Paper ID: 15028
oral
student

SPACE SYSTEMS SYMPOSIUM (D1)
Space Systems Architectures (4)

Author: Mr. Fabio Nichele
Politecnico di Torino, Italy, fabio.nichele@polito.it

Mr. Guido Ridolfi
Politecnico di Torino, Italy, guido.ridolfi@polito.it
Dr. Sabrina Corpino
Politecnico di Torino, Italy, sabrina.corpino@polito.it

SYSTEM OF SYSTEMS ANALYSIS OF LOW-COST SMALL-SATELLITES SOLUTIONS FOR END-USER ORIENTED SPACE-BASED SERVICES

Abstract

The low-cost exploitation of space has experienced an increasing trend of interest from the scientific community in the last decade. The will of providing reliable space-based services at lower cost dictates for brand-new approaches to space activities, driven by the assessment of different design alternatives to focus the interest on most promising architectures. Objective of the research is to study the impact of a low-cost non-commercial constellation of small satellites and ground stations in a System of Systems (SoS) scenario. The idea is to integrate the constellation as a complementary distributed system in existing space SoS, exploiting emergent behaviours of this interaction. The interoperability of existing ground and space assets, together with the shift from a product-oriented design to a service-oriented one, addresses the SoS as an end-user oriented architecture. A set of solutions based on the users' requirements and priorities have been evaluated and potential additional services identified. Preliminary analysis focused on how the existing space and ground architectures for science, Earth imaging, navigation, and commercial GSM communication could be used as a SoS in support of the identified purpose, and to what extent a low-cost constellation could integrate more expensive payloads already in orbit. The best architecture providing global coverage and low-cost requirement has been pursued. Performances , in terms of number of users and quality of service, have been used as main drivers to set up an optimization process. Distributed, multi-system, mathematical models have been developed to assess the performances. The number of satellites has been adjusted to study the effect on performances and constraints, in perspective of an eventual expansion of the constellation, further discussing the effect of a potential loss of some satellites. Cost and global coverage figures-of-merit have been identified as main objectives for the design and optimization process. Cost-minimizing has been studied on qualitative measure based on the number of satellites, orbital parameters, different orbital planes, Orbit Cost Functions. The global coverage has been considered on a time basis using GAP-time functions aimed at minimizing the global gap. Amongst the innovative aspects of the proposed research it is worth mentioning the innovative approach to space SoS modeling and design. As an example of the design methodology, the development of a new use of GNSS for low-cost Earth-observation has been pursued, and the implementation of the related technology proposed for the development of a remote sensing nano-satellite constellation.