Improving Small Spacecraft Mission Operations in Deep Space through the use of Disruption Tolerant Networking and Spacecraft-Initiated Operations

E. Jay Wyatt, Marc Sanchez Net, Nathaniel Richard
Jet Propulsion Laboratory/California Institute of Technology, Pasadena, CA, USA

Benjamin Malphrus, Emily Walter, Nathan Fite
Morehead State University, Morehead, KY, USA

Small spacecraft missions in deep space are inherently different in many ways than traditional larger-scale deep space missions. They can be lower priority when competing for scarce communication resources, have less redundancy, simpler fault protection systems, less funding for operations, less experienced operations teams, and unproven mission enabling technologies, to name a few. Moreover, the forward looking mission landscape for small spacecraft missions is unique. Small spacecraft, for example, can be used to create constellations, fleets, and contribute to large-scale Lunar exploration in the coming decade. For these and other reasons, deep space small spacecraft missions can be considered novel within the worldwide space community. What is not novel, however, is the strong tendency to operate these missions in much the same way as flagship missions or similar larger mission classes. It generally isn't well known, however, that there are highly mature capabilities that can be used to create operations concepts better suited for small spacecraft. These capabilities can lower mission risk, increase science return, improve operational efficiency, or lower mission operations cost. Moreover, if adopted, space agencies worldwide over time can operate more effectively and improve our collective ability to explore the Solar System. Two of these capabilities will be described. The first is Space Networking. Just as the internet has become pervasive on Earth, the space-based analog to the terrestrial internet can allow missions (even single missions) to be operated more effectively, enable networked spacecraft mission concepts, enable coordinated observations between two or more spacecraft, and improve automation for space-based relays. Space networking enables interoperability among spacecraft, which means that each spacecraft launched can become a node of the solar system internet. Over time, this can create permanent communication infrastructure in space by adding communications redundancy, improved performance, and decreased mission lifecycle cost. The other capability to be discussed is Spacecraft-initiated Operations. With this approach, pre-planned communication periods can be largely eliminated for most mission phases and a more adaptive means of communicating adopted. The spacecraft determines when to communicate and signals the ground system and mission operations team to activate when telemetry downlink or command uplink is required. These capabilities are largely available today, flight validated, and especially suited to small spacecraft missions. This briefing will describe how these technologies work, specific capabilities and services that are currently available, mission use-cases, and overall benefits for deep space small spacecraft missions.