RFID-Enabled Autonomous Logistics Management (REALM) Experiment on the International Space Station

Patrick W. Fink*, James L. Broyan, Jr., Phong H. Ngo, Timothy F. Kennedy,
Lazaro Rodriguez, Haley Boose, Gregory Lin, Andrew Chu, Shelley Baccus [(1)]
Gary Grobe, Wayne Cope, John Dusl [(2)]
[(1)] NASA Johnson Space Center, [(2)] Jacobs Technology, Inc.

NASA is initiating a three-year experiment on the International Space Station (ISS) to advance the agency's roadmap area of Autonomous Logistics Management, or *ALM*. The capability of constant awareness of the location, and possibly the status, of all physical items in a spacecraft or habitat is one of the key aspects of ALM. This capability is deemed critical for human exploration of space beyond low-Earth orbit (LEO), in which resupply opportunities are extremely limited or non-existent, and communication delays may render ground support ineffective. The experiment, titled *REALM-1* for RFID-Enabled ALM, is one of five tasks within NASA's Advanced Exploration Systems (AES) Logistics Reduction Project (J. L. Broyan, et al, Proceedings, *AIAA Space 2014 Conference and Exposition*, AIAA 2014-4334). Follow-on projects *REALM-2* and *-3* are anticipated but are not officially flight projects at the time of this writing.

Full realization of the REALM vision is expected to involve three generic technology types: (i) dense zone technologies, defined as shielded containers with attached readers and interior feeds, or antennas (sometimes collectively referred to as "smart drawers") for assessing dense populations of assets; (ii) sparse zone technologies, defined as fixed and mobile readers for regions exclusive of the dense zones, and (iii) software applications capable of providing operational intelligence to infer tagged item locations when real time interrogation of said item tag cannot be achieved. REALM-1 will establish a core infrastructure comprising: (i) two readers in each of three ISS axial modules that are targeted for this experiment, and (ii) a ground-based Complex Event Processing (CEP) center to establish the operational intelligence. Each reader will switch between four antennas and will forward data sets to the CEP center for processing. The spatial resolution goal for REALM-1 is ½ of an approximately 6m long module, with the aim of refinement in subsequent REALM phases.

Although NASA began operating smart drawer technology on the ISS in 2014, lower mass versions are being developed as a REALM-3 project. The existing smart drawers are of aluminum construction and were developed for tracking ISS medical supplies. Since mass reduction is critical for beyond-LEO exploration, REALM-3 smart containers will take the form of duffle bags with an e-textile RF feed system. An anticipated REALM-2 project will involve a mobile, autonomous robotic free-flyer, equipped with a reader and antennas, that will serve to refine localization of tagged items. Data from the REALM-3 containers and from the REALM-2 free-flyer will provide additional CEP context to improve tracking accuracy and resolution.

In addition to the REALM subsystems that are described, a smart packaging concept that fits into the REALM ecosystem is discussed, enabling item level tracking without item-level RFID tags. The concept permits tracking of very small items, such as pills, without the burden of individually tagging each item and the performance degradation typically associated with such small tags.