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VIRTUAL SATELLITE MISSIONS FOR EARTH OBSERVATION: DEMOCRATIZING ACCESS TO
SPACE**Abstract**

Access to space, including space-based Earth Observation capabilities, is restricted to a very limited number of stakeholders and players worldwide. Among other factors, this is due the high capital cost barrier of entering the space business. In order to amortize such large investments and hedge financial risks associated with launch, current Earth Observation missions adopt two different paradigms: either use highly-capable monolithic spacecraft with long lifetimes (to reduce number of launches), or use a series of smaller spacecraft to distribute risk among multiple missions. However, both approaches have downsides. No replacements and on-orbit repair activities are currently possible for large monolithic spacecraft; therefore, those platforms require expensive redundancy in order to ensure sustained performance over their lifetimes. On the other hand, while distributed satellite missions offer an advantage in terms of resiliency and the ability to take spatially and temporally distributed measurements, they do not overcome the issue of high launch costs. Furthermore, small platforms imply more stringent mass, power, and size constraints, which limit the performance of the instruments being flown.

The goal of this paper is to describe the concept of Virtual Satellite Missions (VSMs). Building on the concept of federated satellite systems and in-space cloud computing infrastructure, virtual missions leverage the particular capabilities and instrumentation of deployed spacecraft of any size to create customized, mission-tailored sensory architectures, by leasing services and obtaining data products across different platforms without launching a new dedicated mission. The use of multi-observation data fusion techniques and the implementation of the federated satellite systems paradigm enable new types of user-configured missions to be executed by existing assets supporting space missions without large upfront investments.

In this paper we introduce the notion of VSMs and propose a framework to define and identify opportunities for virtual missions. The proposed framework identifies virtual missions gaining the greatest profit in terms of cost and/or performance, and defines the conditions for which virtual missions appear to be favorable compared to traditional missions. The paper illustrates our proposed approach developing a case study for the assessment of value of virtual satellite missions for Earth Observation applications, starting from the analysis of capabilities of Earth Observation missions currently in orbit. The paper ends with recommendations for further development of the virtual satellite missions' concepts and identifies areas of opportunity for the democratization of access to space and to affordable space-based Earth Observation.