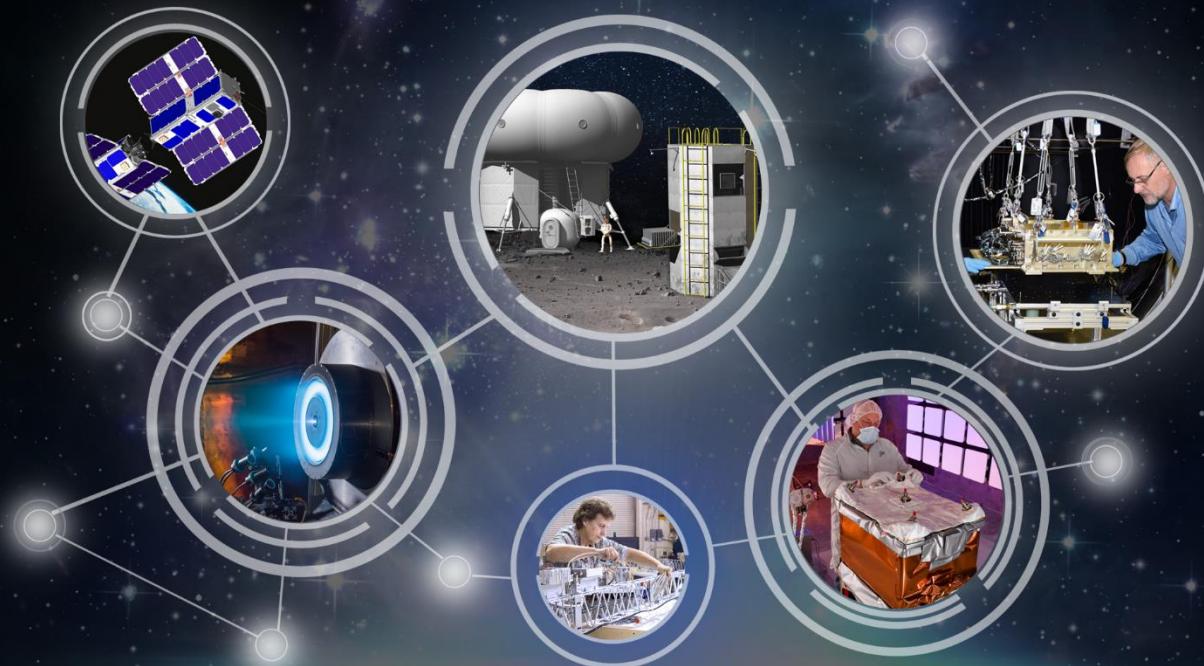




# EXPLORE SPACE TECH



## NASA Space Technology Mission Directorate Research Needs and Directions

Mr. James Reuter, Associate Administrator (Acting) for NASA STMD | March 2019

## Early Stage Innovation

- NASA Innovative Advanced Concepts
- Space Tech Research Grants
- Center Innovation Fund/Early Career Initiative

## SBIR/STTR



## Partnerships & Technology Transfer

- Technology Transfer
- Prizes and Challenges
- iTech

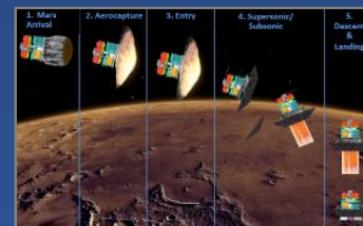
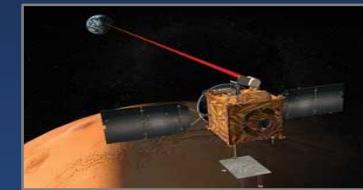
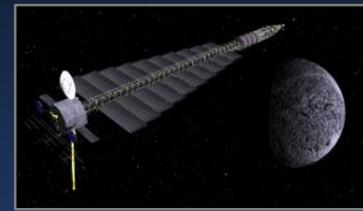
## Technology Demonstrations

- Technology Demonstration Missions
- Small Spacecraft Technology
- Flight Opportunities

# TECHNOLOGY PIPELINE

# Key Technology Focus Areas

- ❖ Advanced environmental control and life support systems and In-Situ Resource Utilization
- ❖ Power and propulsion technologies
- ❖ Advanced communications, navigation and avionics
- ❖ In-space manufacturing and on-orbit assembly
- ❖ Advanced materials
- ❖ Entry, Descent and Landing
- ❖ Autonomous operations



# Priority Technologies for Flight Demonstration

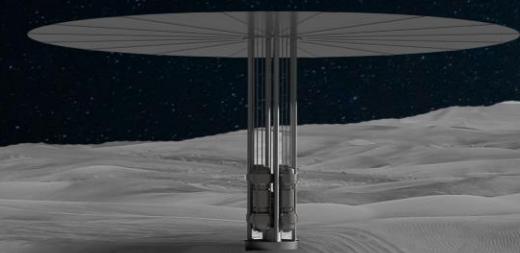
High Performance  
Spaceflight Computing



Solar Electric  
Propulsion



Precision  
Landing

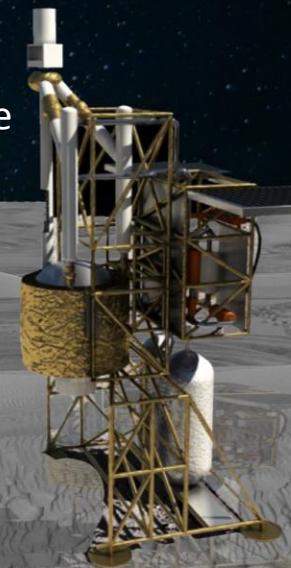


Kilopower



Cryofluid  
Management

In Situ Resource  
Utilization



# Lunar Surface Innovation Initiative

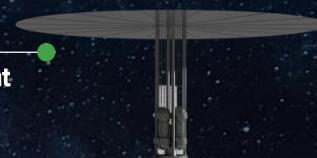
## In Situ Resource Utilization

Collection, processing, storing and use of material found or manufactured on other astronomical objects



## Sustainable Power

Enable continuous power throughout lunar day and night



## Extreme Access

Access, navigate, and explore surface/subsurface areas



## Extreme Environments

Enable systems to operate throughout the full range of lunar surface conditions



## Surface Excavation/Construction

Enable affordable, autonomous manufacturing or construction



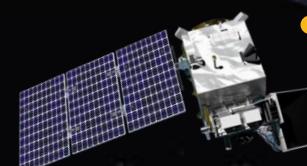
## Lunar Dust Mitigation

Mitigate lunar dust hazards



## Space Weather Modeling

Mitigation of space weather hazards



# Commercial Suborbital Flight Update

**167 Flights facilitated by Flight Opportunities through the end of FY2018**

## **Recent suborbital flights with Flight Opportunities in FY2019**

- First and second Virgin Galactic SpaceShipTwo flights to space (12/13/18 & 2/22/19) each carried 4 payloads for NASA
- First dedicated Blue Origin New Shepard flight for NASA carried 8 payloads (1/23/19)
- First NASA flights with BlackSky Aerostar (high altitude balloon) and EXOS SARGE (suborbital rocket)
- Two high altitude balloon flights with NSC and four aircraft flights with Zero-G for reduced gravity

**152 Technologies tested to date.** 53 in queue for additional or initial testing. 10 to 20 new selections anticipated in FY2019.

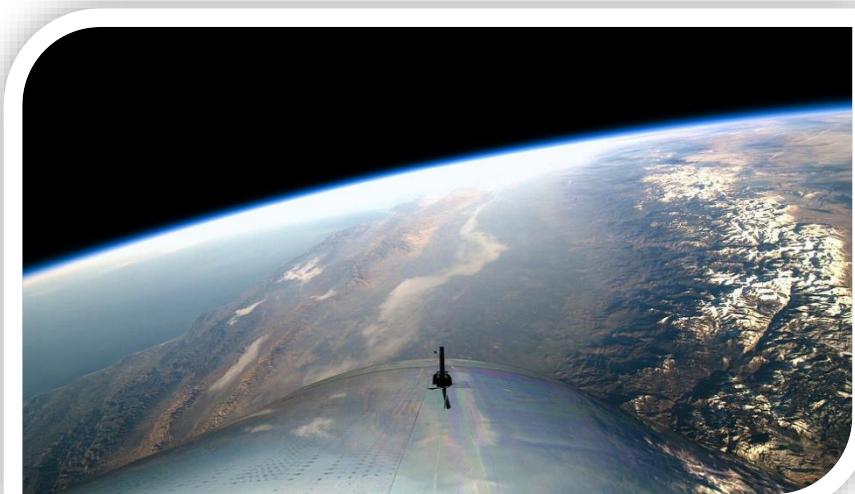
## **Commercial Flight Providers:**



**Masten**



**RAVEN**



# Exploration Technology in Cryogenic Fluid Management



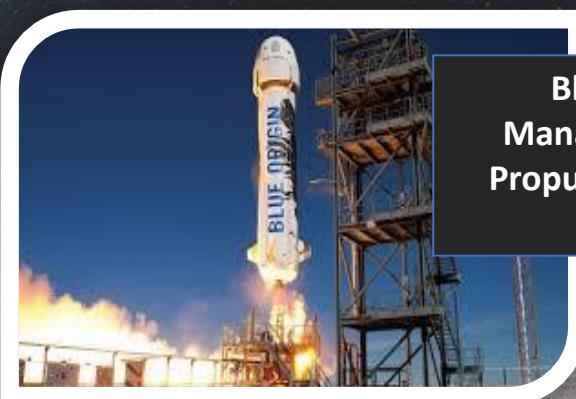
The Robotic Refueling Mission 3(RRM3) will demonstrate cryogenic fluid transfer and storage technologies



The Evolvable Cryogenics (eCryo) project



Flight Demo  
Gateway & Lunar  
Precursor CFM  
Formulation



Blue Origin: "Cryogenic Fluid Management-Enhanced Integrated Propulsion Testing for Robust Lander Services"



Cryocooler  
Development enabling  
zero boil-off

Paragon Space Development Corp.: Cryogenic Encapsulating Launch Shroud and Insulated Upper Stage (CELSIUS)



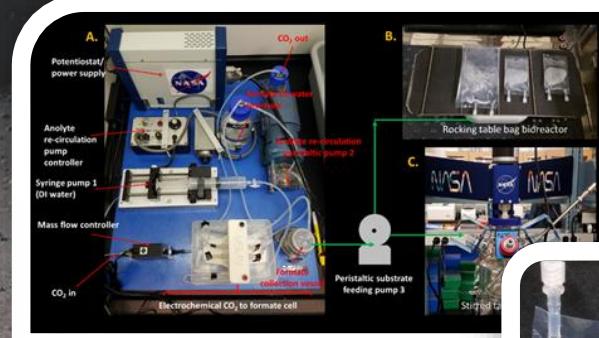
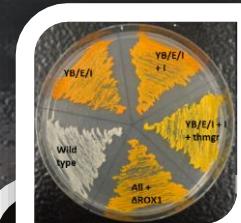
# Exploration Technology in Bio Manufacturing



NASA Centennial  
Challenges Program  
Vascular Tissue And CO<sub>2</sub>  
Conversion Challenges



Space Technology Research  
Institute: The Center for the  
Utilization of Biological  
Engineering in Space  
(CUBES)

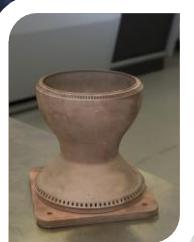


CO<sub>2</sub>-Based  
Biomanufacturing

Biosensors for Radiation Exposure

In-Space Targeted Nutrient Production

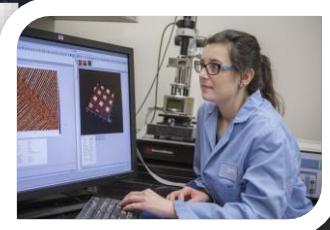
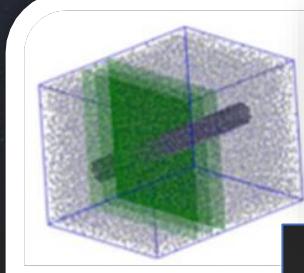
# Exploration Technology in Advanced Materials



The Rapid Analysis and Manufacturing Propulsion Technology (RAMPT)

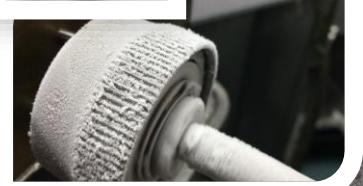


Centennial Challenges Program 3D Printed Habitat



Improvement of manufacturing high-strength Carbon Nanotube Technology: >2x strength and lower costs

Space Technology Research Institute (STRI): Ultra-Strong Composites by Computational Design (US-COMP)



Bulk Metallic Glass Gears (BMG)



Deployable Composite Boom (DCB)

# Exploration Technology for On-orbit Servicing, Assembly, and Manufacturing (OSAM)

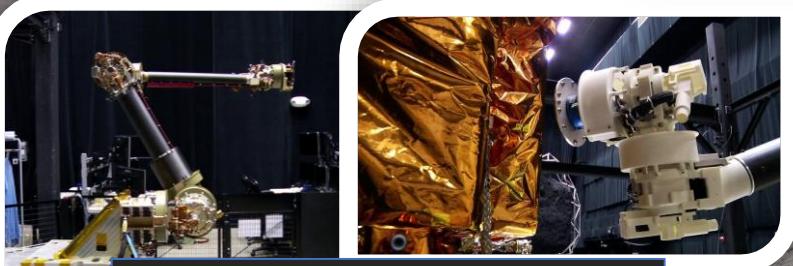
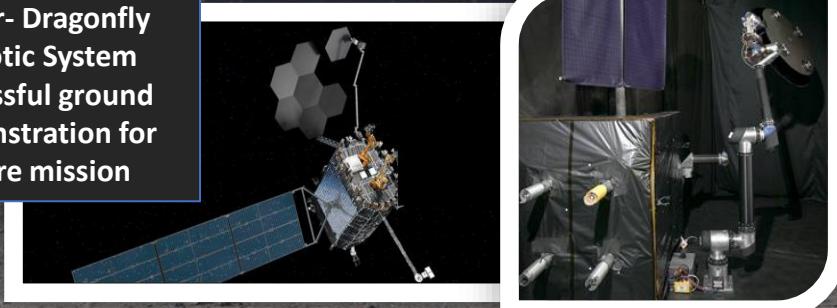


Made In Space validated additive manufacturing and robotic assembly with a future mission –Archinaut One

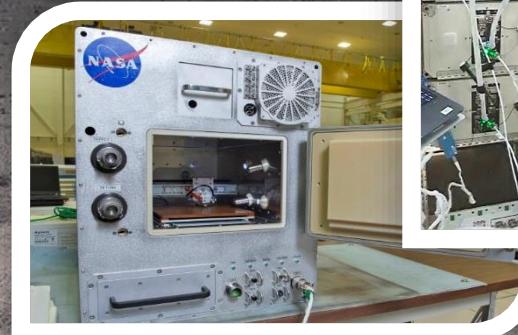


FabLab- Development of a first-generation, in-space, multi-material fabrication laboratory for space missions

Maxar- Dragonfly Robotic System successful ground demonstration for future mission



Robotics Satellite Servicing - Restore-L approaching CDR



Refabricator is the first integrated 3D printer and recycler in space and currently aboard ISS

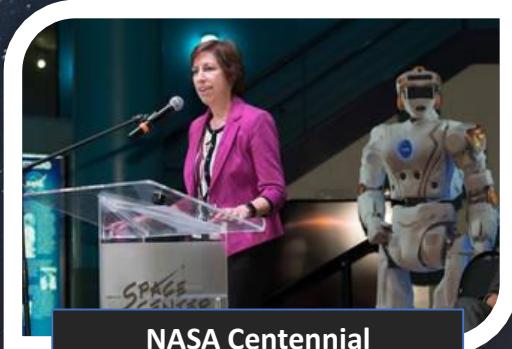
# Exploration Technology in Autonomous Systems



Astrobee- A self-flying robot



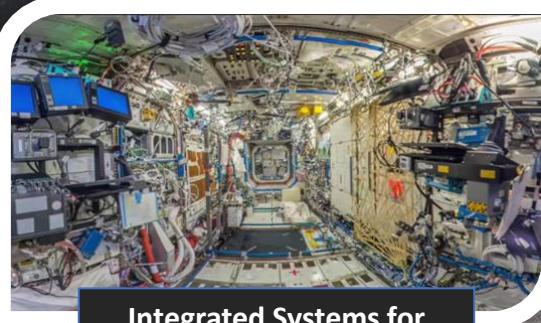
Autonomous Medical Operations (AMO)



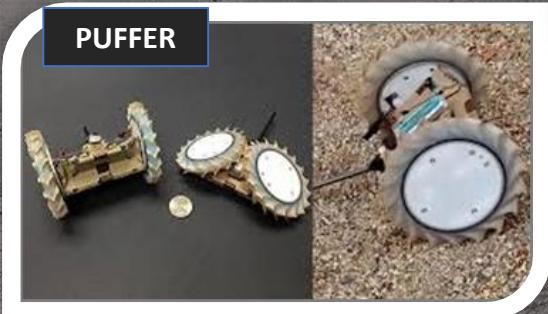
NASA Centennial Challenges Program Space Robotics Challenge Phase III



Distributed Spacecraft Autonomy (DSA)



Integrated Systems for Autonomous Adaptive Caretaking (ISAAC)



PUFFER



Space Technology Research Institutes (STRI): Smart Deep Space Habitats (SmartHabs) for resilient and autonomous operation.

# STMD By The Numbers (FY 2018)





# EXPLORE SPACE TECH

TECHNOLOGY DRIVES EXPLORATION

