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Author: Dr. Lorenzo Frezza  
Sapienza University of Rome, Italy

Mr. Angelo Fabbri  
Sapienza University of Rome, Italy

Ms. Michela Boscia  
Sapienza University of Rome, Italy

Mr. Sidhant Kumar  
Sapienza University of Rome, Italy

Prof. Patrick Seitzer  
University of Michigan, United States

Mr. Niccolò Picci  
Sapienza University of Rome, Italy

Mr. Emanuele Bedetti  
Sapienza University of Rome, Italy

Mr. Diego Amadio  
Sapienza - University of Rome, Italy

Dr. Lorenzo Mariani  
Sapienza University of Rome, Italy

Dr. Gaetano Zarcone  
University of Rome "La Sapienza", Italy

Mr. Lorenzo Cimino  
Sapienza University of Rome, Italy

Mr. Matteo Rossetti  
University of Rome "La Sapienza", Italy

Mr. Shariar Hadji Hossein  
Sapienza University of Rome, Italy

Ms. Mascia Bucciarelli  
University of Rome "La Sapienza", Italy

Ms. Carolina Ghini  
Sapienza University of Rome, Italy

ADVANCES IN SPACEBORNE LED PAYLOADS ATTITUDE DETERMINATION AND  
AUTONOMOUS UNITS DESIGN FOR SPACE TRAFFIC MANAGEMENT

**Abstract**

In the extremely complex framework of space debris prevention and Space Traffic Management (STM) tasks, Light-Emitting Diodes (LEDs) payloads for ground-based optical identification, orbit and attitude determination have been recognized of innovative tracking methods for new satellite missions and included in the IAF-IAA-IISL Space Traffic Management report signed in 2022. The LED usage for Space Traffic Management exploits LED-based payloads on-board spacecraft that are commanded to flash with

pre-determined or ground-controlled patterns, and observatories at ground for the data collection and interpretation. Technology demonstrations have been performed by the Sapienza Space Systems and Space Surveillance (S5Lab) research team with two nano-satellite missions (WildTrackCube-SIMBA and LEDSAT, both coordinated by the Italian Space Agency, ASI) launched in 2021. This experimentation has led to the first results in 2021 and 2022 with the LED-standalone identification of both satellites (with focus on WildTrackCube-SIMBA being immediately identified in a cluster of 29 CubeSats), orbit determination, light-based back-up communication and preliminary attitude reconstruction. In the last year, the operations team has managed to exploit the LEDSAT data to achieve and optimize the LED-stand-alone attitude determination. This topic is of exceptional importance since attitude cannot be in general determined from ground for non-cooperating or malfunctioning objects, while LEDs have demonstrated to provide sufficient accuracies of few degrees per-axis. The determination has been performed over several observations, combining the operations of LED panels mounted on different faces of the nano-satellite over passes over the optical ground stations. The final determination exploits advanced methods of optimization, such as Particle Swarm filters. Furthermore, as LED payloads for LEDSAT and WildTrackCube-SIMBA are specifically designed for 1U CubeSats, a generalization of the design for all spacecraft, with the design of autonomous units with common nano-, micro- and larger satellite platforms has been carried out with the proposal of the project LEDSAT 2 for the new call of the “FYS Design Booster” project by ESA. This paper will deal with the advances in LED design and exploitation for space environment monitoring, space debris remediation and STM of all satellites. After an introduction over the missions and previously achieved results, the advances from the last year of satellite operations will be in-detailed described. Such achievements will be described with the main lessons learned from the operations in the perspective of a future broader utilization of LED payloads. Finally, future tasks, planned operations and possible future mission profiles will be described.