NASA SBIR 2018 Phase I Solicitation

Z8.01 Cubesat Propulsion Systems

Lead Center: GRC

Participating Center(s): GSFC, JPL, MSFC

Technology Area: TA2 In-Space Propulsion Technologies

The CubeSat market shows significant promise to enable low cost science and exploration missions. However, at present many CubeSat technology development activities do not reach flight, and missions that are flown are often selected for concept or component demonstration activities as the primary objectives. Several technology limitations challenge high value science from low-cost CubeSat missions. Limitations include, but are not limited to, post-deployment propulsion capabilities, radiation hardened flight computers, deep space communication, and available instruments. Additionally, propulsion systems often place restrictions on handling, storage, and operations that may limit a CubeSatâ€™s ability to launch as a secondary payload. Nevertheless, opportunities are anticipated in the near future to conduct a larger percentage of CubeSat missions based on application goals and pursue exploration and science return as the primary objectives.Â

Towards that end, this subtopic seeks to develop innovative long-life, reliable, and low-cost electric/chemical propulsion technologies that can enable small satellite science and exploration missions. This year, proposals are specifically sought for complete propulsion system solutions (thrusters, valves, propellant, sensors, electronics, etc.) capable of full scale flight demonstration on 27U, 12U, 6U, or 3U CubeSats in support of deep space and/or swarm topology missions. Proposers should place special emphasis on propulsion system solutions offering long life, reliability, and minimalistic use of CubeSat resources (power, energy, volume, and mass), while delivering propulsion capabilities within the scope of interests described below. Proposals will not be considered that focus purely on features, benefits, and advantages of a new technology, without addressing how their innovative propulsion solution supports improved mission outcome, cost, and productivity.Â

Proposers are expected to show a clear understanding of the current state-of-the-art (SOA) and quantitatively (not qualitatively) describe improvements over relevant SOA technologies that will substantiate the investments in the new technology. Quantification of improvement over the SOA should include any significant advancements that improves the capability of a CubeSat to carry out high-value science missions. For example, advancements are desirable in propulsion system lifetime, reliability, radiation tolerance, cost, energy utilization, miniaturization, thermal management, safety, propellant storage, etc. Potential opportunities for mission infusion for both technology demonstration and long-term mission application should be identified along with potential technology gaps that need to be addressed or assessed. Extensibility of technologies up to 180 kg satellites may be identified, though extensibility beyond 27U CubeSats is not required.Â

Green propellants are a subset of the propulsion technologies of interest. Green considerations may aid in reducing system mass, increase system safety, reduce cost of handling, and reduce integration risks in secondary payloads. Regardless of toxicity or propellant hazards, propulsion systems must show clear consideration for safe containment of the propellant through launch and system operations. These considerations may include the number of inhibits, post-launch pressurization schemes, etc.Â

Proposals are sought that can deliver hardware products and proof-of-concept demonstrations in Phase I. Proposals are sought that can deliver hardware at or greater than TRL 6 suitable for flight demonstration within the Phase II resources provided. Propulsion systems requiring Phase II-E or II-X funding will be considered if justified through mission enabling capabilities.Â Component level development proposals shall be considered, but must enable important new CubeSat mission capability and identify opportunities for near-term infusion. While component level development shall be considered, preference will be given to complete propulsion system solutions.Â

Specific propulsion capabilities of interest follow below. Metrics are provided either per unit of anticipated spacecraft volume (Usc) or per unit of propulsion system volume (Up). Where one unit of volume is defined as 10 cm cubed. Assume CubeSat wet mass as 2 kg/Usc. Proposers should specify to what S/C size (27U, 12U, 6U, and/or 3U) their propulsion system solution scales to meet or exceed the metrics below.Â If the propulsion solution can scale to satisfy multiple needs, proposers should quantitatively evaluate their solutions at each applicable scale and concisely present those capabilities in tables or figures. Proposers should also specify at what scale they intend to develop their demonstration hardware. Propulsion systems proposed should conceptually utilize no more than 1/3 the S/C total volume (e.g., propulsion system solutions for a 12U S/C should fit in 4U or less):Â

- High impulse propulsion systems meeting the following criteria:
  - Example applications: deep space, interplanetary, orbit capture.
  - Total impulse per unit of propulsion system volume > 4000 N-sec/Up.
  - Electric propulsion with thrust per S/C volume > 0.1 mN/Usc.
  - Lifetime > 2 years.
  - Propulsion system peak power per S/C volume < 5 W/Usc.
  - Design for deep space application (radiation tolerance, thermal attributes, etc.).
  - Propulsion systems including ACS.
- High thrust propulsion systems meeting the following criteria:
  - Example applications: Orbit raising (MEO, GEO), long life LEO.
  - Total impulse per unit of propulsion system volume > 750 N-sec/Up.
  - Chemical propulsion thrust per S/C volume > 5 mN/Usc.
  - Electric propulsion thrust per S/C volume > 0.5 mN/Usc.
  - Lifetime > 2 years.
  - Propulsion system peak power per S/C volume < 5 W/Usc.
  - Low soakback (i.e., minimal increase to local bus temperature).
  - Propulsion systems including ACS.
- Precision Control:
  - Example applications: formation flying, tight pointing requirements.
  - Minimum impulse bit per S/C volume < 0.1 microN-sec/Usc.
  - Lifetime > 2 years.
  - Propulsion system peak power per S/C volume < 5 W/Usc.Â

Preference for systems:Â

- Optimized for the rigors of interplanetary / deep space missions (i.e., radiation, thermal, etc.).
- placing no demanding storage or handling requirements prior to launch.
- Remaining quiescent under ambient conditions for > 6 months prior to launch.
- remaining quiescent under post-deployment conditions.Â

For small satellite propulsion technologies applicable to satellites larger than 27U (54 kg), please see subtopic Z10.02, â€œPropulsion Systems for Robotic Science Missions.â€