SYMPOSIUM ON BUILDING BLOCKS FOR FUTURE SPACE EXPLORATION AND DEVELOPMENT (D3)
Space Technology and System Management Practices and Tools (4)

Author: Prof. Alessandro Golkar
Skolkovo Institute of Science and Technology, Russian Federation, golkar@skolkovotech.ru

FEDERATED SATELLITE SYSTEMS: A CASE STUDY ON SUSTAINABILITY ENHANCEMENT OF SPACE EXPLORATION SYSTEMS ARCHITECTURES

Abstract

Manned and unmanned space exploration programs are facing times of uncertainty due to political and financial constraints – making future programmatics a challenging endeavor and eventually hindering humankind's ability to explore space beyond Low Earth Orbit. Traditionally, exploration programs have not fully exploited all possible synergies with other space endeavors, such as with Earth Observation, Navigation, Telecommunications missions and so forth. Nevertheless, a significant potential for collaboration between space assets in orbit exists nowadays, allowing manned and unmanned exploration programs to hedge programmatic uncertainty by sharing resources with other programs, and creating potential sources of revenue to enhance sustainability of science and exploration focused space missions.

This paper presents a case study based on the concept of Federated Satellite Systems (FSS) as applied to enhance sustainability and hedge programmatic uncertainty of manned and unmanned space exploration systems architectures. FSS is a novel paradigm in space systems architecture and spacecraft design, that consists in allowing spacecraft to share in-orbit resources in an opportunistic fashion. Examples of in-orbit resources include processing power, link capacity, and data storage. Resources in distributed allocation environments, in a similar way to what is done in cloud computing systems for terrestrial applications. Commercial implementations of the FSA concept are designed to create in-orbit markets of space resource commodities, and to enhance sustainability, cost-effectiveness, robustness, and reliability, of participating missions.

The paper shows how manned and unmanned exploration programs can benefit from the FSS paradigm by participating to federated infrastructures as both customers and suppliers of in-space resources. Impacts of FSS on mission architecture and spacecraft design are discussed, along with the identification of architectural tradeoffs that are inherent to distributed allocation systems. A preliminary analysis of the stakeholders scenario and proposed systems architectures are presented, discussing FSS implementation strategies designed to provide incentives to human spaceflight and robotic exploration customers and beneficiaries to share resources as means to convert non-recurring capital expenditures in recurring operating expenditures, thereby hedging programmatic uncertainty and improving system-level efficiency in the architecture.

The paper closes with recommendations from the case study to stakeholders concerned with human and robotic exploration missions, outlining a roadmap for potential implementation of Federated Satellite Systems in future programs.