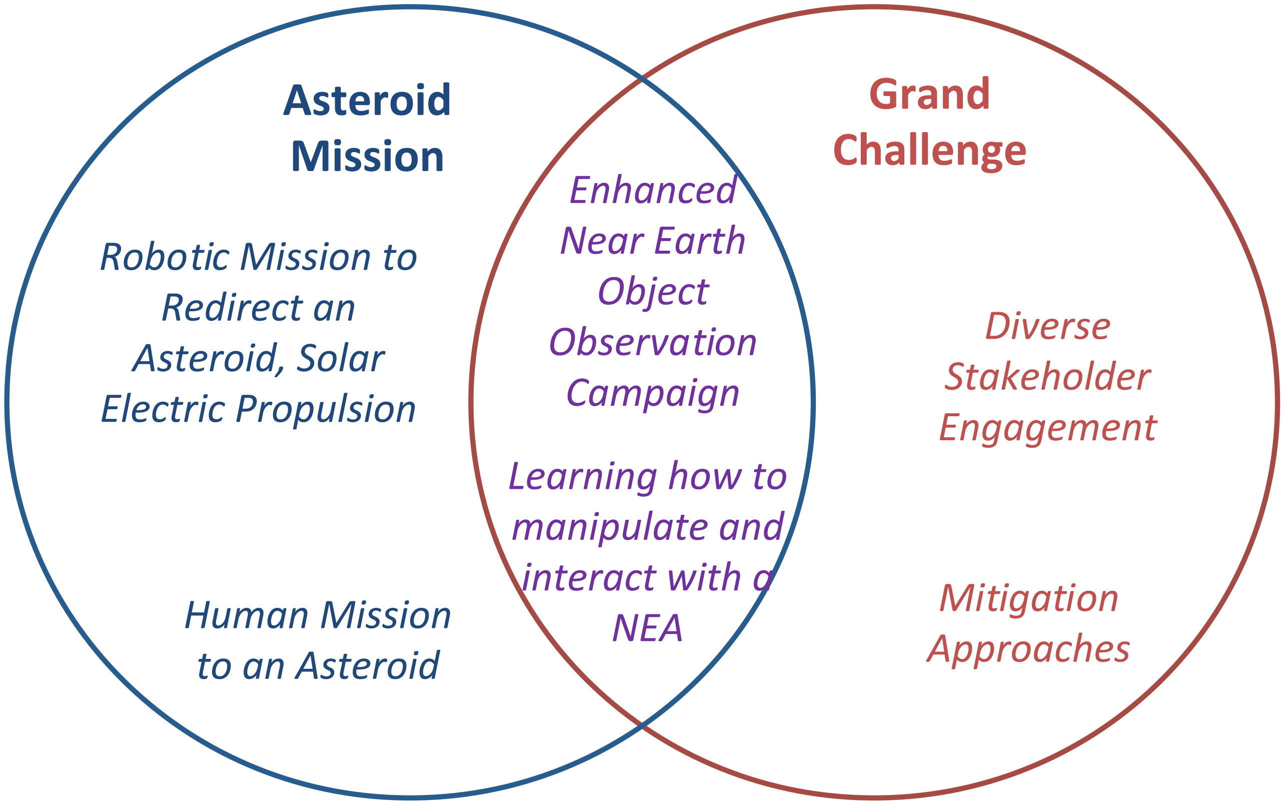

Space Technology
Major Events & Milestones
2012
2013
2014
2015
2016
2017
2018
HIAD
IRVE 3
Telerobotics
MEDLI
Telerobotics
PhoneSat
Edison Demo
SmallSat
Solar
Sail
Telerobotics
ISARA
OCSD
Supersonic
Inflatable
Aerodynamic
Decelerator
CPOD
Atomic
Clock
Green
Propellant
Supersonic
Inflatable
Aerodynamic
Decelerator
Cryogenic
Propellant
SEP Demo
Mission
Laser
Communications
Future Planning
8

Asteroid Initiative: Asteroid Redirect Mission & Agency Grand Challenge

- NASA is planning a first-ever mission to capture and redirect an asteroid to earth-moon space. The effort aligns and leverages relevant portions of NASA's Science, Space Technology, and Human Exploration capabilities
- NASA will also lead a broad effort to find all asteroid threats to human populations and know what to about them: a "Grand Challenge"
- The overall mission is composed of three independently compelling elements:
  - Detection and characterization of candidate near earth asteroids
  - Robotic rendezvous, capture and redirection of an asteroid to earth-moon space
  - Crewed mission to explore and sample the captured asteroid using the Space Launch System (SLS) and the Orion crew capsule
- Space Technology will focus on high-powered Solar Electric Propulsion (SEP)
  - SEP is the primary propulsion for the robotic asteroid rendezvous and redirection
  - The retrieval mission is not possible without SEP
  - SEP is also enabling for deep space human exploration
  - SEP component technologies serve commercial needs
  - In FY14 STMD will accelerate SEP development

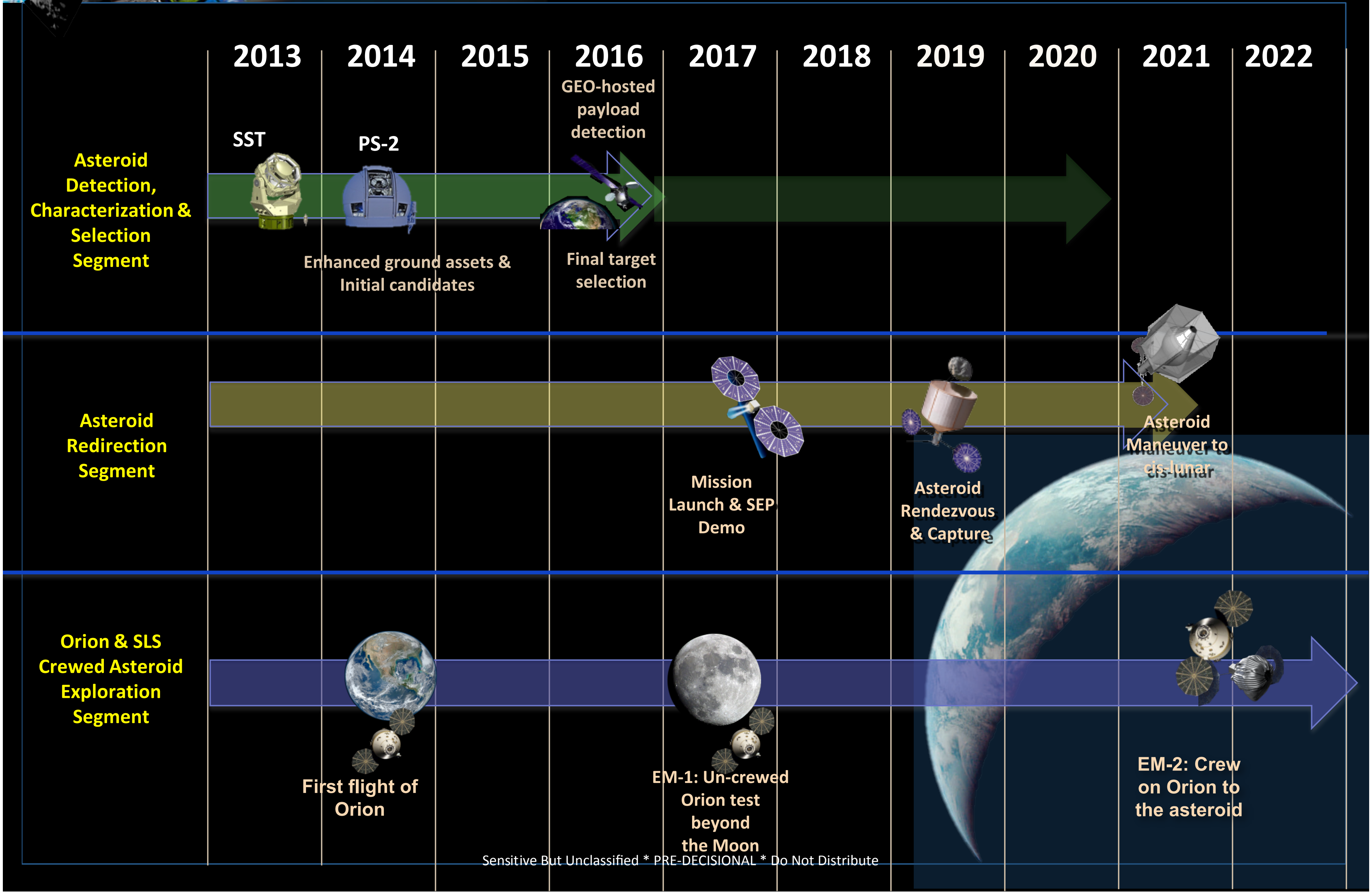


FY14 Asteroid Initiative

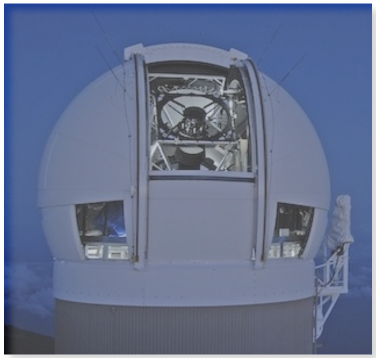


Both sets of activities leverage existing NASA work while amplifying participatory engagement to accomplish their individual objectives and synergize for a greater collective purpose.

Alignment Strategy



Space Tech Role in Agency Asteroid Strategy



Early Stage programs will foster innovation regarding:

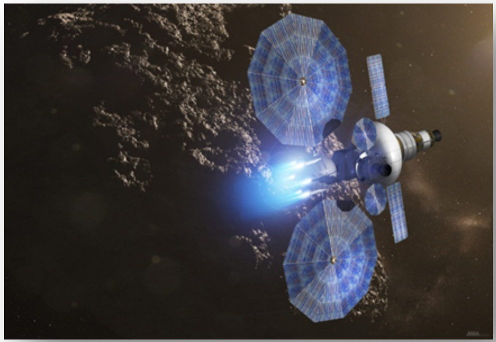
- Asteroid detection, characterization and mitigation for planetary defense and asteroid retrieval mission target selection
- Asteroid proximity operations and resource utilization techniques

Game Changing will complete high power SEP tech development:

- Advanced solar array systems
- Advanced magnetic shielded Hall thrusters
- Power processing units (PPUs)

Technology Demonstration Missions will develop, test and demonstrate the SEP system as part of the redirect mission:

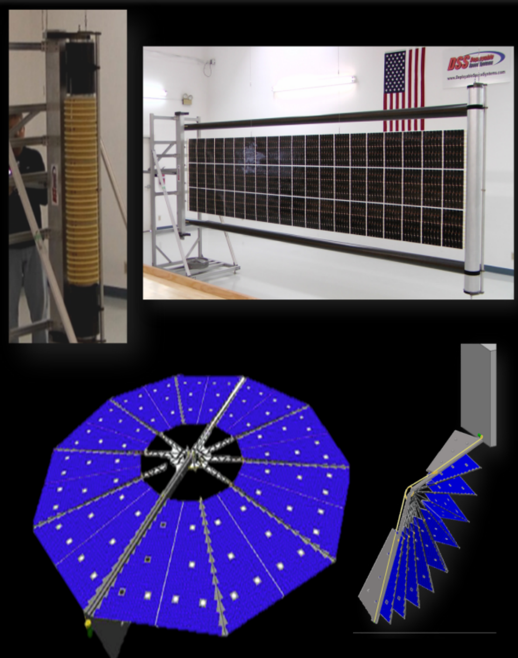
- 30kW – 50 kW advanced solar arrays
- EP thrusters & Power Processing
- Xenon propellant tanks



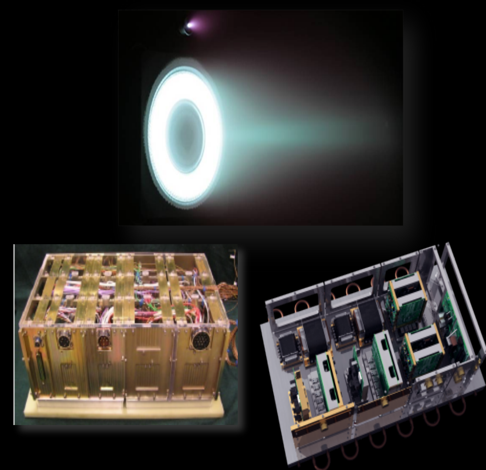
Additional Asteroid Redirect funding in FY2014 will cover:

- Flight hardware solar array procurements
- EP thruster engineering development units
- Design of Xenon propellant tanks

High-Powered
Solar Electric Propulsion



Solar Arrays

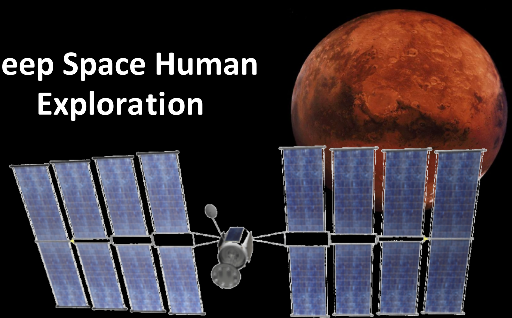


Thruster and
Power
Processing Unit

Propellant Feed System
and Storage Tanks

High-powered SEP Enables Multiple Applications

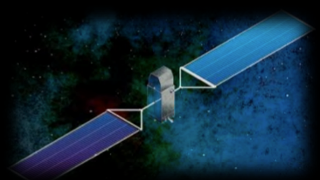
Deep Space Human Exploration

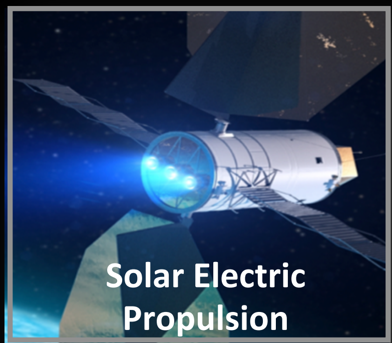


Satellite Servicing

Payload Delivery

Commercial Space Applications



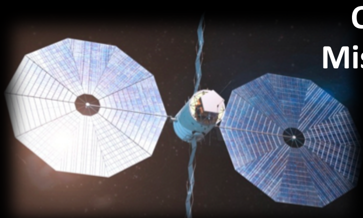


ISS Utilization

Orbital Debris Removal

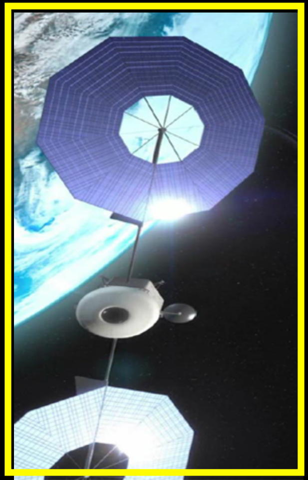
Space Science Missions

OGA Missions



Advancing Solar Electric Propulsion Technology




Deep Space 1 1998	Dawn 2007	AEHF Recovery 2010	Asteroid Redirect Mission	Far-term Exploration Missions circa 2030's
Technology Demonstrator	Deep-Space Science Mission	Satellite orbit established with Hall Thrusters	Robotic Mission to Redirect Asteroid to Trans-Lunar Orbit	Crewed mission beyond Earth space
2.5 kW power system 2kW EP system	10 kW power system 2.5kW EP system	~16kW-class power ~4.5kW-class EP	50kW-class power system 10 kW-class EP	350kW-class power system 300kW-class EP

HEOMD / STMD Programmatic Synergy

Exploration Technology Development (ETD) work resides in two Space Technology Programs:

- Game Changing Development (GCD)
- Technology Demonstration Missions (TDM)

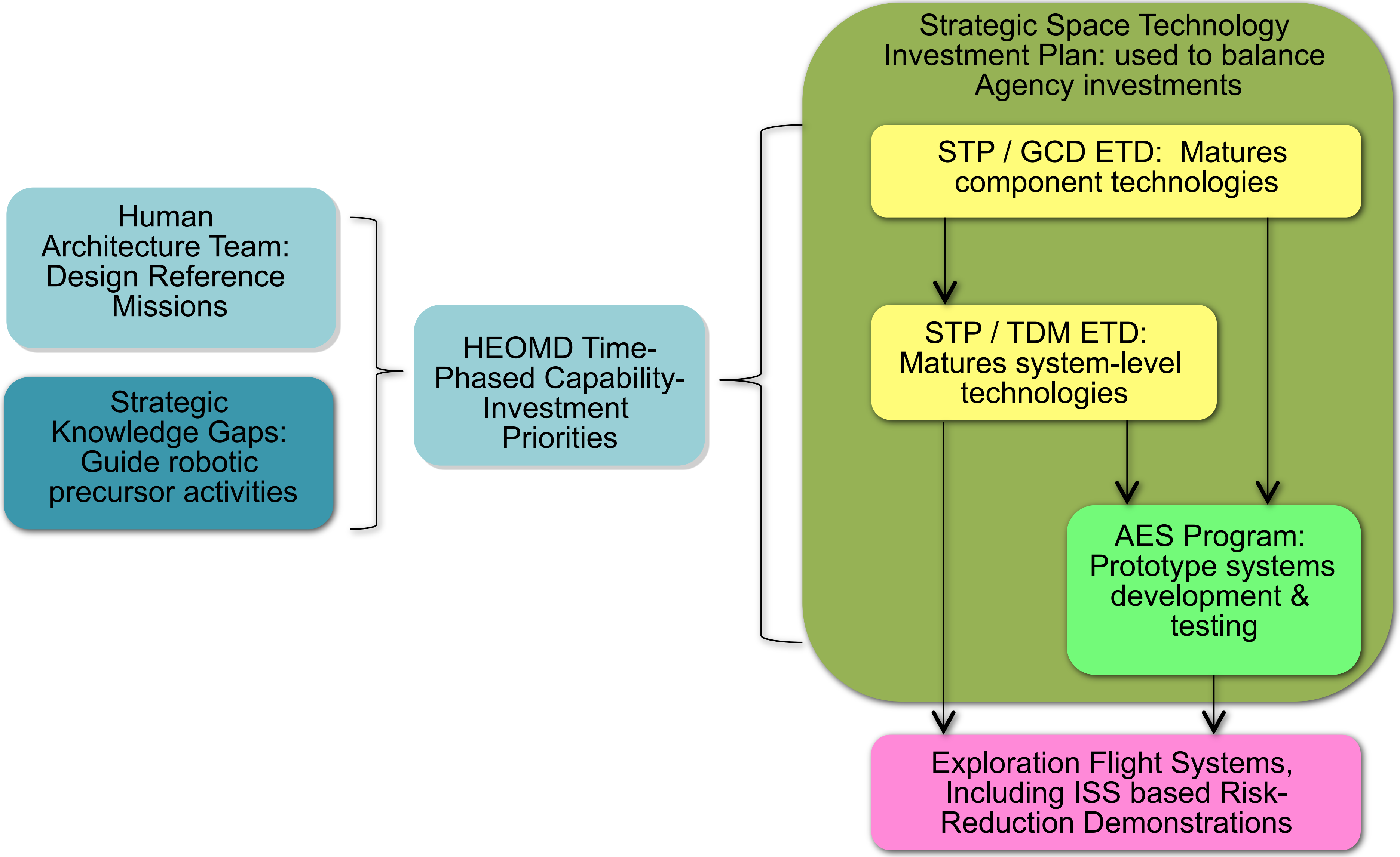
ETD Focus:

- Cross-cutting, pioneering technology development
- Not systems level development or integration
- TRL 7 or below
- Infusion into HEOMD; SMD, OGAs and the Aerospace Enterprise

AES Program within HEOMD manages system-level integration work and prototype / design development for future exploration architecture elements.

The Human Research Program (HRP) undertakes technology development and basic research in related areas, e.g. radiation mitigation

Guidance for the Combined AES/STMD Portfolio



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

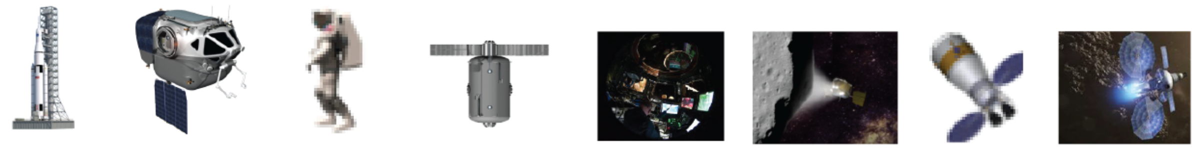
STMD/ETD Investments

HEOMD/ESD/AES Investments

HEOMD/ESD/AES + STMD/ETD Investments

Exploration Technology Development

Infusion



ETD: GCD	SLS/ MPCV	SEV	EVA	DSH	Mission Operations	Robotic Precursors	In-Space Propulsion	Asteroid Return
Electric Propulsion Thrusters							●●	●
Solar Array Systems (SAS)							●	●
Advanced In-Space Power		●						
Human-Robotic Systems (HRS)		●	●			●		●
Autonomous Systems (AS)				●	●			●
Next-Generation Life Support (NGLS)			●●	●				
In-Situ Resource Utilization (ISRU)						●●		
Composite Cryogenic Propellant Tank (CCPT)	●						●	
Advanced Radiation Protection (ARP)		●						
Woven TPS (W-TPS)	●							
Composite Cabin		●						
EVA Glove			●					
ETD: TDM								
Cryogenic Propellant Storage and Transfer (CPST)							●	
Solar Electric Propulsion (SEP)							●	●

MARS CHALLENGES

Surface Power

Life Support

Human Ops Support and Robotics

Mars Resource Utilization and Ascent from Surface

Space Radiation

Entry, Descent, and Landing (EDL)

Communications and Navigation

Transit (Cargo and Humans)

MARS CHALLENGES

TECHNOLOGY SOLUTIONS

NASA

Surface Power

- Fission/solar power
- Fuel cells/batteries

Life Support

- Next-Gen highly reliable and closed-loop life support.
- Advanced EVA suits

Human Ops Support and Robotics

- Telerobotics
- Robotics—task removal from astronauts
- Autonomous systems

Mars Resource Utilization and Ascent from Surface

- Utilization of in-situ resources
- Generation of human consumables
- Creation of propellant

Space Radiation

- Radiation protection
- Radiation modeling, characterization, and measurement

Entry, Descent, and Landing

ECL Systems for Human Class Missions

- Hypersonic entry systems
- Supersonic descent systems

Communications and Navigation

- Optical communication
- Advanced guidance systems

Transit (Cargo and Humans)

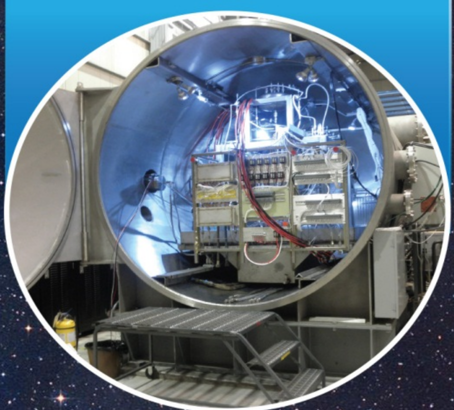
- Solar electric propulsion
- Lightweight structures and materials
- Cryogenic propellant storage and transfer

MARS CHALLENGES

STMD INVESTMENTS

Surface Power

- Advanced batteries
- Regenerative fuel cells
- Fission nuclear systems
- Solar arrays

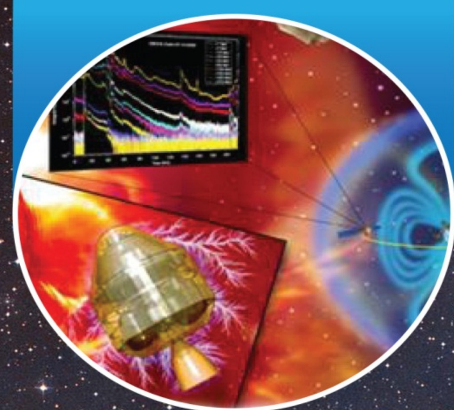


Life Support

- CO_2 to O_2 recovery
- Water processing
- Air regulators

Space Radiation

- Advanced radiation protection
- Radiation modeling and forecasting
- Dosimeters



Entry, Descent, and Landing

- Hypersonic Inflatable Aerodynamic Decelerator/High-Energy Atmospheric Reentry Test
- Adaptive Deployable Entry Systems Project
- Low-Density Supersonic Decelerator
- MSL Entry, Descent, and Landing Instrument
- Heat Shield for Extreme Entry Environment Technology
- Supersonic Retro Propulsion
- Hypersonic Entry, Descent, and Landing

MARS CHALLENGES

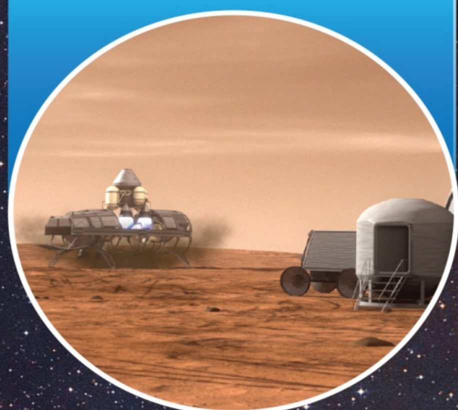
STMD INVESTMENTS

Transit (Cargo and Humans)

- Composite Cryotank
- Cryogenic Propellant Storage and Transfer
- Lightweight Materials and Structures
- Solar Electric Propulsion

Mars Resource Utilization and Ascent from Surface

- O_2 from Mars atmosphere
- RESOLVE instruments
- Propellant production

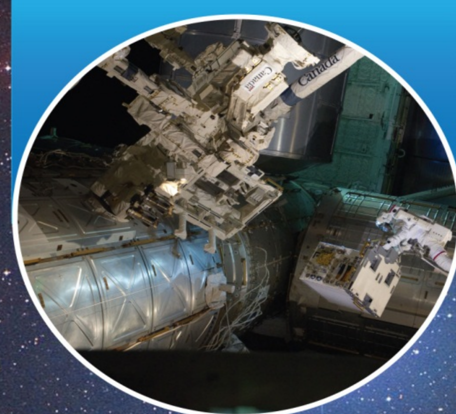


Communications and Navigation

- Deep Space Atomic Clock
- Laser Communication Relay Demonstration
- Deep Space Optical Communications

Human Ops Support and Robotics

- Automated system ops
- Robotic, human safe, maintenance and ops
- Avionics/multicore processor



Working Together to Innovate


National Aeronautics and
Space Administration
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