NASA STTR 2019 Phase I Solicitation

T4.03 Coordination and Control of Swarms of Space Vehicles

Lead Center: JPL

Technology Area: TA4 Robotics, Telerobotics and Autonomous Systems

EnablingÂ Technologies for Swarm of Space Vehicles

This subtopic is focused on developing and demonstrating technologies that are enabling to cooperative operation of swarms of space vehicles in a dynamic environment. Primary interest is in technologies appropriate for low-cardinality (4-15 vehicle) swarms of small spacecraft, as well as planetary rovers and flyers (e.g., Mars helicopter); Large swarms and other platforms are of interest if well motivated in connection to NASAâ€™s strategic plan and needs identified in decadal surveys.

The proposed technology should be motivated by a design reference mission presented in the proposal.

Possible areas of interest include but are not limited to:

- High precision relative localization and time synchronization in orbit and on planet surface.
- Coordinated task planning, operation, and execution.
- Fast, real-time, coordinated motion planning in areas densely crowded by other agents.
- Human-Swarm interaction interfaces for controlling the multi-agent system as an ensemble.
- Distributed fault detection and mitigation due to hardware failures or compromised systems.
- Communication-less coordination by observing and estimating the actions of other agents in the multi-agent system.
- Cooperative manipulation and in-space construction.
- Close proximity operations of spacecraft swarms including sensors required for collision detection and avoidance.

Subtopic technology directly supportsÂ NASA Space Technology RoadmapÂ TA-04Â regarding Robotics and Autonomous Systems (4.5.4 Multi-Agent Coordination, 4.2.7 Collaborative Mobility, 4.3.5 Collaborative Manipulation)Â Strategic Space Technology Investment Plan (Core)Â Robotic and Autonomous Systems: Relative GNC and Supervisory control of an S/C team:

- Multi-robot follow-on to the M2020+Mars Helicopter programs are likely to necessitate close collaboration among flying robots as advance scouts and rovers.
- Pop-Up Flat-Folding Explorer Robots (PUFFERs) are being developed at JPL and promise a low-cost swarm of networked robots that can collaboratively explore lava-tubes and other hard to reach areas on planet surface.
- A convoy of spacecraft is being considered, in which the lead spacecraft triggers detailed measurement of a

very dynamic event by the following spacecraft.
- Multiple concepts for distributed space telescopes and distributed synthetic apertures are proposed that rely heavily on coordination and control technologies developed under this subtopic.

Phase I awards will be expected to develop theoretical frameworks, algorithms, software simulation and demonstrate feasibility. The expected Technology Readiness Level (TRL) range at completion of the project is 2-3.Â Phase II awards will be expected to demonstrate capability on a hardware test bed.Â The expected Technology Readiness Level (TRL) range at completion of the project is 4-6.

NASA has plans to purchase services for delivery of payloads to the Moon through the Commercial Lunar Payload Services (CLPS) contract.Â Under this subtopic, proposals may include efforts to develop payloads for flight demonstration of relevant technologies in the lunar environment.Â The CLPS payload accommodations are yet to be precisely defined, however at least for early missions, proposed payloads should not exceed 15 kilograms in mass and not require more than 8 watts of continuous power.Â Smaller, simpler, and more self-sufficient payloads are more likely to be accommodated.Â Commercial payload delivery services may begin as early as 2020 and flight opportunities are expected to continue well into the future. Â In future years it is expected that payloads of higher mass and with higher power requirements might be accommodated. Â Selection for award under this solicitation will not guarantee selection for a lunar flight opportunity.

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- Evan Ackerman, "PUFFER: JPL's Pop-Up Exploring Robot; This little robot can go where other robots fear to roll, " https://spectrum.ieee.org/automaton/robotics/space-robots/puffer-jpl-popup-exploring-robot
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- Space Studies Board, "Achieving Science with CubeSats: Thinking Inside the Box," National Academies of Sciences, Engineering, and Medicine, 2016. http://sites.nationalacademies.org/SSB/CompletedProjects/SSB_160539Â