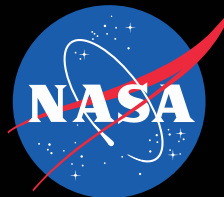




# NASA's Small Spacecraft Systems Virtual Institute and Small Spacecraft Enterprise



69<sup>th</sup> International Astronautical Congress

Bremen, Germany

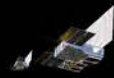
October 5, 2018

NASA Space Technology Mission Directorate and  
NASA Science Mission Directorate

Bruce D. Yost

*S3VI Director*

[www.nasa.gov/smallsat-institute](http://www.nasa.gov/smallsat-institute)



# S3VI Charter

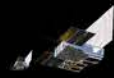
- Advance clear communications, coordination, and consistent guidance regarding small spacecraft activities across NASA.
- Provide the US smallsat research community with access to mission enabling information.
- Maintain engagement with small spacecraft stakeholders in industry and academia. Support the overall small spacecraft community.

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S3VI is a NASA-wide institute managed at NASA Ames Research Center, with participation from LaRC, GSFC, JPL, MSFC, and GRC.

S3VI is jointly sponsored by NASA's Space Technology Mission Directorate (STMD) and the Science Mission Directorate (SMD).

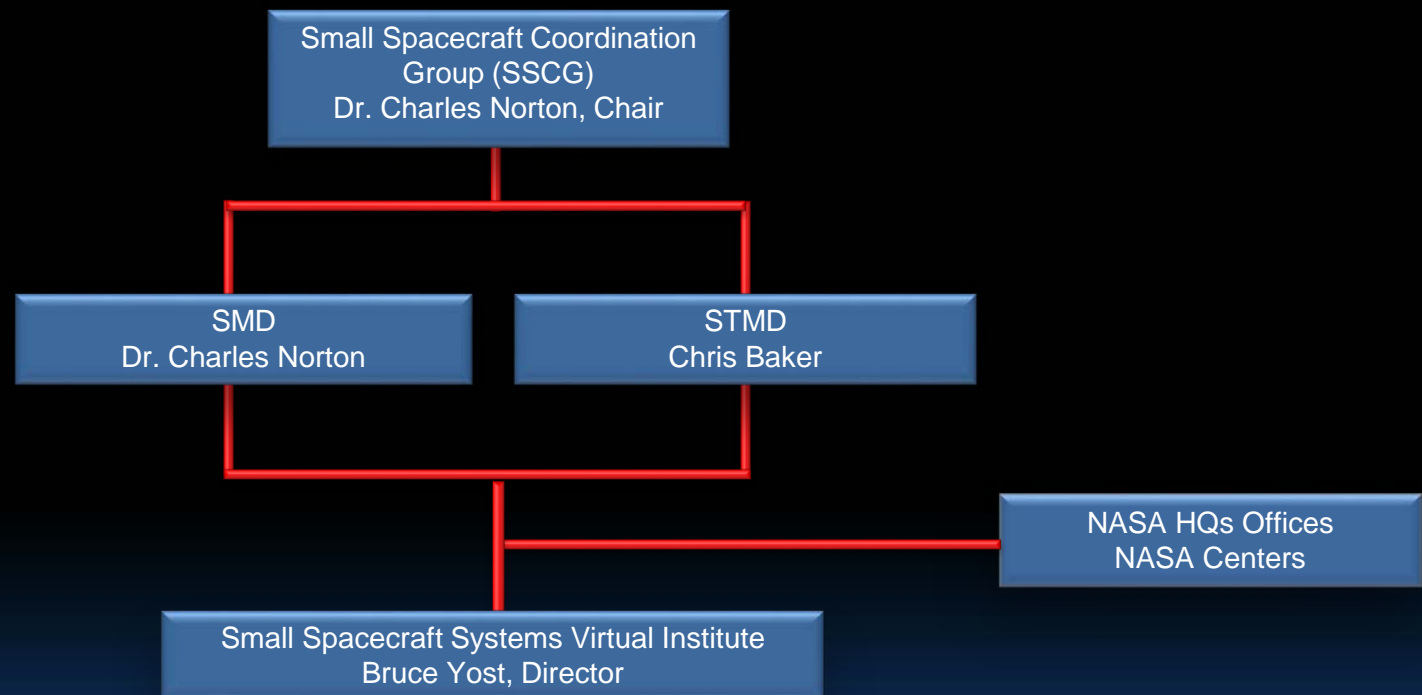
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# S3VI Management and Governance

NASA Small Spacecraft Technology Program Executive: **Christopher Baker, NASA HQ**

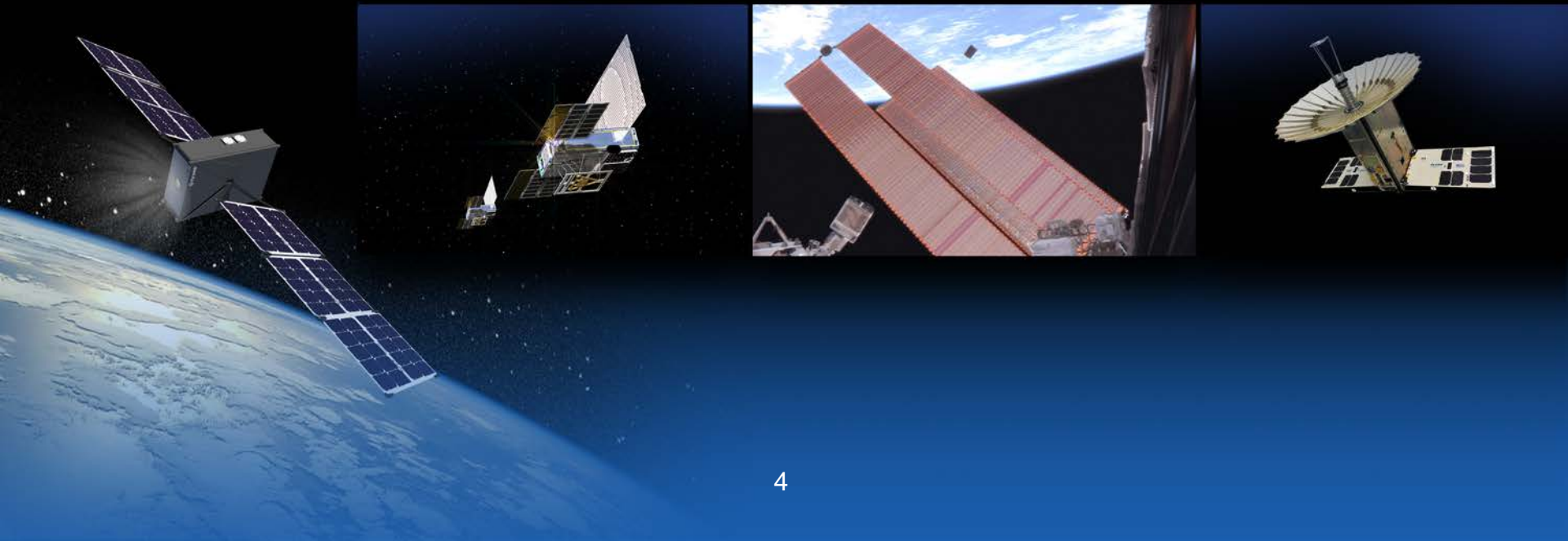
NASA Science Mission Directorate Assistant Deputy Associate Administrator  
for Small Spacecraft Programs: **Charles Norton, NASA HQ**





# S3VI Focused Tasks

- S3VI Web Portal ([www.nasa.gov/smallsat-institute](http://www.nasa.gov/smallsat-institute))
- Small Spacecraft Technology State of the Art Report
- Small Spacecraft Community of Practice
- Small Spacecraft Coordination Group (SSCG)





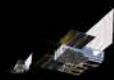
# Web Portal Implementation

- Small Spacecraft Body of Knowledge
- Working Groups
  - Small Satellite Reliability Initiative
  - Access to Space (in work)
  - Debris Mitigation (proposed)
- Federated Parts Databases
  - Smallsat Parts on Orbit Now (SPOON)
  - NASA Electronic Parts Packaging (NEPP)
  - TechPort
- Common / Federated Search Capability



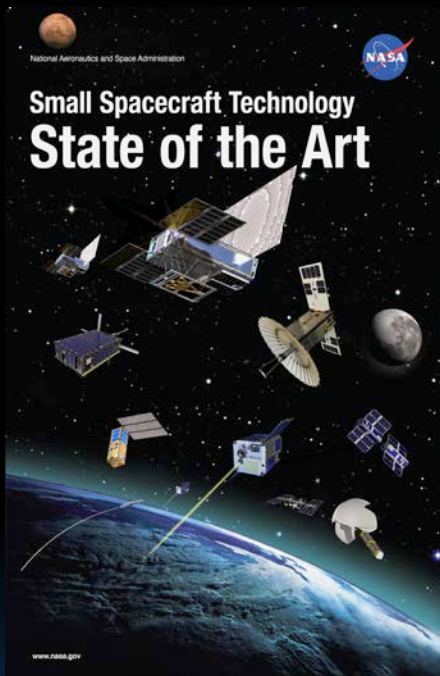
[www.nasa.gov/smallsat-institute](http://www.nasa.gov/smallsat-institute)





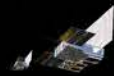
# Small Spacecraft Technology State of the Art

Select 2015 state of the art technologies targeted for deep space small spacecraft



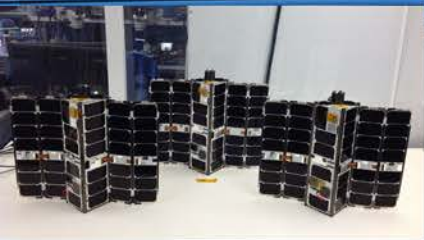
| Subsystem                   | Technology             | Product              | FOM*                         | TRL*                      | Comments   |
|-----------------------------|------------------------|----------------------|------------------------------|---------------------------|--|
| Comms                       | Deep Space Transponder | IRIS V2              | X Band<br>62.5 – 256k BPSK   | 6                         | No other radios compatible with DSN have been successfully researched.   |
| Electric Propulsion Systems | Ion Engine             | BIT-3 & RIT- $\mu$ X | 1 – 10 mN<br>1000 – 3500 s   | Xenon TRL 8, Iodine TRL 4 | Provides high Isp and thrust, good for interplanetary transfer; BIT-3 has 3km/s dV capability for a 6/12U to reach lunar orbit from GTO/GEO.                                   |
|                             | Hall Effect Thruster   | BHT-200              | 10 – 50 mN<br>1000 – 2000 s  | Xenon TRL 8, Iodine TRL 4 | Provide high Isp and thrust, good for interplanetary transfer; Iodine propellant is attractive due to its high density, providing high dV maneuvers for transfer trajectories. |
|                             | Resistojets            |                      | 5 mN – 0.5 mN<br>70 – 1140 s | Xenon TRL 8, Iodine TRL 4 | Resistojets and pulsed plasma thrusters provide small thrust good for orbit corrections, or attitude control   |
| GNC                         | Reaction Wheels        | BCT RWA              | Up to 1Nm-s momentum storage | 9                         | BCT Zero momentum RWA = 100mNm-s and 15mNm-s (x3) BCT wheels to be used on NEA Scout.  |

Current Small Spacecraft Technology State of the Art Report is available at <https://sst-soa.arc.nasa.gov>



# Small Spacecraft Community of Practice and Coordination Group

- Community of Practice Virtual Seminar Series
- CubeSat 101 Complementary Video Series
- Investigator Lessons Learned
- Swarms for Science and Exploration Workshops (under consideration)
- High Volume Manufacturing of Small Spacecraft Workshop (under consideration)









# NASA Small Spacecraft Investments

## Science Mission Directorate (SMD)

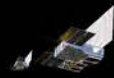
- **ESTO InVEST**
- **Planetary Deep Space Smallsat Studies (PSDS3)**
- **PICASSO/MatISSE**
- **Astrophysics Smallsats**
- **SMEX, SALMON, MOO**
- **Undergraduate Student Instrument Project (USIP)**

## Human Exploration Mission Directorate (HEOMD)

- **Cubesat Launch Initiative**
- **EM-1 Deep Space missions**

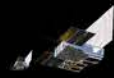
## Space Technology Mission Directorate (STMD)

- **Small Spacecraft Technology Program (SSTP)**
  - **Flight Capability Demonstration Projects**
  - **Smallsat Technologies Partnerships**
  - **Technology development**
- **Small Business Innovative Research (SBIR)**
- **Tipping Point and Public/Private Partnerships**
- **Centennial Challenges Program**
  - **CubeQuest Challenge**



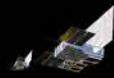
# Utility of Small Spacecraft for Cis-Lunar and Deep Space Applications

- Scout Terrain
- Characterize the Environment
- Identify Risks
- Prospect for Resources
- Provide Cost Effective Communications,  
Monitoring, and Inspection Infrastructure



# Critical Technology Gaps for NASA Small Spacecraft Missions

- Advanced / High  $\Delta V$  Propulsion for Deep Space Small Spacecraft
- Affordable Radiation Tolerance for Small Spacecraft Missions
- Deep Space Navigation and Attitude Determination for Small Spacecraft
- Affordable Distributed Spacecraft Missions



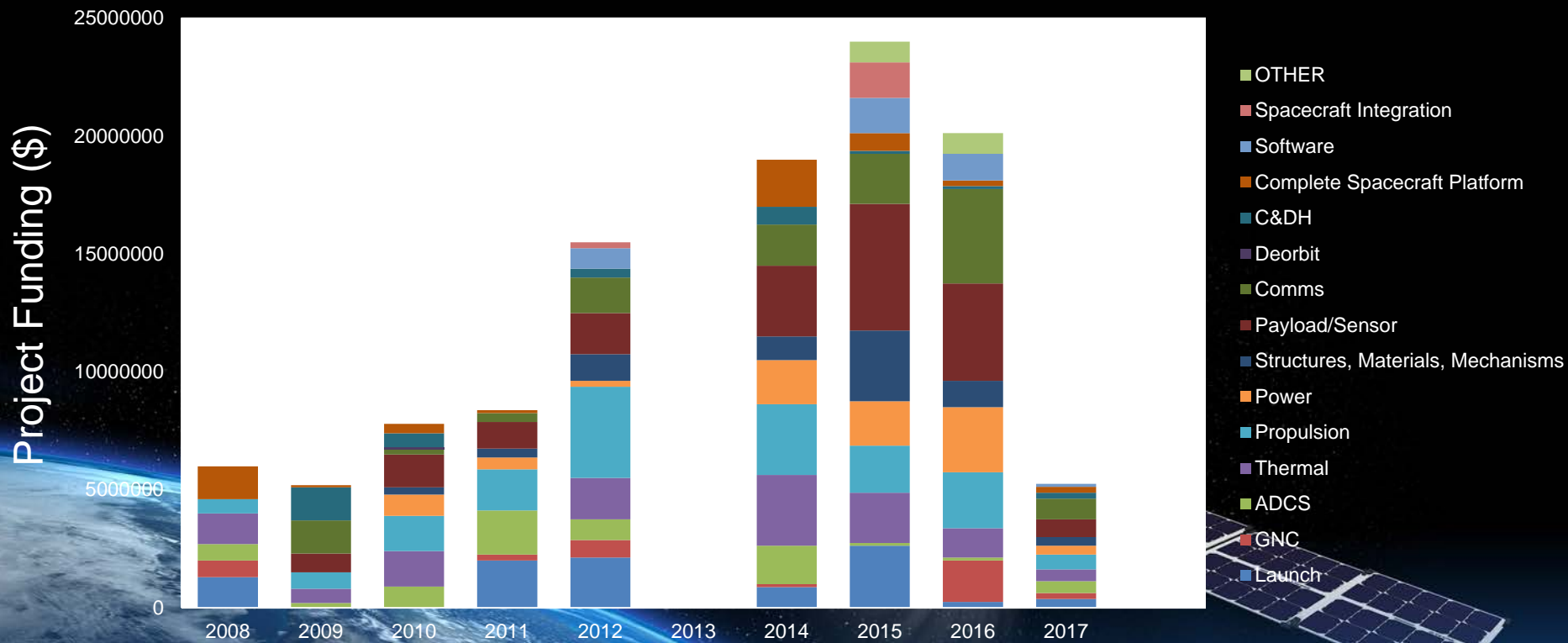
# Planned U-class Exploration and Technology Demonstration Missions

- **Deep Space Propulsion Technology Development and Demonstration**
  - **Geostationary Transfer Orbit to Cis-Lunar Demonstration**
  - **High  $\Delta V$  Propulsion for Deep Space Small Spacecraft**
- **Lunar Communications Relay Demonstration**
- **Lunar Surface / Subsurface Mapping**





# SBIR Smallsats



- Over 350 projects funded
- Over \$110M invested

No solicitation in 2013

Partial data for 2017



# Plans for 2019

- Survey of NASA Investments in Small Spacecraft
- Continued Database Federation
- Launch Portal Development
- Virtual Seminar Series
- Small Business Innovation Research (SBIR) study follow-on
- S3VI Quarterly Newsletter





# Acknowledgements and Websites

S3VI acknowledges the following NASA Centers and individuals for continued support and guidance

*NASA Headquarters:* **Christopher E. Baker, Charles D. Norton**

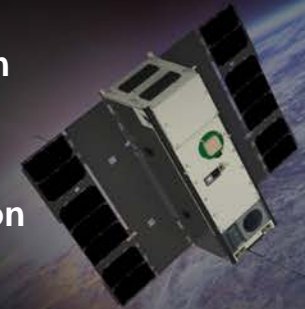
*Ames Research Center:* **Roger C. Hunter, Elwood F. Agasid**

*Glenn Research Center:* **Frederick Elliot**

*Goddard Space Flight Center:* **Larry Kepko, Michael A. Johnson**

*Jet Propulsion Laboratory:* **Anthony Freeman**

*Langley Research Center:* **Stephen Horan**



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## Website References

- Space Technology Mission Directorate - [www.nasa.gov/directorates/spacetech/home/index.html](http://www.nasa.gov/directorates/spacetech/home/index.html)
- Science Mission Directorate - [science.nasa.gov](http://science.nasa.gov)
- Human Exploration and Operations Mission Directorate - [www.nasa.gov/directorates/heo/index.html](http://www.nasa.gov/directorates/heo/index.html)
- Small Spacecraft Systems Virtual Institute - [www.nasa.gov/smallsat-institute](http://www.nasa.gov/smallsat-institute)
- CubeSat Launch Initiative - [www.nasa.gov/directorates/heo/home/CubeSats\\_initiative](http://www.nasa.gov/directorates/heo/home/CubeSats_initiative)
- Small Business Innovation Research Program - [sbir.nasa.gov](http://sbir.nasa.gov)
- Small Spacecraft Technology State of the Art Report 2015 - <https://sst-soa.arc.nasa.gov>