NASAfacts

# Nodes

## Spacecraft Network Operations Demonstration Using Multiple Spacecraft in an Autonomously Configured Space Network Allowing Crosslink Communications and Multipoint Scientific Measurements

Nodes is a technology demonstration mission that was launched to the International Space Station on December 6, 2015. The two Nodes satellites subsequently deployed from the Station on May 16, 2016 to demonstrate new network capabilities critical to the operation of swarms of spacecraft. The Nodes satellites accomplished all of their planned mission objectives including three technology 'firsts' for small spacecraft: commanding a spacecraft not in direct contact with the ground by crosslinking commands through a space network; crosslinking science data from one Nodes satellite to the second satellite before sending it to the ground; and autonomous reconfiguration of the space communications network using the capability of Nodes to automatically select which satellite is best suited to serve as the ground relay each day.

The Nodes mission consists of two 1.5-unit (1.5U) CubeSats, each weighing approximately 4.5 pounds (2 kilograms) and measuring about 4 inches x 4 inches x 6.5 inches (10 centimeters x 10 centimeters x 16 centimeters). This mission followed last year's attempted launch of the eight small satellites of the Edison Demonstration of Smallsat Networks (EDSN) mission, which were lost in the failure of the launch vehicle. The Nodes hardware is identical to that developed for the EDSN mission. However the EDSN software capabilities were enhanced for the Nodes mission. Nodes and EDSN continue the legacy of the Phonesat series that introduced the use of commercial Android smartphone technology to perform many of the spacecraft functions normally accomplished with expensive, customized electronics components. The Nodes satellites used the Android operating system with specific software programmed to perform command and data handling tasks that allowed the satellites to accomplish the noted three technology 'firsts' for small spacecraft.

Each satellite was equipped with three radios: one S-band radio for ground communication, one ultra high frequency (UHF) radio for crosslink communication, and an additional UHF beacon radio to transmit state-of-health information.

*Nodes spacecraft deployed into low Earth orbit*

The Nodes science instruments, identical to those on the EDSN satellites, collected data on the charged particle environment at an altitude of about 250 miles (400 kilometers) above Earth. These Energetic Particle Integrating Space Environment Monitor (EPISEM) radiation sensors were provided by Montana State University in Bozeman, Montana, under contract to NASA. The Nodes satellites demonstrated their networking capabilities through communication of this space environment data with each other and the ground.

Each Nodes spacecraft collected multiple coordinated readings of Earth's charged particle environment and passed the data to the "Captain" spacecraft for downlink to the ground. The selection of the Captain was made generally once per day based on the exchange of key parameters, such as how much science data had been collected and the state of spacecraft health.

The two satellites formed a hub and spoke network to share data and transmit it to the ground. Each day of the 20-day mission, commands were sent from the ground to the selected relay satellite and that satellite transmitted the commands to the other satellite, showing that a network of satellites

can be controlled without communicating to each satellite directly. These crosslinking 'firsts' are important milestones in developing constellations of small spacecraft for future high value science and exploration missions.

As part of a partnership with Ames, Santa Clara University in California conducted ground operations for the two-week mission. Amateur radio operators around the world participated in the Nodes mission by receiving the Nodes beacon data packets and submitting them to the project team.

The satellites are expected to remain in orbit for up to six months, after which the satellites' orbits will decay, and the Nodes spacecraft will re-enter and disintegrate in the atmosphere.

Networked swarms of small spacecraft will open new horizons in astronomy, Earth observation, and solar physics. Their range of applications includes the formation of synthetic aperture radars for Earth sensing systems, as well as large aperture observatories for next-generation telescopes and the collection measurements distributed over space and of time to study the Earth's magnetosphere, gravity field, and Earth-Sun interactions.

The Nodes project was developed and managed by NASA's Ames Research Center at Moffett Field, California. The Nodes mission was funded by NASA's Small Spacecraft Technology Program (SSTP), which is chartered to develop and mature technologies to enhance and expand the capabilities of small spacecraft. SSTP is one of nine programs within NASA's Space Technology Mission Directorate.

**For more information about the SSTP, visit:**
http://www.nasa.gov/smallsats

**For more information about the Ames Engineering Directorate, visit:**

http://www.nasa.gov/centers/ames/engineering/

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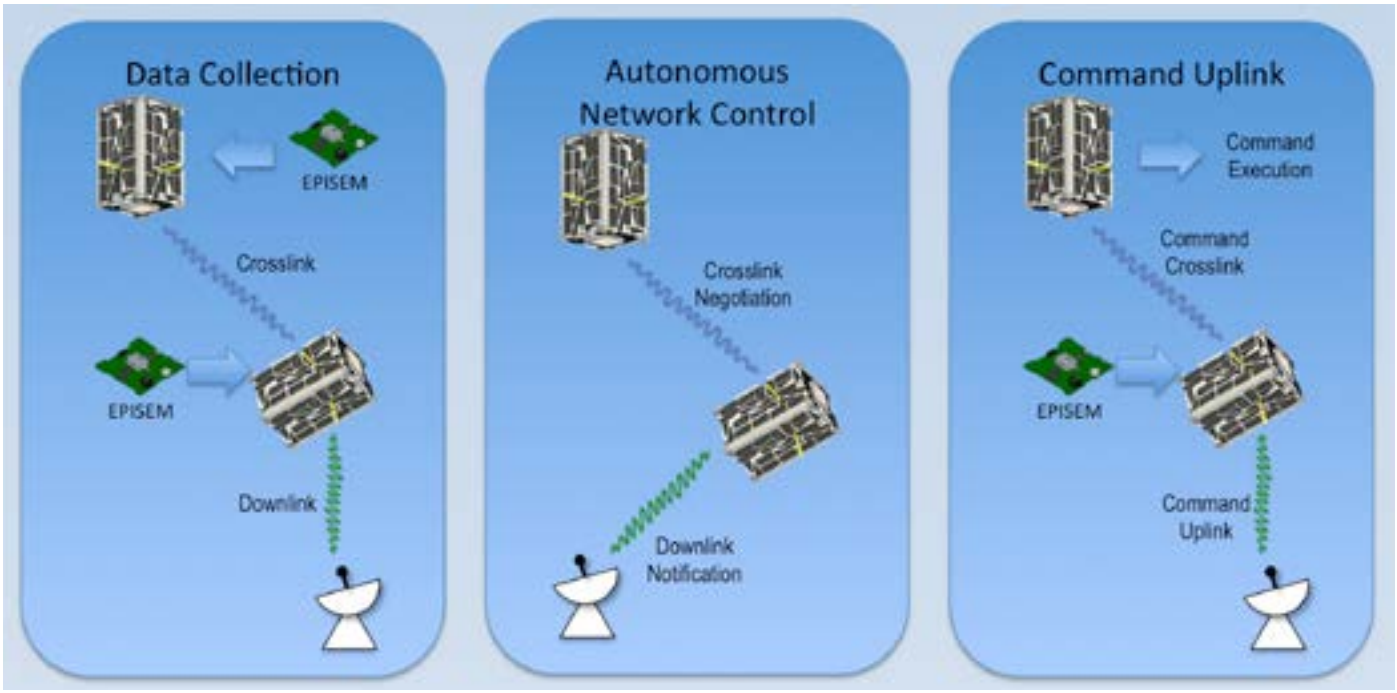


*Nodes Inter-Satellite and Space-to-Ground Communications Concept of Operations*

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