National Aeronautics and Space Administration

NASA**facts**

# Space Technology

## Game Changing Development

### Distributed Spacecraft Autonomy

Engineers have dramatically improved the design and capabilities of autonomous vehicles, uncrewed air vehicles, and autonomously-capable general-purpose computing within the last decade. However, very few have demonstrated autonomy in spacecraft.

A crucial part of the Distributed Spacecraft Autonomy (DSA) project is developing methods for scalable command and control of missions that involve multi-spacecraft performing joint activities. Examples of such missions that require coordination between multi-spacecraft include resource prospecting (where multi-spacecraft coordinate the search for resources on a planetary surface), communications relay (where many spacecraft work together as one big antenna), or distributed telescopes (an array of telescopes produce an image rather than using an image from a single large telescope).

Autonomy is an essential technology for multi-spacecraft missions. Autonomy allows spacecraft to decide their next activities, as opposed to having the spacecraft send their status to a control station on the ground and await further instructions. Autonomous decision making is needed for deep-space multi-spacecraft missions. The time delay on the round-trip communications and the amount of data that can be sent make it impractical to follow the classic model of receiving status on the ground then commanding, especially for multiple spacecraft. Autonomous decision-making would allow mutliple spacecraft to share data and make quick decisions together, thus overcoming any latency and bandwidth constraints. Additionally, autonomy can significantly increase the effectiveness of multi-spacecraft missions by operating them as a collective rather than individually. To address the needs

of future missions, the DSA project will advance command and control methodologies for controlling a swarm of spacecraft as a single entity, demonstrate autonomous coordination between multiple spacecraft in the swarm, and demonstrate approaches for adaptive reconfiguration of the swarm's plan and distributed decision-making across a swarm of spacecraft.

The project will contribute to NASA's Space Technology Mission Directorate's Small Spacecraft Technology Starling Program's 2021 mission, which involves four CubeSats that will carry NASA payloads. After this 2021 in-space demonstration, DSA software will then be tested on ground hardware with up to 100 spacecraft. This ground hardware test will validate the scalability of the software.

The autonomy demonstration will involve the swarm performing smart filtering. Each of the spacecraft (up to four) in the formation can store the phase delay information of (up to) five GPS satellites. Some GPS signals will have higher quality data that is worth collecting from multiple vantage points, and so the formation spacecraft will communicate the perceived quality of these signals to the other spacecraft in the swarm. The spacecraft will then reach consensus on how to partition the set of GPS signals, with the goal of allowing multiple spacecraft to monitor a single GPS satellite's broadcast. A channel that many spacecraft listen to is called a "priority" channel. A core argument of the demonstration is scalability, i.e., the solutions implemented on up to four will also work reliably well on up to 100 spacecraft.

Much like the "cloud computing" architectures that now exist in the computing domains, the DSA project aims to change the conversation regarding how to architect large constellations, or swarms, of spacecraft in future NASA missions. DSA plans to create a technology foundation in autonomy on which future missions can build.

The Game Changing Development (GCD) program is part of NASA's Space Technology Mission Directorate. The GCD Program aims to advance exploratory concepts and deliver technology solutions that enable new capabilities or radically alter current approaches.

For more information about GCD, please visit
http://gameon.nasa.gov/

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