

Munich Quantum Network (MuQuaNet)



The MuQuaNet (“Munich Quantum Network”) is a QKD testbed that is building the first quantum-secure network in the Munich region, funded by dtec.bw, with a project window from October 1, 2020, to December 31, 2026. It links partners, including ZITiS, LMU, Airbus, BWI, DLR, and several UniBwM institutes, over leased dark fiber or free-space, and operates QKD devices from different

vendors/protocols as well as a self-developed free-space system, together with LMU. The target scale is 13 nodes, combining terrestrial fiber with free-space optical paths to study networked QKD and its integration with classical network technologies like VPNs. Beyond the transport layer, MuQuaNet develops a QKD key-management system with demonstrator applications and conducts security analyses, positioning the network as a blueprint for future high-security communications for ministries, agencies, industry, and the military.



MuQuaNet AVLS Studio

A: Brief Information

Testbed Title	Munich Quantum Network (MuQuaNet)
Institution/Organization	Universität der Bundeswehr München
Contact	Dr. Nils gentschen Felde, felde@unibw.de
	Fabian Farina, fabian.farina@unibw.de
Status	DLR-LMU and ETTI-EIT are planned; all others are active

B: Technical Information

Start Point	End Point	Length [km]	Losses [dB]	Supported Wavelengths [nm]	polarization stabilization
Deutsches Zentrum für Luft- und Raumfahrt (DLR)	Oberpfaffenhofen - Ludwig-Maximilians-Universität (LMU)	-	-	C-Band (1550 nm)	No
Ludwig-Maximilians-Universität (LMU)	BWI	9.7	3.0	C-Band (1550 nm)	No
Ludwig-Maximilians-Universität (LMU)	Zentrale Stelle für Informationstechnik im Sicherheitsbereich (ZITiS)	17.4	3.9	C-Band (1550 nm)	No
BWI	Zentrale Stelle für Informationstechnik im Sicherheitsbereich (ZITiS)	11.6	4.8	C-Band (1550 nm)	No
Zentrale Stelle für Informationstechnik im Sicherheitsbereich (ZITiS)	Forschungsinstitut CODE	12.5	4.0	C-Band (1550 nm)	No
Forschungsinstitut CODE	Universität der Bundeswehr München (UniBwM), Fakultät für Informatik	6.1	4.2	C-Band (1550 nm)	No
Universität der Bundeswehr München (UniBwM), Fakultät für Informatik	Universität der Bundeswehr München (UniBwM), Rechenzentrum	0.7	0.4	810 nm	Yes
Universität der Bundeswehr München (UniBwM), Fakultät für Informatik	Universität der Bundeswehr München (UniBwM), Fakultät für Elektrotechnik und Technische Informatik (ETTI)	3.2 & 1.1	1.4 & 2.3	C-Band (1550 nm) & 810 nm	Yes
Universität der Bundeswehr München (UniBwM), Fakultät für Informatik	Universität der Bundeswehr München (UniBwM), dtec.bw-Geschäftsstelle	0.7 & 1.6	0.5 & 0.6	810 nm & 810 nm	Yes

Universität der Bundeswehr München (UniBwM), Rechenzentrum	Universität der Bundeswehr München (UniBwM), dtec.bw-Geschäftsstelle	1.6	0.6	810 nm	Yes
Universität der Bundeswehr München (UniBwM), Rechenzentrum	Universität der Bundeswehr München (UniBwM), Fakultät für Elektrotechnik und Technische Informatik (ETTI)	1.6	0.5	C-Band (1550 nm)	Yes
Universität der Bundeswehr München (UniBwM), dtec.bw-Geschäftsstelle	Universität der Bundeswehr München (UniBwM), Fakultät für Elektrotechnik und Technische Informatik (ETTI)	3.2	1.4	C-Band (1550 nm)	Yes
Universität der Bundeswehr München (UniBwM), Fakultät für Elektrotechnik und Technische Informatik (ETTI)	Universität der Bundeswehr München (UniBwM), Fakultät für Elektrotechnik und Informationstechnik (EIT)	-	-	C-Band (1550 nm)	Yes
Universität der Bundeswehr München (UniBwM), Fakultät für Elektrotechnik und Technische Informatik (ETTI)	Airbus, Ottobrunn	3.0	30	850 nm	No
Type of Transmission	UniBwM, ETTI – Airbus, Ottobrunn: free space link, all other segments: dark fiber				
Type of Fiber	single mode				
Type of Deployment	UniBwM, ETTI – Airbus, Ottobrunn: Aerial, all other segments: underground				
Quantum Communication Infrastructure	refer to the photos				
Available Infrastructure for external Parties	access upon request and cooperation agreement				

C: Additional Information

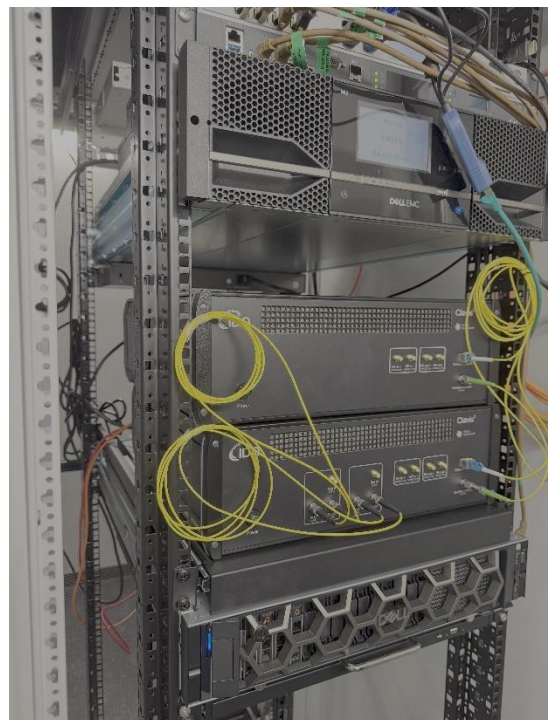
Linked Projects	<ul style="list-style-type: none">• MuQuaNet: https://www.unibw.de/muquanet
Press Release and Publications	<ul style="list-style-type: none">• Lucks, Stefan, David Schatz, and Guenter Schaefer. "On the Security of Opportunistic Re-Keying." ,2025• Kastrup, Swantje, and Nils gentschen Felde. "Towards Interconnected Quantum Networks: A Requirements Analysis." <i>IFIP International Conference on Information Security Theory and Practice</i>. Cham: Springer Nature Switzerland, 2024• Schatz, David, et al. "Virtual Private Networks in the Quantum Era: A Security in Depth Approach." <i>SECRYPT</i>. 2023• Farina, Fabian, et al. "QKD Key Management for Military Applications: A Study in the MuQuaNet Testbed." <i>Proceedings NATO STO: IST-SET-198 Research Symposium on "Quantum Technology for Defence and Security</i>, Amsterdam, 2023• Rohde & Schwarz Cybersecurity demonstriert quantensichere Verschlüsselung, 2022• Blaupause für den Aufbau hochsicherer Kommunikationsnetz, 2022• Europaweit erstes verschränkungsbasiertes System zur Quantenschlüsselverteilung an der Universität der Bundeswehr München in Betrieb genommen, 2022• Erste Teilstrecke im Dauerbetrieb, 2021

<p>Demonstrated Milestone</p>	<ul style="list-style-type: none">• deployment of first QKD link between UniBwM Campus and FI CODE (12/2021)• hacking QKD devices by exploitation of classical IT vulnerabilities (06/2022)• deployment of the second QKD link between FI CODE and ZITiS, which is the first with a project partner besides UniBwM (11/2022)• development and demonstration of UniBwM KMS for QKD relay with static routes (12/2022)• security analysis of the MuQuaNet infrastructure, together with TÜV IT (03/2023)• first in-field tests of free-space QKD link between ETTI (UniBwM) and Airbus, together with the LMU (05/2023)• development of a frigate remote maintenance demonstrator where QKD is used to secure the communication between a 3D-printed model and the operator working in a VR environment (08/2024)• development and demonstration of a multi-hop KMS for using real QKD systems with R&S®SITLine, together with Rohde & Schwarz (12/2024)• development and demonstration of a solution to integrate QKD into the SINA VPN architecture, based on Multipath Key Reinforcement, deployable in scenarios with partially deployed QKD links, together with secunet and TU Ilmenau (12/2024)• demonstration of the feasibility of the QKD SINA VPN solution by deploying Satmon@Home (DLR satellite monitoring program), together with DLR and TU Ilmenau (04/2025)• deployment of six entanglement-based QKD links on the UniBwM-Campus using optical beam splitters to reduce the number of required entanglement-sources (08/2025)• demonstration of a key loading station in combination with QKD paths for usage at the last mile or where QKD deployment is not feasible (09/2025)
--------------------------------------	---

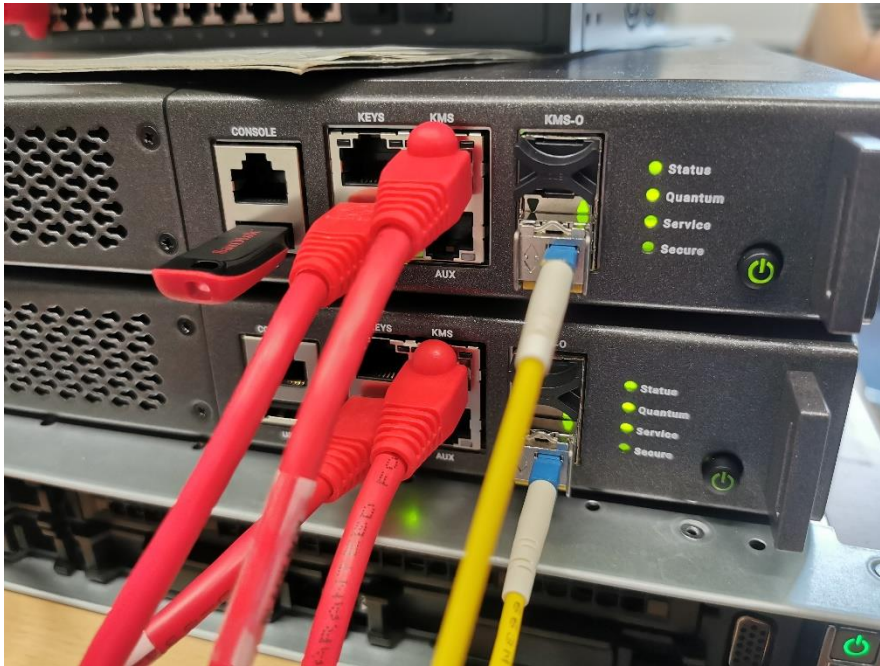
<p>Outlook</p>	<ul style="list-style-type: none">• Integration of QKD and classical networks by the development of integrated management concepts• Improving the security of key management by developing new methods for multipath relaying and for multi-domain QKD networks with varying trust assumptions• Improvement of the existing key management system by adding dynamic multipath routing and management interfaces• Demonstration of quantum communication for civil and military applications, i.e. encryption of sensitive data and integration of QKD in highly secure data streaming• Miniaturization of QKD components for the free-space link• QKD enhanced crypto telephony for military applications
<p>Suggested Use Cases</p>	
<p>Other Comments/ Information</p>	



Sina VPN with QKD test



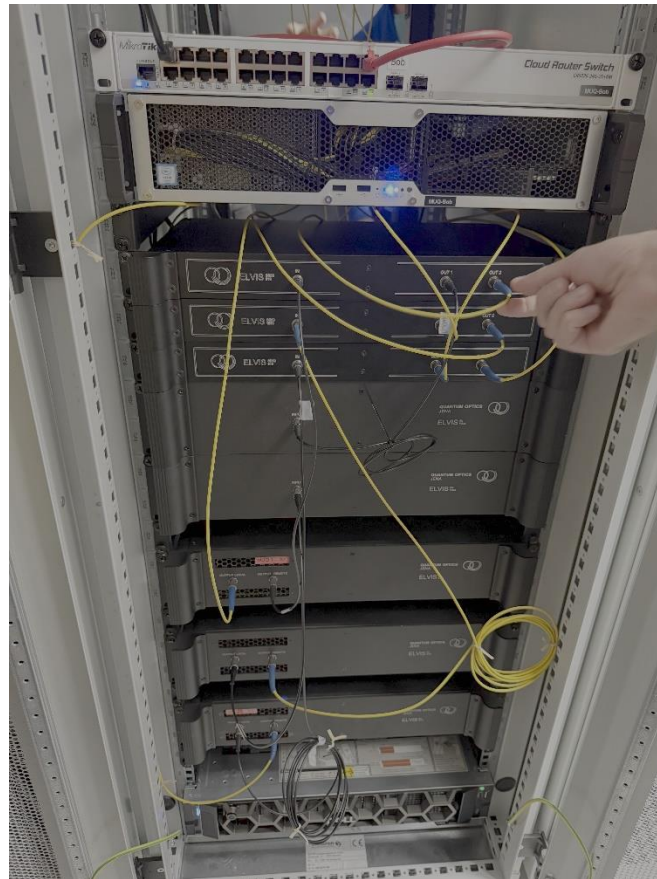
Code rack with IDQ clavis3



IDQ Clavis XGR devices



Rohde & Schwarz SitLine KMS with QKD-Test



Quantum Optics Jena elvis series with beam splitters



Rohde & Schwarz container patch panels