Scientific Objective and Infrastructure of Space Exploration (1)
Scientific Objective and Infrastructure of Space Exploration (2)

Author: Mr. Sebastian Martin
ESA, Germany

Ms. Toril Bye Rinnan
Solenix GmbH, Germany

## USING DELAY TOLERANT NETWORKING ON ISS ANALOGUE ACTIVITIES TO ENABLE FUTURE HUMAN-ROBOTIC EXPLORATION SCENARIOS

**Abstract**

In preparation for future human missions towards a sustainable exploration of the surface of Mars, a step-wise approach is devised by the global exploration roadmap of the International Space Exploration Coordination Group (ISECG). This step-wise approach foresees using the ISS for preparation of exploration missions beyond LEO, implementing robotic precursor missions to the Moon, asteroids and Mars and maximizing the synergies between human and robotic missions. The development of new advanced technologies, systems and infrastructures including demonstration and validation through analogue activities will enable future mission scenarios.

One likely scenario involves astronauts in orbit of a planetary body controlling or supervising rovers on the surface with different degrees of support and observation from Earth Mission Control Centres. The reduced delay of the orbiting crew compared to Earth controlled operations allows for more complex tasks with the possibility of direct human intervention.

To define and validate requirements for operations, systems and technologies in analogue activities, the ESA led METERON project has been utilizing the International Space Station to conduct a series of experiments with increasing complexity over the past years. From crew controlling a simple LEGO test rover in 2011, multiple ESA rovers in concert in a Lunar Lander scenario in 2014 to an ExoMars test platform in an artificial cave in 2016, METERON has installed and expanded on an infrastructure built on the Disruption Tolerant Network (DTN) design.

The first step of controlling robots from space requires a suitable network technology to send commands and receive information - and the Disruption Tolerant Network assures correct operation in the less-than-ideal conditions of space communications. The bundle protocol (BP) is the end-to-end protocol for the exchange of messages (bundles) in Delay Tolerant Networking, connecting mixed ground and space networking technologies into a single network and transmitting the messages using a store-and-forward technique. The protocol ensures automatic storage, buffering and resending of the data in the network chain, making it possible to automatically route the messages via multiple paths. This can cause the messages to be received out of order or multiple times, but will ensure successful delivery.

This paper is describing the lessons learned and current conclusions on utilising DTN in mission control systems for robotic scenarios in the context of the recent experiments conducted in the METERON frame.