Croatian Optical Ground Station as a QKD Node Connecting Zagreb Metropolitan Network and Germany via European Eagle-1 Satellite

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Across Europe, the push for quantum-safe communication networks has accelerated the design and construction of optical ground stations (OGS) tailored to support satellite-based quantum key distribution (QKD). QKD leverages quantum mechanics principles to enable unconditionally secure key exchange and eavesdropping detection. While terrestrial fiber-based QKD faces distance limitation due to attenuation (~0.2 dB/km at 1550 nm), satellite-mediated links can overcome this constraint by utilizing free-space properties.

We present the Croatian Optical Ground Station in Zagreb (OGSZG) as a pivotal element in the bilateral Croatia–Germany QuGNOPs (Deployment and Operations of Quantum Ground Nodes) project, launched on January 1, 2026. QuGNOPs establishes infrastructure for satellite-based QKD using the European Eagle-1 satellite, connecting optical ground stations in Zagreb and Oberpfaffenhofen (near Munich) to demonstrate secure cross-border quantum links. The OGSZG continues and extends the national Croatian Quantum Communication Infrastructure (CroQCI) into the space domain, bridging terrestrial and satellite quantum networks.

Scheduled for completion by mid-2026 with CroQCI funding, Phase 1 equips the station with an 80 cm Ritchey-Chrétien telescope (Coudé path, C-band/1550 nm optimized), a motorized dome and LEO-tracking mount, wide- and narrow-field cameras for pointing, acquisition, and tracking (PAT), tip-tilt compensation to address atmospheric turbulence, and integration into CroQCI's entanglement-based BBM92 terrestrial QKD network. [1]

Phase 2, backed by QuGNOPs, will add adaptive optics for enhanced turbulence correction, a classical optical communications terminal, and a quantum receiver designed for Eagle-1 compatibility featuring superconducting nanowire single-photon detectors. This configuration ensures full compatibility with Eagle-1's C-band phase-encoded decoy-state BB84 protocol [2] and positions the station for planned European space-based QKD initiatives, including future missions.

This integrated architecture addresses key challenges in free-space quantum links, particularly atmospheric turbulence in an urban setting, while improving coupling efficiency into single-mode fiber and secret key rates. By positioning OGSZG within QuGNOPs, the project strengthens Germany–Croatia cooperation, advances sovereign European quantum-secure communications, and contributes to the European Quantum Communication Infrastructure (EuroQCI).

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References

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