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Author: Prof. Marco Sabatini
Sapienza University of Rome, Italy

Mr. David Paolo Madonna
Sapienza University of Rome, Italy
Dr. Leonard Felicetti
Cranfield University, United Kingdom
Mr. Alex Shufflebotham
Cranfield University, Cranfield UK, United Kingdom
Dr. Saurabh Upadhyay
Cranfield University, United Kingdom
Mr. Konstantinos Platanitis
Cranfield University, UK, United Kingdom
Prof. Rene Laufer
Luleå University of Technology, Sweden
Mr. Olle Persson
Luleå University of Technology, Sweden
Mr. Harish Rao Ramavaram
Department of Space Engineering, Lulea University of Technology, Sweden

ADVANCES IN THE REALIZATION OF A FEDERATED LABORATORIES NETWORK FOR TESTING FORMATION FLYING TECHNOLOGIES

Abstract

The growing interest in distributed space systems composed of numerous small satellites, combined with the low readiness level of key technologies for autonomous and coordinated relative motion, has been the primary driver for the implementation of the FedLabs project. This initiative, part of NATO's Science for Peace and Security Programme, brings together three research centers—Sapienza University of Rome (Italy), Cranfield University (United Kingdom), and Luleå University of Technology (Sweden). The project aims to establish a network of Federated Laboratories (hence the name FedLabs), where, much like in satellite formations, technological capabilities are shared across multiple research facilities in different countries to achieve a common goal. The project primarily focuses on testing Guidance, Navigation, and Control (GNC) algorithms, particularly for micro- and nano-satellites. At the International Astronautical Congress 2024 in Milan, the rationale, objectives, and organizational structure of FedLabs were introduced. Now, after a year of progress, we present the latest advancements and the current status of the FedLabs infrastructure. The project activities are divided into two key areas:

1. **Numerical development and assessment** of formation mission objectives and the required GNC architecture.
2. **Design and implementation** of the hardware infrastructure

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Regarding the first area, two primary mission scenarios have been investigated, with corresponding guidance strategies and control algorithms developed and numerically tested: the case of multiplatform

Earth observation missions, and the case of constellations of satellites ensuring resilient communication between two ground stations thanks to time varying intersatellite links. Results, performance and potential for experimental replication within FedLabs will be presented. In parallel, the second area involved analyzing the capabilities and limitations of each partner laboratory to define, procure, and implement the necessary upgrades. As a result, the facilities are now fully operational and ready to conduct formation-flying experiments. These experiments will involve at least three free-floating platforms simulating both Earth observation and inter-satellite communication missions. This paper will showcase the achieved milestones, ongoing developments, and the future experimental roadmap of the FedLabs initiative