Politecnico di Torino

AEROSPACE ENGINEERING

DIMEAS/INAF - Design, analysis, and validation of the highly stable optomechanical system for a 32U CubeSat to achieve sub-milliarcsecond measurements precision

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Context of the research activity	Astrometric space missions require exceptional stability (often demanding picometer-level precision) to achieve their scientific objectives. While traditional missions utilize large platforms, the emerging trend toward cost-effective CubeSats presents a paradigm shift alongside unprecedented optomechanical challenges. Preliminary investigation about the feasibility of the miniaturization of opto-mechanical configuration 1-meter telescope for CubeSat environment is already performed. This PhD project details the comprehensive design, analysis, and validation of the highly stable optomechanical system for a 32U CubeSat dedicated to achieving sub-milliarcsecond measurements precision.
Objectives	The core challenge addressed of the proposed research is maintaining the optical system's Line-of-Sight (LOS) stability and Wavefront Error (WFE) integrity within the CubeSat's severe thermal and vibration environments, constrained by limited volume and stringent mass budgets. The adopted approach integrates a custom TMA (three mirror anastigmat) telescope housed within a low Coefficient of Thermal Expansion (CTE) structure. Critical efforts focused on developing novel, semi-kinematic mirror mounting interfaces designed to decouple the sensitive optical elements from the thermally- and mechanically-driven structural deformations of the satellite bus. Iterative Finite Element Analysis (FEA) and Thermal Distortion Analysis (TDA) need to be employed to model and mitigate LOS jitter and WFE degradation across launch, survival, and operational thermal cycles. A key aspect is the design of a passive thermal compensation strategy utilizing strategic material placement to nullify residual long-term thermal gradients. Environmental testing, including thermal-vacuum and representative vibration campaigns, will be required, to demonstrate that the WFE degradation remains below lambda/50 and to achieve a LOS stability better than 100 micro-as RMS across the primary field of view. The architecture needs to provide compelling evidence that the CubeSat platform is mature enough to host cutting-edge,

	high-precision astronomical instrumentation, thereby enabling next-generation distributed constellation missions for astrophysics and exoplanet detection. The objectives of the proposed research are: 1. Define and analyse the boundary conditions and the interfaces given by the astronomic requirements, given by the exo-planets search study case. 2. Provide a schematic conceptual mechanical design of the payload, integrated with FEA analysis and TDA analysis, as much as possible. 3. Develop an opto-mechanical breadboard design, suitable for hosting the electronic subsystem, for laboratory tests aimed at demonstrating the results. 4. Carry on laboratory activities on a TMA+FPA System lab prototype in order to validate the model and the results 5. Provide a detailed opto-mechanical report in ECSS format. The activities will be conducted in strict collaboration with the Opto-mechanical team and the Electronical team of the satellite project.

Skills and competencies for the development of the activity	The ideal candidate must have good background in mechanical design, optomechanical analysis, finite element analysis (FEA), and TDA. Knowledge of 3D-CAD software, programming languages such as Python and ECSS standards are also required. Knowledge in thermal-centric modeling software (Ansys Thermal Desktop), experimental skills and familiarity with laboratory equipment are a plus. The candidate must demonstrate analytical thinking and the ability to work in an interdisciplinary environment, as well as proficiency in scientific English.