

Multi-Functional Optical Ground Station Testbed and Hardware-in-the-Loop Simulator

This contribution presents the development of an experimental testbed and hardware-in-the-loop simulator for a multi-functional optical ground station (OGS) being established in Portugal. The system is centered around a 43 cm Planewave CDK17 telescope mounted on an L500 Alt-Az platform, enhanced with a Planewave Series 5 focuser and a custom-designed optical breadboard integrated at the Cassegrain focus. This modular breadboard supports a range of advanced functionalities, including imaging, plate-solving, real-time beacon acquisition, closed-loop tip-tilt correction using one or two fast steering mirrors, and a quadrant photodiode, and turbulence analysis through a custom Shack-Hartmann sensor assembly.

The OGS further supports classical free-space optical communication at C-band, for both transmission and reception, leveraging FPGA-based systems within open-source development frameworks. Quantum communication capabilities are also integrated, with a dedicated broadband optical path for BB84 polarization-encoded signal detection and an alternative configuration for phase-encoded signals at telecom wavelengths. In the latter, quantum signals are coupled to single-mode fibers for delivery to remote detection nodes. Multiplexing and demultiplexing strategies combine dichroic elements with configurable wavelength division multiplexing, enabling reconfigurable operation across classical and quantum domains.

Lab integration is ongoing, with field tests planned to evaluate performance under diverse sky conditions ranging from urban high-Bortle environments to dark-sky locations. The testbed is conceived as a flexible, open architecture platform to support experimentation, training, and integration into international optical and quantum communication initiatives. We welcome collaborative opportunities to further develop and share this emerging capability.

Author: NIEHUS, Manfred (Physics Department ISEL - Instituto Superior de Engenharia de Lisboa, Instituto Politécnico de Lisboa)

Co-authors: Dr SERRADOR, António (Electronic, Telecommunication and Computer Engineering Department ISEL - Instituto Superior de Engenharia de Lisboa, Instituto Politécnico de Lisboa); Mr CASTANHEIRA DA SILVA, João (Electronic, Telecommunication and Computer Engineering Department ISEL - Instituto Superior de Engenharia de Lisboa, Instituto Politécnico de Lisboa); Mr M. CARVALHO, João (Mechanical Engineering Department CIMOSM, ISEL - Instituto Superior de Engenharia de Lisboa, Instituto Politécnico de Lisboa); Dr FERNANDES, Miguel (Electronic, Telecommunication and Computer Engineering Department ISEL - Instituto Superior de Engenharia de Lisboa, Instituto Politécnico de Lisboa); Dr J.G.C.MENDES, Mário (Mechanical Engineering Department CIMOSM, ISEL - Instituto Superior de Engenharia de Lisboa, Instituto Politécnico de Lisboa)

Presenter: NIEHUS, Manfred (Physics Department ISEL - Instituto Superior de Engenharia de Lisboa, Instituto Politécnico de Lisboa)

Session Classification: Poster Tea Time