National Aeronautics and
Space Administration

Space Technology Mission Directorate Update

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Space Technology Mission Directorate

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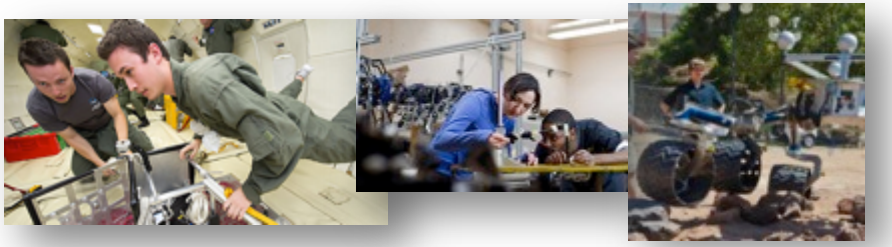
www.nasa.gov/spacetech

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.

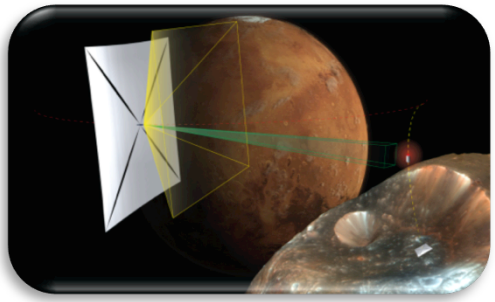
Who:

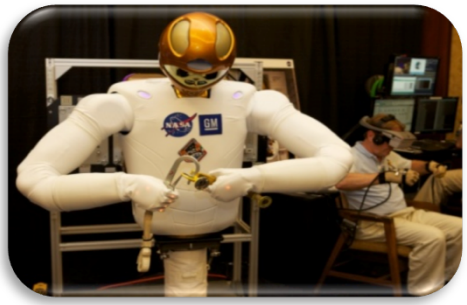
The NASA Workforce
Academia
Industry & Small Businesses
Other Government Agencies
The Broader Aerospace Enterprise

Guiding Principles of the Space Technology Program

Space Technology Program

- **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





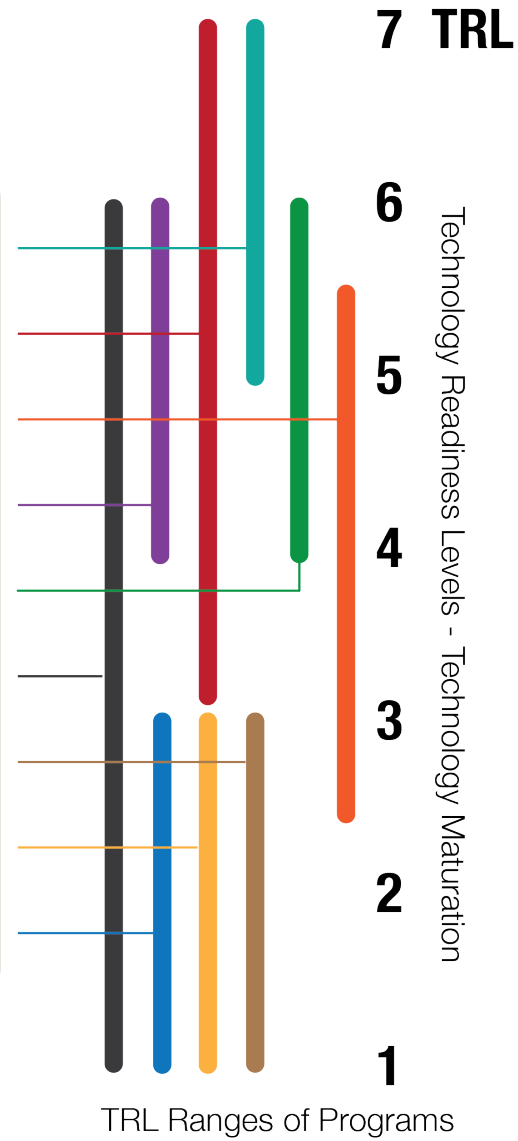
Space Technology Portfolio

Transformative & Crosscutting Technology Breakthroughs

Creating New Markets & Growing the Innovation Economy

Pioneering Concepts & Developing the Innovation Community

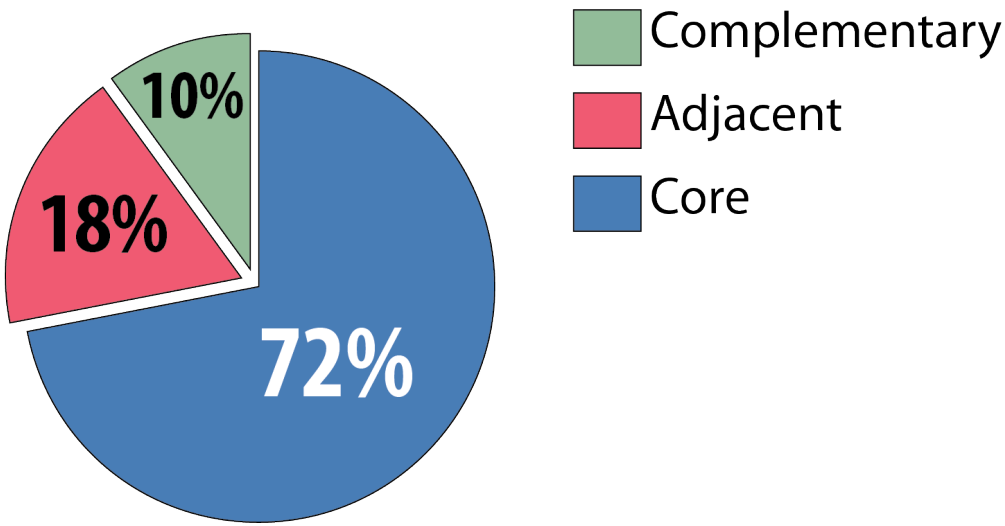
- Technology Demonstration Missions — **TDM**
- Small Spacecraft Technology — **SST**
- Game Changing Development — **GCD**
- Flight Opportunities — **FO**
- Centennial Challenges — **CC**
- **SBIR/STTR**
- Center Innovation Fund — **CIF**
- NASA Innovative Advanced Concepts — **NIAC**
- Space Technology Research Grants — **STRG**



Strategic Investments in Technology

Evaluating current STMD investments as recommended by the Strategic Space Technology Investment Plan (SSTIP, NRC, other Stakeholders)

- Initial evaluation is consistent with the SSTIP Core, Adjacent, and Complementary recommendations
- Approximately 72% of investments are in Core areas
- STMD has investments in all 14 Technology Areas
- Approximately 10% of investments are low TRL (1-3) consistent with the recommendation by the National Research Council (NRC) Final Report on Space Technology Roadmaps and Priorities



STMD investments are consistent with the Strategic Space Technology Investment Plan (SSTIP)

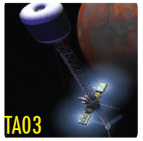
Space Technology Roadmap TAs

TA01 

Launch propulsion systems

TA02 

In-space propulsion technologies

TA03 

Space power & energy storage

TA04 

Robotics, telerobotics, & autonomous systems

TA05 

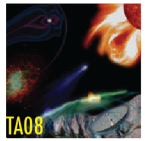
Communication & navigation

TA06 

Human health, life support, & habitation systems

TA07 

Human exploraiton destination systems

TA08 

Science instruments, observatories & sensor systems

TA09 

Entry, descent & landing systems

TA10 

Nanotechnology

TA11 

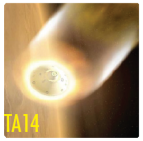
Modeling, simulation, infotech & processing

TA12 

Materials, structures, mechanical systems & manufacturing

TA13 

Ground & launch systems processing

TA14 

Thermal management systems

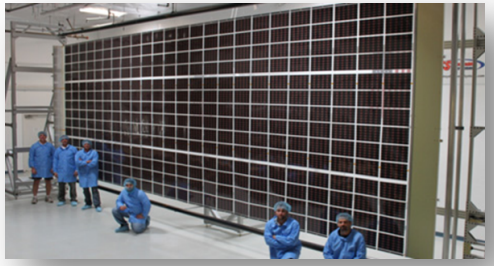
Space Tech Role in Agency Asteroid Strategy

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

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

- Advanced **Solar Array Systems (SAS)**
- Advanced magnetic shielded **Hall thrusters**
- **Power processing units** (PPUs)
- 30kW – 50 kW advanced **solar arrays**
- Magnetically shielded Hall thrusters & Power Processing
- Xenon **propellant tanks**

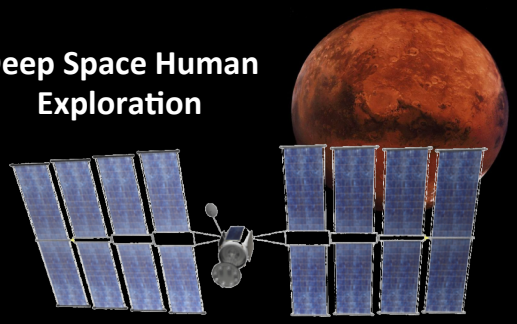


Additional Asteroid Retrieval funding in FY2014 will cover:

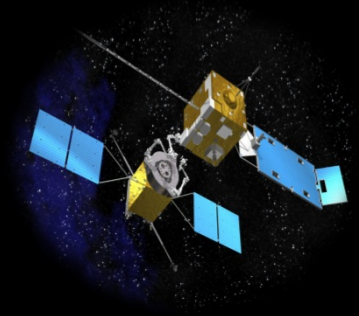
- Flight hardware solar array procurements
- Hall thruster engineering development units
- Design of Xenon propellant tanks

High-powered SEP Enables Multiple Applications

Deep Space Human Exploration

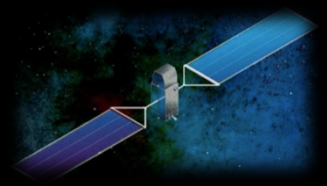


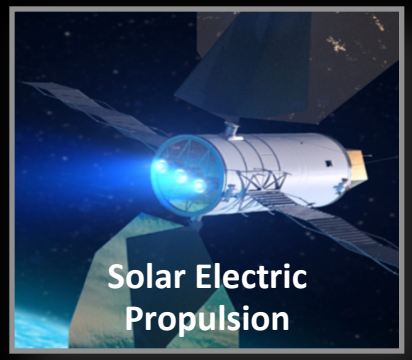
Satellite Servicing



Payload Delivery

Commercial Space Applications



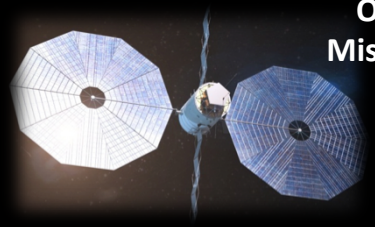


ISS Utilization

Orbital Debris Removal

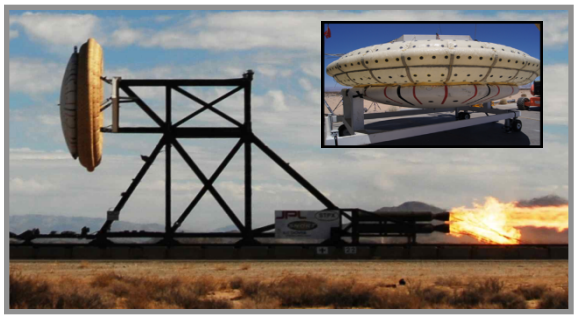
Space Science Missions

OGA Missions



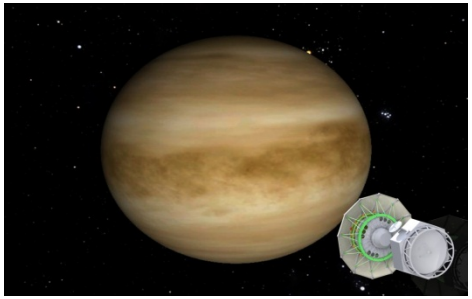
STMD Support for SMD – Planetary

- **Planetary Science (currently funded)**
  - **Woven TPS:** suitable for Venus, Giant Planets entries; Earth Sample Return capsules
  - **Conformal TPS:** suitable for MSL-2020 backshell
  - **ADEPT:** deployable aeroshell for Venus entry with lower g-loads
  - **LDSD:** suitable for high Mach number parachute for Mars entry
  - **Deep Space Optical Comm:** 1-2 orders of magnitude higher data rate; thus enabling full data return from planetary surface mapping missions
  - **Deep Space Atomic Clock:** low mass, low power, affordable solution for Discovery and New Frontiers class planetary missions

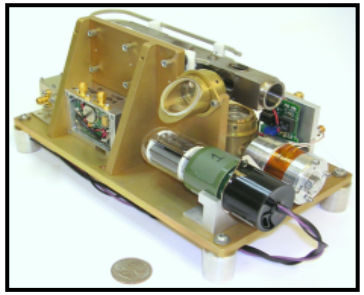


Low Density Supersonic Decelerator Sled Test

Woven TPS



ADEPT Venus Approach

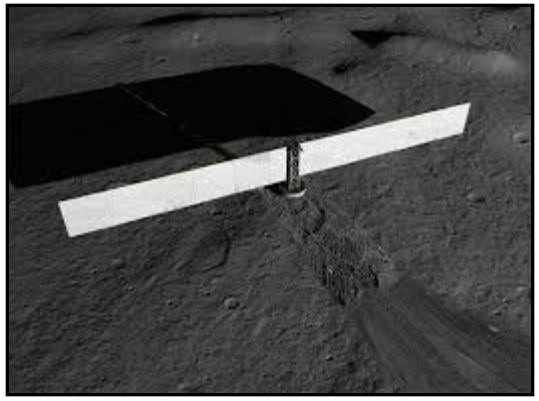


Deep Space Atomic Clock

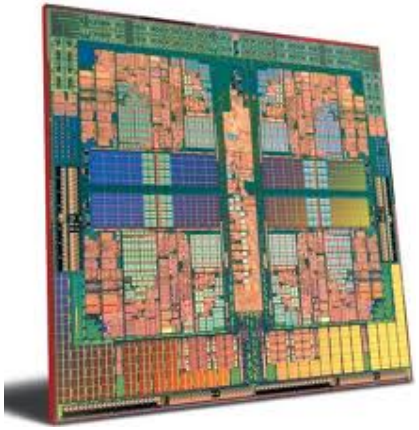
STMD Support for SMD – Planetary

- **Planetary Science (funded *or under consideration*)**
  - **Multi-core processor:** 100x increase for on-board data processing and autonomy (BAA)
  - **High performance battery:** for planetary surface operations
  - ***Kilowatt Power:*** *Small fission surface reactor for planetary missions*
  - ***Amorphous Metals:*** *for lubrication free gears on MSL-2020*
  - ***Variable Heat Rejection:*** *for interplanetary spacecraft and lander thermal management*

Amorphous Metals



Surface Reactor

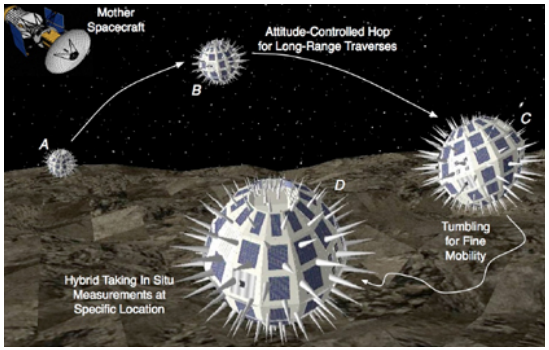


Multi-core processor

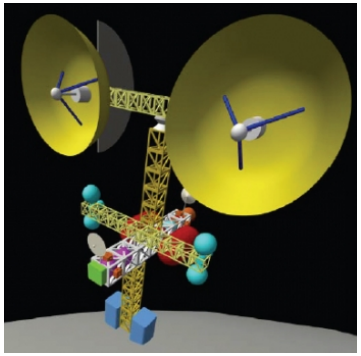
High Performance Space Battery

STMD Support for SMD – Planetary

- **Planetary Science (currently funded)**
  - **Spacecraft/Rover Hybrids for the Exploration of Small Solar System Bodies (NIAC):** develop a mission architecture that allows a systematic and affordable in situ exploration of small bodies, using hopping, rolling, and ballistic flight
  - **Robotic Asteroid Prospector (RAP) Staged from L-1: Start of the Deep Space Economy (NIAC):** to assess feasibility of asteroid mining in terms of means, methods, and systems
  - **Technologies Enabling Exploration of Skylights, Lava Tubes and Caves; Cavehopping Exploration of Planetary Skylights and Tunnels (NIAC)**
  - **Modern Estimation Techniques and Optimal Maneuver Targeting for Autonomous Optical Navigation around Small Bodies (STRG):** advance algorithms for estimation techniques, maneuver feedback control, and fast onboard processing



S/C-Rover Hybrids



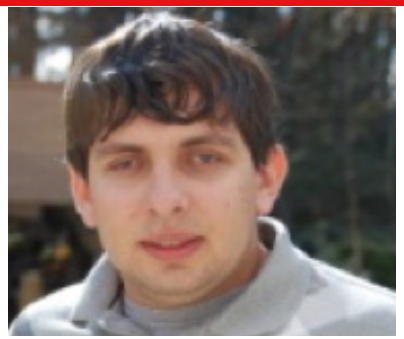
RAP Spacecraft

Skylight on the Moon

STRG: Corwin Olson
The U of Texas at Austin

STMD Support for SMD – Planetary

- **Planetary Science (currently funded)**
  - **Rapid Design & Navigation Tools to Enable Small-Body Missions (STRG):** broaden the number and scope of available missions by making the most of advances in astrodynamics and in computer software and hardware.
  - **Proximity Navigation Near & Mapping of Asteroids (STRG):** using sensor algorithms for range sensors, with synchronized Inertial Momentum Unit (IMU) and HD video camera; provides insight into asteroid geometry
  - **Stability Analysis of Spacecraft Motion in the Vicinity of Asteroids (STRG):** modeling research, accounting for movement perturbations, gravity differences; solar pressure changes; s/c and asteroid rotations; stability and other factors



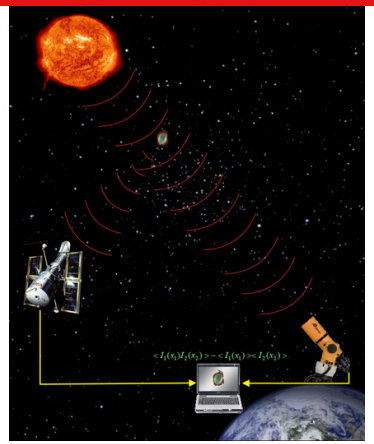
STRG: Demyan Lantukh
GeorgiaTech

STRG: Dylan Conway
Texas A&M University

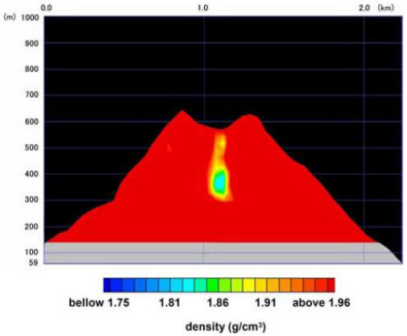
STRG: Samantha Rieger
U of Colorado, Boulder

STMD Support for SMD – Planetary

- **Planetary Science (currently funded)**
  - **Ghost Imaging of Space Objects (NIAC):** optical imaging using correlations between optical fields in two channels. One of the channels contains the object, however lacks any spatial resolution. In the other, empty channel, a space-resolving optical detection is allowed
  - **Deep Mapping of Small Solar System Bodies with Galactic Cosmic Ray Secondary Particle Showers (NIAC):** mapping interior structures using galactic cosmic ray (GCR) secondary particle shower products, such as pions and muons
  - **Vision Based Object Detection and Navigation for Spacecraft (STRG)**: using small low cost IR and vision sensors, to operate over a wide distance range from a few meters to several km; COTS sensors combined with a robust algorithm



Ghost imaging

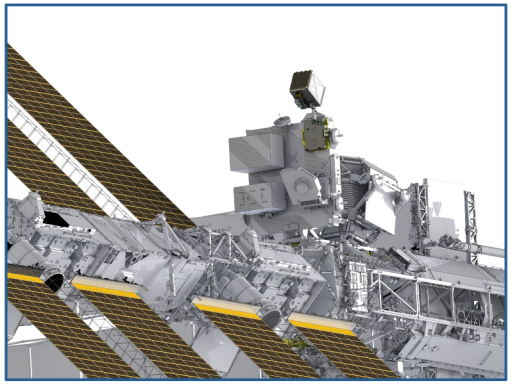


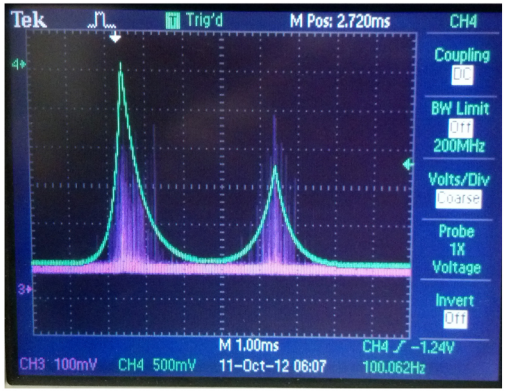
Muon radiographic map

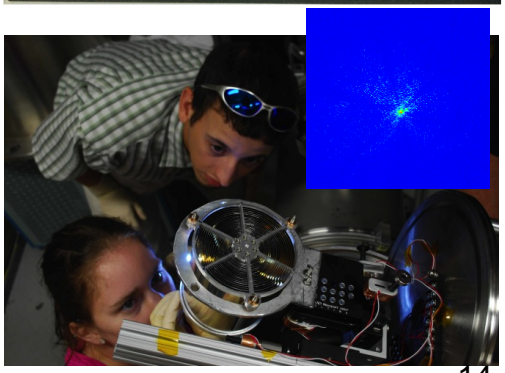
STRG: Christopher McBryde
U of Texas at Austin

STMD support for SMD – Astrophysics

- **NICER/SEXTANT – explorer class ISS demo (2017)**
  Joint Science and Technology Demo Mission on ISS
  - **NICER: X-ray optical telescope demonstration**
    Neutron star Interior Composition ExploreR (NICER), would observe (in the X-ray band) the thermal, magnetic, and rotational traits of neutron stars
  - **SEXTANT: X-ray navigation (XNAV) demonstration**
    Station Experiment for X-ray Timing and Navigation Technology (SEXTANT) mission, would detect X-ray photons from known steady pulsars to demonstrate spacecraft navigation using these naturally-occurring cosmic beacons
- **STMD-SMD collaboration**
  - NICER by SMD / SEXTANT by STMD
  - Shared hardware, ConOps, Data archive, Ops Center; ISS Platform, and target pulsars







STMD support for SMD – Astrophysics

Coronagraph for Direct Imaging of Exoplanets
Potential Joint SMD & STMD Initiative:
Develop a coronagraph for AFTA-WFIRST mission

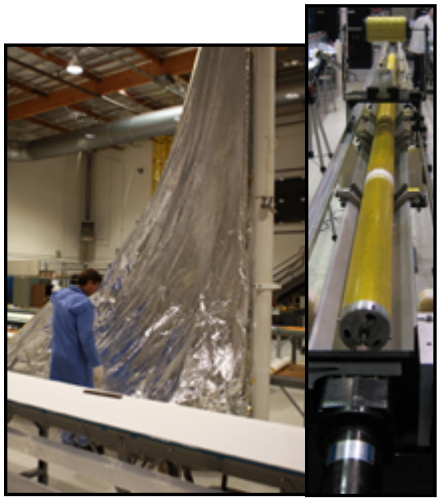
- **SoA Space based observatories:**
  - NASA's Kepler (2009) (Photometry);
  - NASA Hubble & Spitzer (Transit technique);
  - TESS (2017 launch planned)(transit spectroscopy)

1000+ exoplanets discovered to date; Milky Way has 50B+ potentially habitable rocky-planets.

- **Goal:** Develop an advanced high contrast coronagraph + occulter for AFTA-WFIRST
  - Observe fainter planets using advanced direct imaging (10x Earth mass or better)
  - High contrast, high sensitivity, & high optical throughput
  - Small inner working angle (close to star), large discovery space
  - AFTA-WFIRST concept: using a donated 2.4-m telescope;
    - First opportunity for an in-space high contrast coronagraph.
    - Pathfinder mission for future telescopes to characterize Earth-like planets.

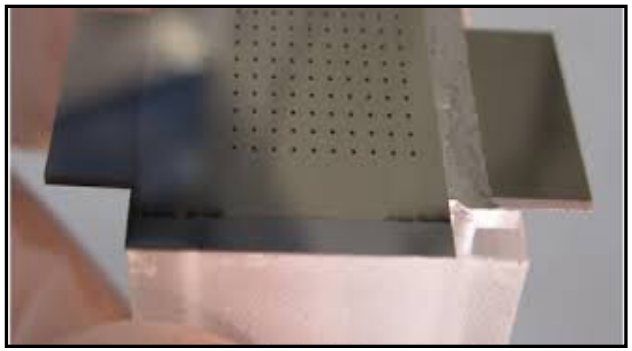
STMD Support for SMD-Heliophysics & Earth Sciences

- **Heliophysics**
  - **Space Weather prediction**
    - Ongoing GCD/AES collaboration for HEO infusion, but benefiting heliophysics as well
  - **Solar Sail**
    - To keep spacecraft at Sun / Earth Lagrangian (L1) point for space weather monitoring (ongoing)



Solar Sail and Boom Fab

- **Earth Sciences**
  - **Deployable space telescope on a 6U cube-sat** (TBC)
  - **Low cost propulsion technologies for small spacecraft**
    - ongoing GCD NRA Appendix under evaluation



Propulsion Technologies

How to get involved with STMD?

- STMD Programs are **periodically releasing solicitations**
- These are **open to all** (NASA, OGAs, Academia, Industry)
- Information on STMD's future solicitations, in the form of Appendices added to the **umbrella solicitation REDDI-2014** can be found on NSPIRES:
  - Space Technology Research, Development, Demonstration, and Infusion 2014 (SpaceTech-REDDI-2014)
  - Solicitation: NNH14ZOA001N
  - http://nspires.nasaprs.com/

STDM's typical solicitation cadence

Program	Appendix	FY 2014 Targeted Release			
		Q1	Q2	Q3	Q4
NASA Innovative Advanced Concepts (NIAC)	A1 - NIAC Phase I	X			
	A2 - NIAC Phase II			X	
Space Technology Research Grants (STRG)	B1 - Early Career Faculty (ECF)	X			
	B2 - Early Stage Innovations (ESI)		X		
Game Changing Development (GCD)	C1 to C* - GCD Technology Topics	X	X	X	
Technology Demonstration Missions (TDM)	D1 - Technology Demonstration Mission Topics	TBD			
Small Spacecraft Technology (SST)	E1 - SST Development and Demonstration	No anticipated release			
	E2 - SST Partnerships	No anticipated release			
Flight Opportunities Program (FOP)	Appendix F1 - FOP Technology Topic	X			

SpaceTech-REDDI-2014 (NNH14ZOA001N): http://nspires.nasaprs.com/

Summary

- STMD's technologies span across the **TRL spectrum**
- Our development **partners** include NASA, OGAs, academia, industry and the broad aerospace sector
- STMD developed technologies - both competed and directed - tend to be **crosscutting and overlap with other MD nee**ds
- We are looking for **feedback from you - the SBAG community**
  - to identify your future technology needs

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