NATIONAL AERONAUTICS AND SPACE ADMINISTRATION (NASA)
AMES RESEARCH CENTER (ARC)
REQUEST FOR INFORMATION (RFI) – NNA15ZPX001L

PATHFINDER TECHNOLOGY DEMONSTRATOR (PTD)

1.0 Background

NASA's Pathfinder Technology Demonstrator (PTD) project is a collaborative effort between NASA Ames Research Center and Glenn Research Center. The project is funded by the Small Spacecraft Technology Program (SSTP), one of nine programs within NASA's Space Technology Mission Directorate (STMD). Pathfinder Technology Demonstrator will flight test a variety of CubeSat propulsion or other technology subsystems in Low Earth Orbit (LEO) thereby elevating the Technology/Manufacturing Readiness Level (TRL/MRL) of these subsystems to TRL/MRL 7. NASA is interested in a spaceflight-qualified 6U CubeSat spacecraft bus to be operated by NASA for its Pathfinder Technology Demonstrator Project to accommodate new propulsion or other technology sub-systems, hereafter referred to as the payload.

One flight demonstration is planned for a low-thrust propulsion system with potential for three or more follow-on technology demonstrations. Follow-on missions may include payloads such as higher thrust propulsion systems or technology demonstrations of other spacecraft subsystems or payloads such as optical communications or high-precision attitude determination and control systems. NASA's seeks a state-of-the-art satellite bus that would require little, or preferably no new technology development for the bus subsystems and desires the most rapid delivery possible for the integrated satellite. Mission-to-mission design variations in the delivered CubeSat bus are acceptable, but for cost and operability concerns, follow-on buses should be as close as possible in design to the initial bus.

2.0 Conceptual Level Specifications

The following are the conceptual-level specifications that NASA anticipates for the overall spacecraft flight demonstration utilizing the Pathfinder Technology Demonstrator CubeSat bus. These specifications are only provided as a reference to characterize the desired capabilities of the satellite bus.

- **Mass**: less than 8 kg
- **Power**: 72W or greater beginning of life generation capability
  44W on-orbit-average power (35min eclipse, and orbits as specified later). Battery will be sized to support up to a 35-minute discharge with all subsystems active without exceeding a 60% depth of discharge.
- **Dimensions**: 6U in a 2U x 3U form factor
- **Mechanical**: The CubeSat bus will be designed to survive shock and vibration loads specified in General Environmental Verification Standards (GSFC-STD-7000A) levels. https://standards.nasa.gov/documents/detail/3315858. The bus will be subject to an Orbit Debris Assessment Report (ODAR) in which no use of titanium is suggested.
- **Environments**: The CubeSat bus will be designed and tested to GEVS (GSFC-STD-7000A) space environments.
- **Radiation tolerance**: 5 krad total ionizing dose and able to handle single-event upsets

- **Attitude control**: Maintain <0.1-degree pointing accuracy, nadir pointed. Reaction wheel control with torque rod momentum dumping presumed, although other solutions may be considered. A 'safe-mode' must be provided that can maintain a power-positive state without use of reaction wheels, star tracker, or IMU, if used for your solution.
- **GPS**: Orbital GPS position measurements at 1 Hz
- **Communications**: S-band command and telemetry capability, compatible with Near Earth Network (NEN) antennas. 100 Mbit/day telemetry volume (downlink). Other options may be considered, including Globalstar, Iridium, or vendor/partner ground station capabilities, if they can meet the data volume requirement. Commanding 2 kbps or greater (uplink) will be performed daily on weekdays. Note: NEN compatibility requires CCSDS Packet format Blue Book standards, see http://public.ccsds.org/publications/default.aspx for reference. (Assume all operations to be performed by NASA.)
- **Flight Software**: Provide all necessary flight software for command and telemetry processing, spacecraft health and status monitoring, memory management, attitude control modes (de-tumble, sun-safe, solar inertial, nadir pointing, slew, thrust, momentum dump), sensor processing, fault management and response, scripted relative and absolute time scripts, and payload interface.
- **Payload Accommodation**:
  - **Power**: Provide up to 60 W of peak switched power, and 5 W of unswitched power (for payload survival heater(s)). Payload on-orbit average power will not exceed 25 W. Power can be unregulated in the range of 12 V +/- 2 V, or regulated at 12 V. Provide a redundant switched power path using separate hardware components that are ground command-selectable. Resettable overcurrent protection of the bus will be provided.
  - **Ground**: Provide separate returns for analog and digital grounds using a single-point star grounding scheme. Payload will be isolated from any bus structure grounding.
  - **Data**: Provide RS-422 asynchronous binary communication links for sending payload commands and receiving payload telemetry at a minimum 19.2 kbps data rate. Bus flight software will need to monitor the payload data stream for fault indicators and perform pre-determined payload safing procedures. Safing procedures and scripts must be modifiable on-orbit.
  - Provide at least 25% spare pins in the payload interface connector.
  - Provide an interface for an analog NASA/GSFC STD S-311-P-18K-compatible temperature sensor that will monitor the payload temperature when power to the payload is switched off.
  - **Mechanical**: Provide 2.5U volume for payload accommodation, and a mounting strategy for Payload. Payload volume should be contiguous and contain one 2U x 1U external face (approximately 25 cm x 10 cm).
  - **Mass**: Support up to 3kg payload mass
  - **Thermal**: Thermally isolate bus from payload volume, while providing ability for payload to radiate excess heat from external surfaces. Specific thermal solution for the payload will be the responsibility of the payload.
  - Payload volume position must enable payload to thrust along the velocity vector through the bus center-of-gravity (CG).

    - **Propulsive force**: The direction of the net propulsion thrust vector will be aligned to within 2 degrees (3-sigma) of the velocity direction and 1.5 mm of the spacecraft CG. Thrust level will be between 50 micro-Newton and 200 micro-Newton. (follow-on missions could achieve up to 2mN)
    - The bus shall be able to route ground commands to the payload and store on-board scripts of payload commands that can be triggered to run by timer or ground command.
- **Mass properties**: Bus CG will need to be known or measured to +/- 2 mm in all three axes.
- **Launch Accommodation**: Spacecraft bus solution must be compatible with common US launch providers.
- **Orbit characteristics**:

	Season	Altitude (km)	Inclination (deg)	BETA (deg)	Solar Flux (W/m2)	Albedo	Earth IR (W/m2)
Cold Case	Summer	800	98	90	1320	0.2	218
Hot Case	Winter	350	98	0	1420	0.4	240

- **Flight Duration**: Up to 4 months on-orbit.
- **Shelf Life**: 9 months minimum (spacecraft bus may need to be held in bonded stores while awaiting launch accommodation or payload delivery).
- **Launch Considerations**: During launch and CubeSat deployment into LEO, the bus will be completely unpowered for up to 45 minutes and tumbling in orbit. During that period, the bus will be unpowered. The bus will automatically power up after this preset time, attain attitude control, deploy solar arrays, and achieve a power-positive safe mode.
- **Electromagnetic Interference (EMI)/Electromagnetic Compatibility (EMC)**: Bus radiation and conduction levels need to be documented to perform compatibility analysis with the payload to determine if filtering or shielding is required. Document generated fields and strengths and note any susceptibility concerns at specific frequencies. The CubeSat bus shall be EMI/EMC self-compatible.
- **Contamination**: The bus and any components shall be delivered visibly clean, plus ultraviolet (VC+UV) at a cleanliness Level of 500 B. Bus and components with high off-gassing concerns, like wiring insulation, will be baked-out prior to delivery. Any specific clean room requirements should be specified, e.g. 100K.

3.0 RFI Responses

Responses to this RFI should address the following.

- **Organization/Company Info**:
    - Name and address of firm,
    - Cage Code and DUNS Number (if available),
    - Points of contact name(s) with phone number(s) and email address(es),
    - Website (if applicable), and name of parent organization (if applicable).

- Business size (Based on NAICS code) and/or Socioeconomic designation (i.e., large, small, SDB, WOSB, VOSB, SDVOSB),
- Average annual revenue for past 3 years and number of employees;
- List of customers covering the past five years (highlight relevant work performed, contract numbers, contract type, dollar value of each procurement). Please provide a short summary of previous vendor experience integrating and testing CubeSat-class spacecraft.
- Whether the firm is under a GSA Schedule Contract for this product (based on the above and below technical specifications identified in this announcement). Please provide contract number if applicable.

- **Technical Solutions -** Please provide the following:
  - Proposed technical specifications of a CubeSat bus meeting the desired bus capabilities characterized by the conceptual specifications stated above. Alternative approaches to meet the desired capability can be described. If unable to meet any specification, indicate your alternative approach and provide rationale for the acceptability of any reduced capability.
  - Proposed approach for qualification of the CubeSat bus.
  - Proposed approach for the integration and system-level qualification of the payload with the CubeSat bus. Payload will be provided as Government Furnished Equipment (GFE) at no cost, but Vendor should assume costs for personnel interactions with the payload developer to ensure a knowledge base adequate to integrate the payload. Describe payload vendor support requirements and assumptions.
  - If the CubeSat bus utilizes a vendor-provided ground data system solution, please provide the proposed solution for the ground data system. Include how NASA operations personnel and facilities could be integrated with the solution. Assume that NASA will perform operations.
  - If appropriate to the design solution, please provide a proposed approach for use of the Globalstar communication system.
  - Proposed plan for shipment of an integrated flight-ready spacecraft to the launch site and any necessary support required for launch container and launch vehicle integration.
  - Proposed support for flight operations at NASA.
  - Vendor should include formal major milestone reviews with NASA participation, review, comments and feedback. Include schedule and facility costs, if applicable, in your estimate.
  - Maturity of the bus technology at a subsystem level (i.e., what parts of the system have been flight qualified, when and by whom or under what project), description of Technology Readiness Level (TRL), and near-term plans or approach for qualification of any components that do not yet have flight heritage.
  - Rough Order of Magnitude (ROM) cost estimate broken down by the elements listed above (bus design, fabrication and delivery, bus qualification, payload integration, ground data system and support of NASA flight operations). The estimate should include one engineering development unit, one software simulator, one flight unit and three optional follow-on flight units.

- Estimated development schedule timeline for the design, fabrication, and testing of a spaceflight-qualified system (in FY16 dollars), relative to a hypothetical contract start date of January 2016. The estimate should include one engineering development unit, one software simulator, one flight unit and three optional follow-on flight units. For purposes of estimation, assume that the technology payload will be delivered six months after contract start.

- Information regarding existing or planned facilities, ground support test equipment, and vendor capabilities.

- Identification of partnerships (if any) represented in the response. This includes but is not limited to joint venture partners, potential teaming partners, prime contractor (if responder is potential subcontractor) or subcontractors (if responder is potential prime contractor).

- NASA is soliciting feedback on the applicable classification codes. Does the selection of NAICS code 336414 (Guided Missile and Space Vehicle Manufacturing) with size standard 750 employees seem appropriate? If not, what alternative NAICS code do you suggest, and why?

- Please advise if the requirement is considered to be a commercial or commercial-type product. A commercial item is defined in FAR 2.101.

4.0 Submission Instructions

Interested firms are requested to submit their response to this RFI via email only to Umetria Thomas at email Umetria.Y.Thomas@nasa.gov, no later than 4:00PM PST on Tuesday, August 18, 2015. Submissions shall be compatible with and accessible using Microsoft Office or Adobe Acrobat software applications. When responding, reference RFI **NNA15ZPX001L – PATHFINDER TECHNOLOGY DEMONSTATOR**.

Documents and attachments should be in Microsoft WORD, POWERPOINT, or PDF format. Files should not be greater than 15 pages for the technical response (no less than 12 point Times New Roman font except in figure captions). ROM costing response is independent of the technical response 15 page count limit. Due to mailbox limitations, attachments should not exceed 10MB. All information received in response to this RFI that is marked "Proprietary" will be handled and protected accordingly. As applicable, NASA may provide proprietary information to its support service contractors who are under an obligation to keep third-party proprietary information in confidence. By submitting a response to this RFI, the responder is deemed to have consented to release of proprietary information to such NASA support service contractors.