



# EXPLORESPACE TECH



## NASA Space Technology Mission Directorate Research Needs and Directions

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

## SBIR/STTR

### Early Stage Innovation

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



## Partnerships & Technology Transfer

- Technology Transfer
- Prizes and Challenges
- iTech

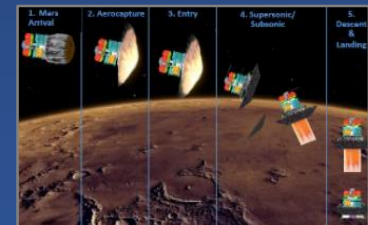
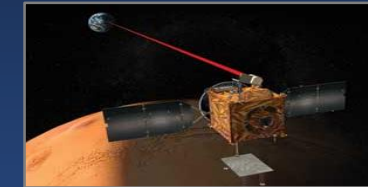
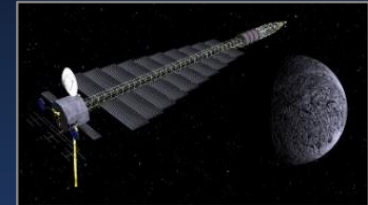
## Technology Demonstrations

- Technology Demonstration Missions
- Small Spacecraft Technology
- Flight Opportunities

# TECHNOLOGY PIPELINE

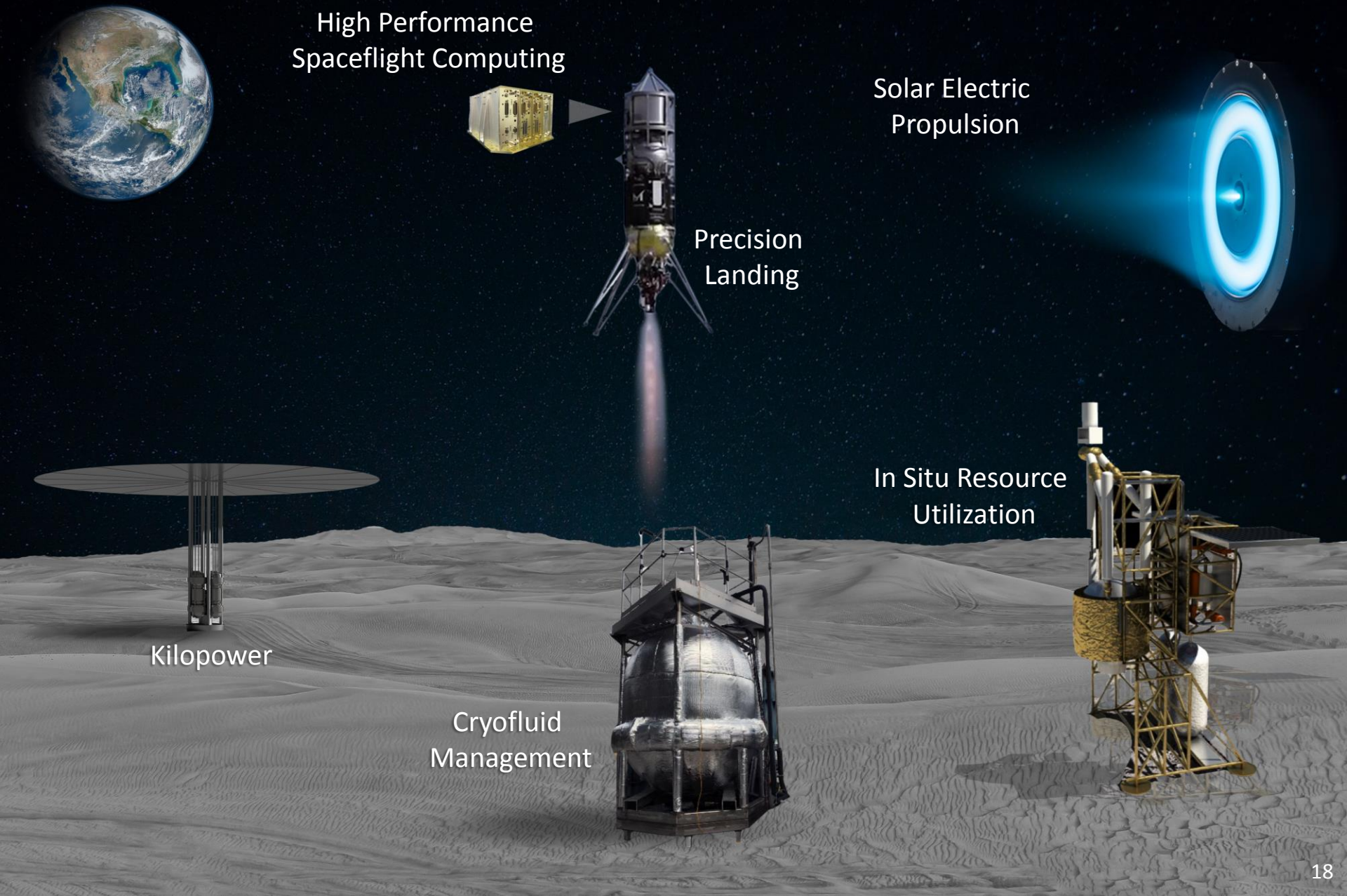
# Key Technology Focus Areas

- ❖ 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

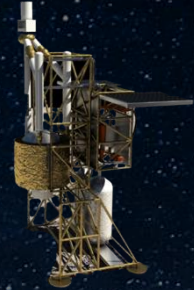




# Lunar Surface Innovation Initiative

## In Situ Resource Utilization

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



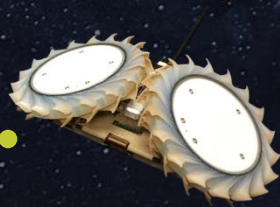
## Sustainable Power

Enable continuous power throughout lunar day and night



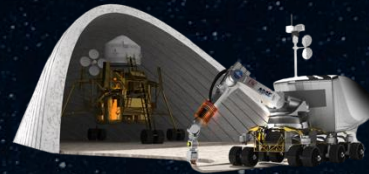
## Extreme Access

Access, navigate, and explore surface/subsurface areas



## Extreme Environments

Enable systems to operate through out the full range of lunar surface conditions

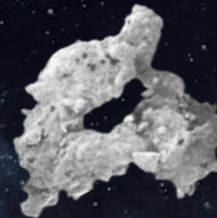


## Surface Excavation/Construction

Enable affordable, autonomous manufacturing or construction

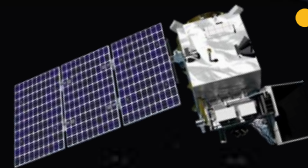
## Lunar Dust Mitigation

Mitigate lunar dust hazards



## Space Weather Modeling

Mitigation of space weather hazards



# Commercial Suborbital Flight Update

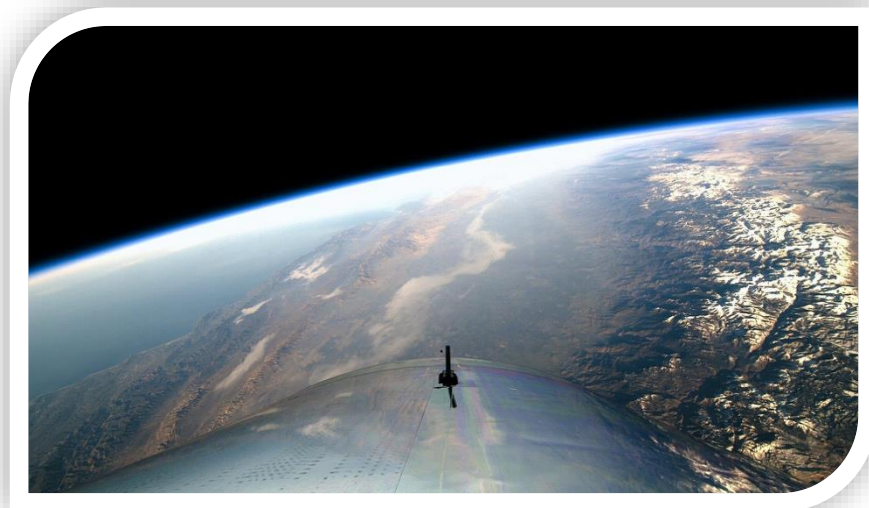
**167 Flights facilitated by Flight Opportunities through the end of FY2018**

## **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:**





# 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

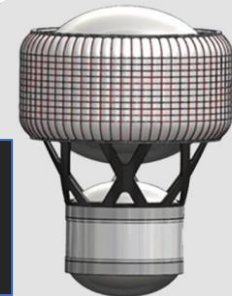


Blue Origin: "Cryogenic Fluid Management-Enhanced Integrated Propulsion Testing for Robust Lander Services"



Cryocooler Development enabling zero boil-off

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



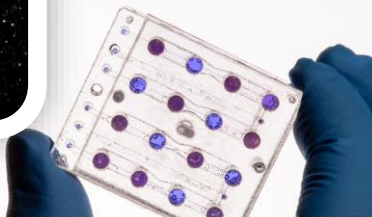
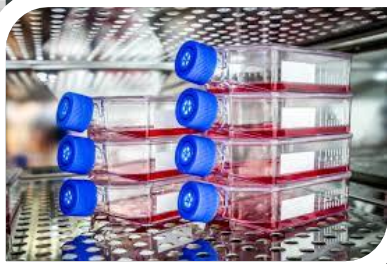


# Exploration Technology in Bio Manufacturing

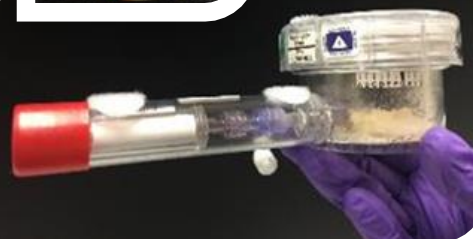
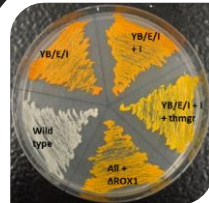
**NASA Centennial Challenges Program  
Vascular Tissue And CO2  
Conversion Challenges**



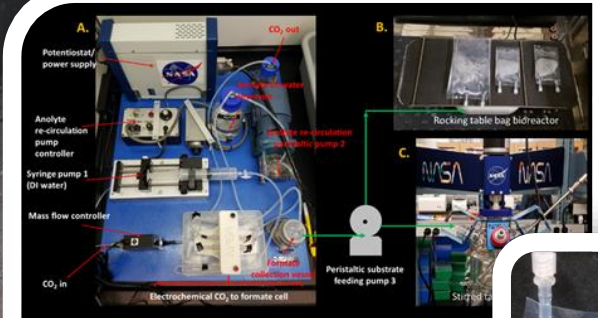
**Space Technology Research  
Institute: The Center for the  
Utilization of Biological  
Engineering in Space  
(CUBES)**



**Biosensors for Radiation Exposure**



**In-Space Targeted Nutrient Production**

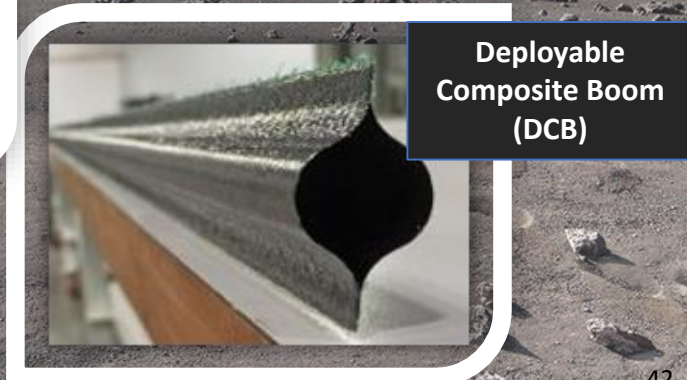
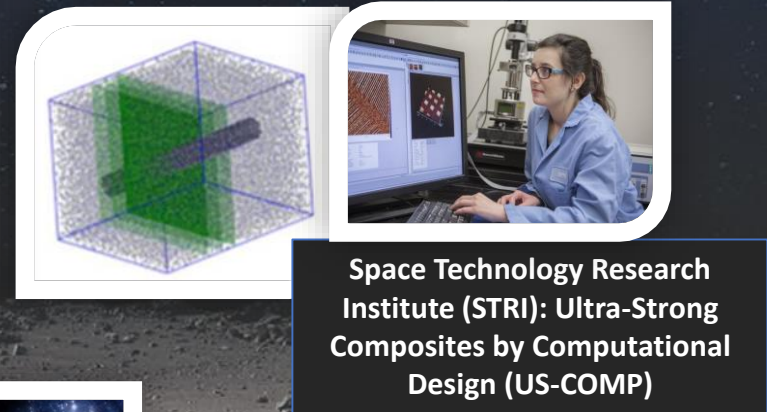
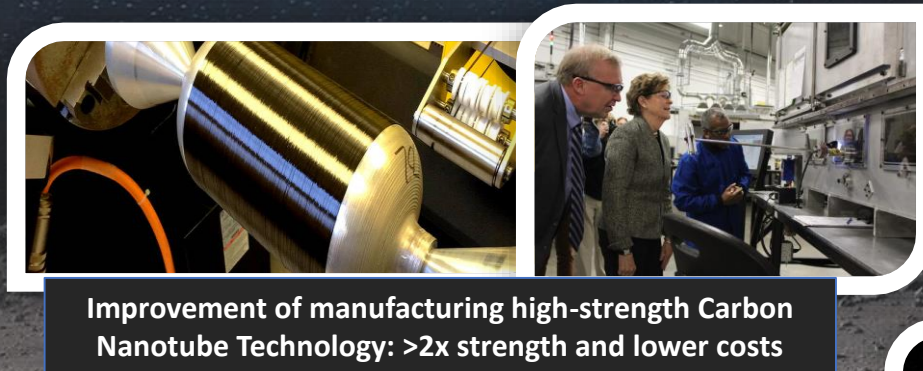


**CO2-Based  
Biomanufacturing**





# Exploration Technology in Advanced Materials





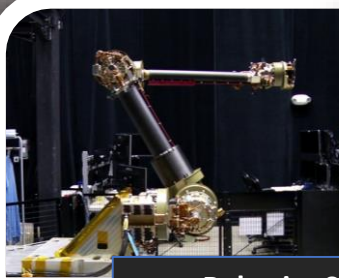
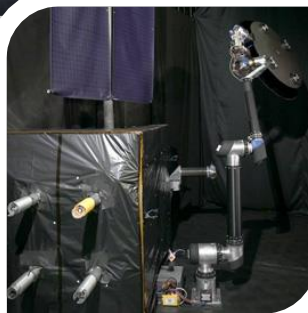
# Exploration Technology for On-orbit Servicing, Assembly, and Manufacturing (OSAM)



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



Maxar- Dragonfly Robotic System successful ground demonstration for future mission



Robotics Satellite Servicing - Restore-L approaching CDR



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



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**



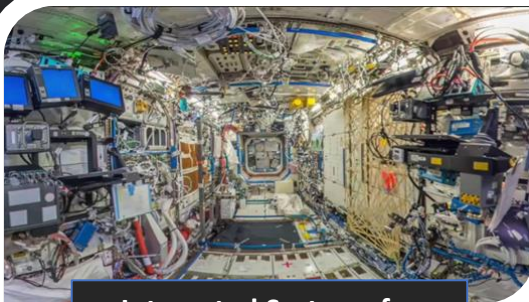
**Autonomous Medical Operations (AMO)**



**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)







# EXPLORESPACE TECH

*TECHNOLOGY DRIVES EXPLORATION*

