Towards Airborne Quantum Links: Drones, High-Altitude Balloons, and Single-Photon Technologies

Christoph Wildfeuer[1], Boris Korzh[2], André Stefanov[3]

[1]*FHNW School of Engineering, 5210, Windisch, Switzerland*

[2]*University of Geneva, 1211, Geneva, Switzerland*

[3]*University of Bern, 3012, Bern, Switzerland*

Free-space quantum communication is a promising route towards secure networks beyond terrestrial fiber and toward future satellite quantum links. We present our ongoing work on airborne free-space quantum communication using drones and high-altitude balloons, with emphasis on the single-photon and optical subsystem technologies required for robust field deployment.

These platforms help bridge the gap between laboratory experiments and operational systems. High-altitude balloons provide a practical environment for testing components under realistic atmospheric and tracking conditions, while drones enable the study of mobile link architectures,

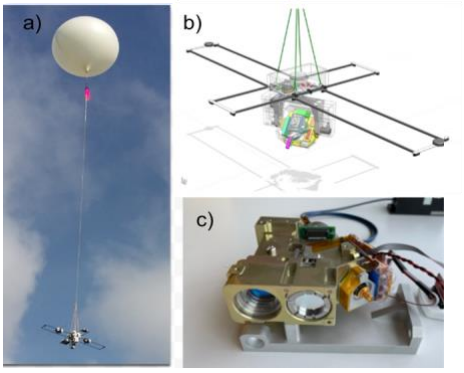

Fig. 1 *a) High-altitude balloon with optical payload designed at FHNW. b) Balloon-gimbal design with c) laser communication terminal below.*

Fig. 2 *(Left) FHNW drone tests with optical ground station (OSG). (Middle) Drone and 2-axis gimbal design. (Right) Portable OGS from GA-Synopta.*

compact optical payloads, and acquisition, pointing, and tracking techniques. Beyond communication engineering, these platforms also support experiments in entanglement distribution and single- and two-photon interference under realistic free-space conditions. Drones and high-altitude balloons thus provide valuable testbeds for future hybrid terrestrial, airborne, and space quantum networks, and are ideal to increase the TRL of quantum technologies towards airborne systems.

References

[1] A. Conrad, et.al., "Drone- and vehicle-based quantum key distribution," arXiv [quant-ph] (2025).

[2] I. Karakosta-Amarantidou, et.al., "Free-space model for a balloon-based quantum network," Phys. Rev. Res. 7(2), (2025).

[3] NA. Villar, et.al., "Entanglement demonstration on board a nano-satellite," Optica 7(7), 734 (2020).

[4] I. Craiciu, B. Korzh, A. D. Beyer, A. Mueller, and J. P. Allmaras, "High-speed detection of 1550 nm single photons with superconducting nanowire detectors," Optica (2023).