HellasQCI - Quantum Communication Infrastructure for Greece

Quantum Communications in Europe: EuroQCI Deployment and the HellasQCI Paradigm

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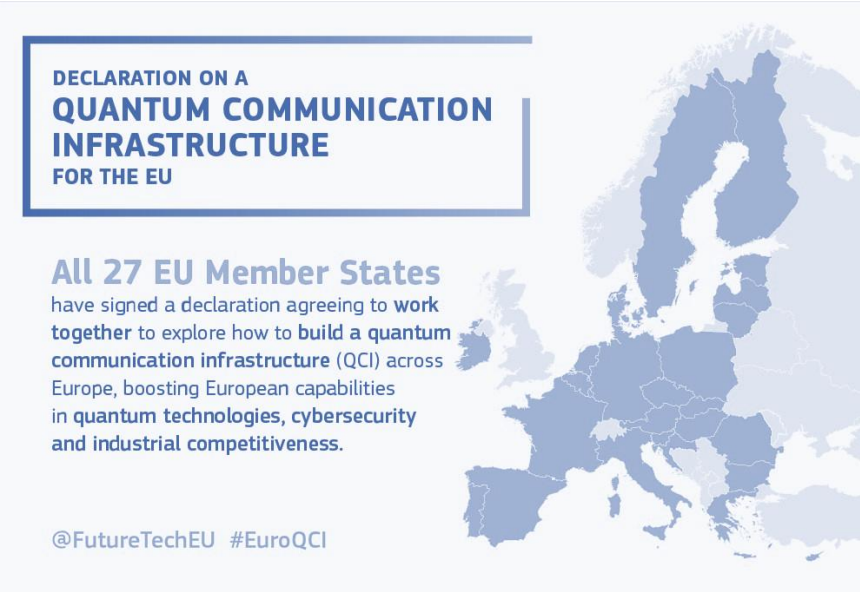
GÉANT SIG-Quantum

1 December 2025

EuroQCI Quantum Communication Infrastructure



June 2019 → All the 27 EU Member States (MS) signed the EuroQCI Declaration to establish the EuroQCI

MS with the European Commission and the European Space Agency to design and deploy the EuroQCI

Aim of the EuroQCI → safeguard sensitive data and critical infrastructures, providing an additional cyber-security layer based on quantum physics

EuroQCI → EU Addressing the quantum threat (Q-day)

Goal is to be operational by 2030 → EU-QCI: Governmental QKD Services - *EU SECRET*

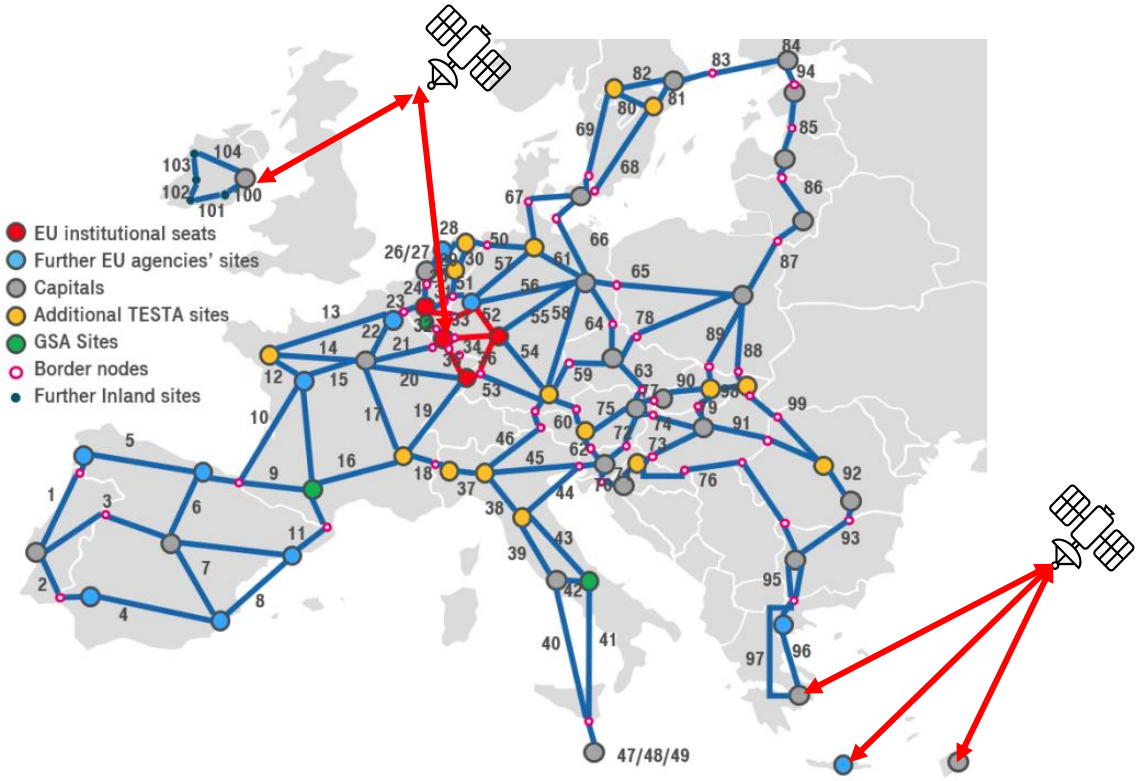
July 2025 → The Quantum Europe Strategy was published and targets to 5 areas R&I, Dual-Use, Quantum Infrastructure, Skills, Quantum Ecosystem

EuroQCI

EuroQCI Terrestrial and Space Segments

Terrestrial segment

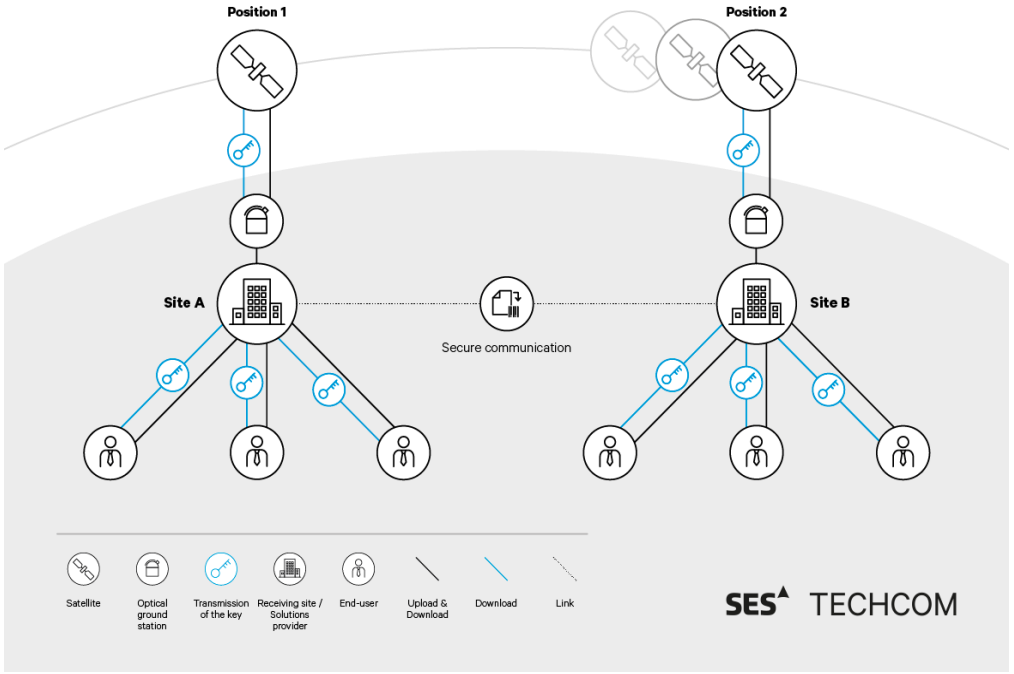
Implemented by the MS and the support of EC
Federation of national terrestrial QCI networks with cross-border connectivity → Total length of fibers 44,000 km



Jean-François Buggenhout "EU Quantum Technologies Flagship and the quantum internet"
ENISA TELECOM SECURITY FORUM, 29 June 2022

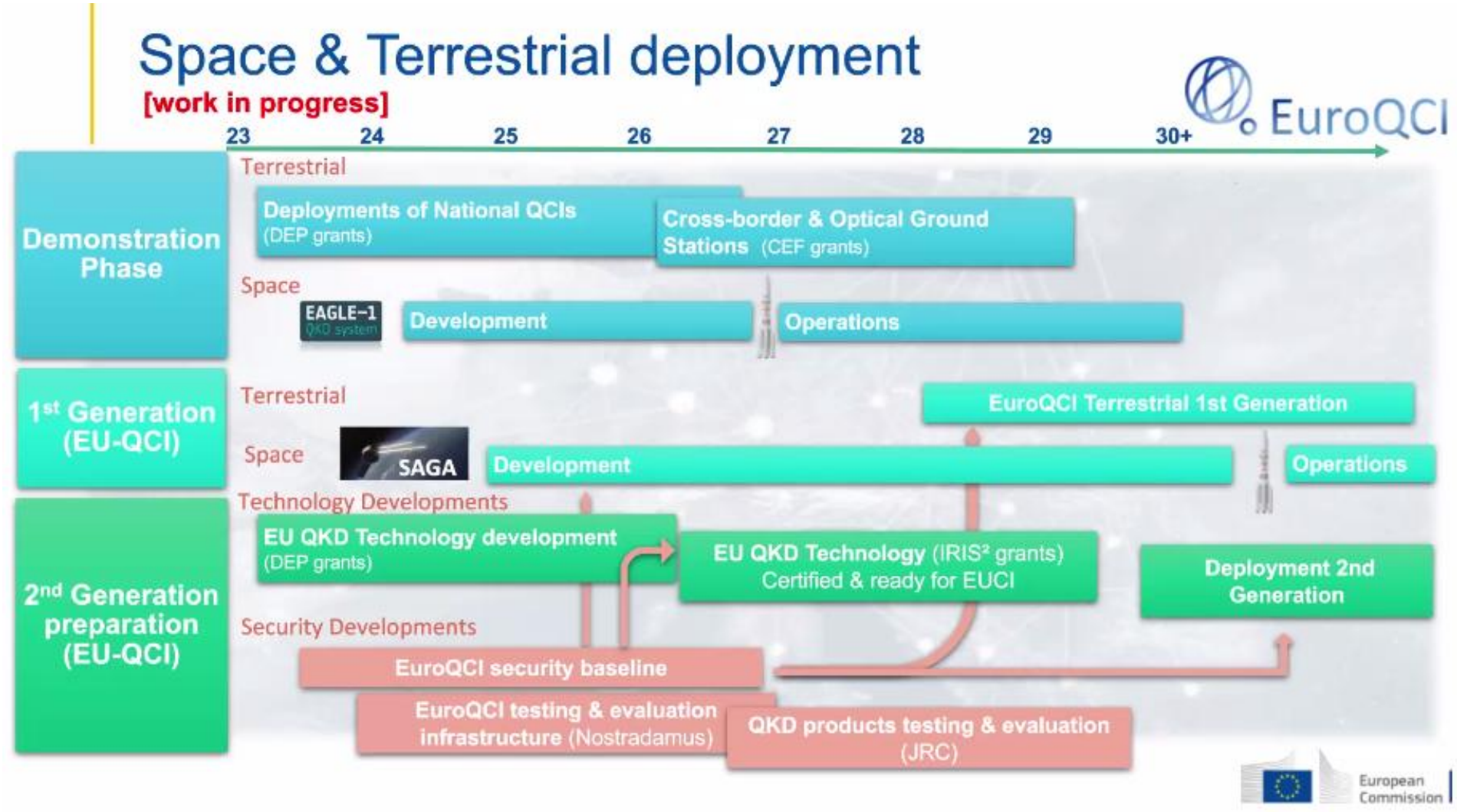
Space segment

Implemented by ESA → EAGLE-1 Satellite (Aug. 2026)
Distribution of quantum-secured encryption keys on an EU scale
Ideal for EU island countries → Alternative route in critical events



Operational EuroQCI → Interoperable and reliable Space and Terrestrial Segments (redundancy)

EuroQCI Timeline (9/2025)



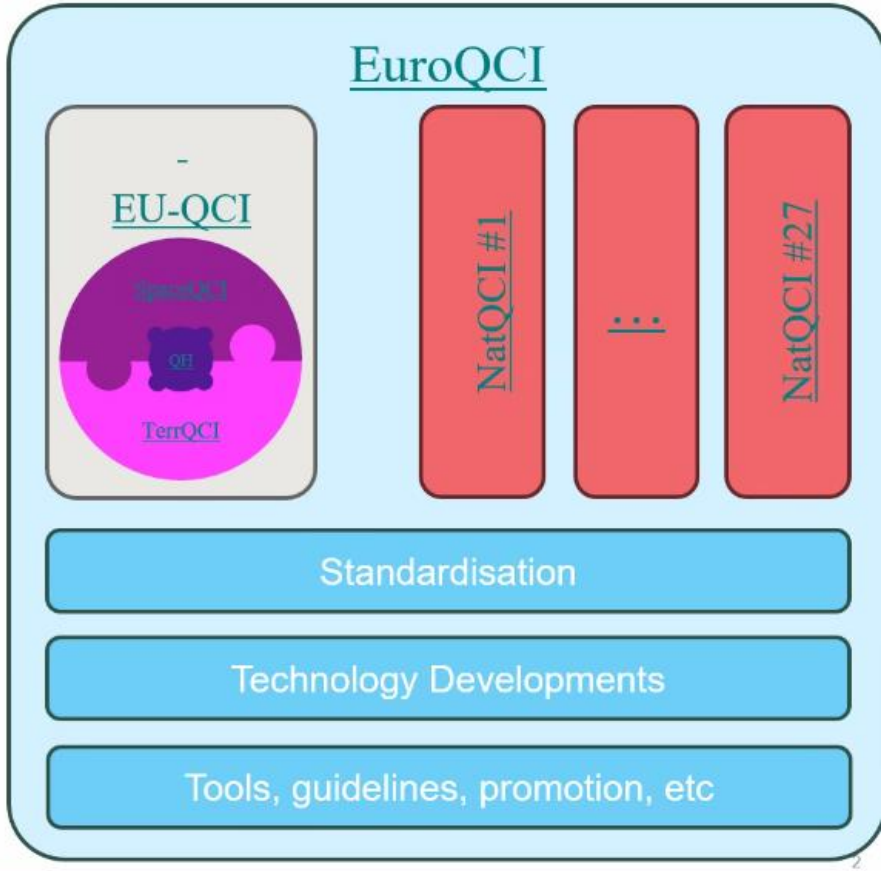
EuroQCI & EU-QCI

EuroQCI overview

EU-QCI - Quantum Communication Infrastructure in charge of the worldwide provision of the **EU Governmental QKD Service** for the protection of **EU Classified Information** (EUCI) only. It is composed of the Quantum Hub, SpaceQCI and TerrQCI.

NatQCI – A Quantum Communication Infrastructure within EuroQCI, owned and managed by a single Member State. NatQCIs may have their own terrestrial and space components.

EuroQCI transversal activities – standardisation, technology developments, tools, guidelines, promotion etc.



→ THE EUROPEAN SPACE AGENCY

EuroQCI Status in Greece

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HELLENIC REPUBLIC
Ministry of Digital Governance

grnet

MinDig signed the EuroQCI Declaration (2019)

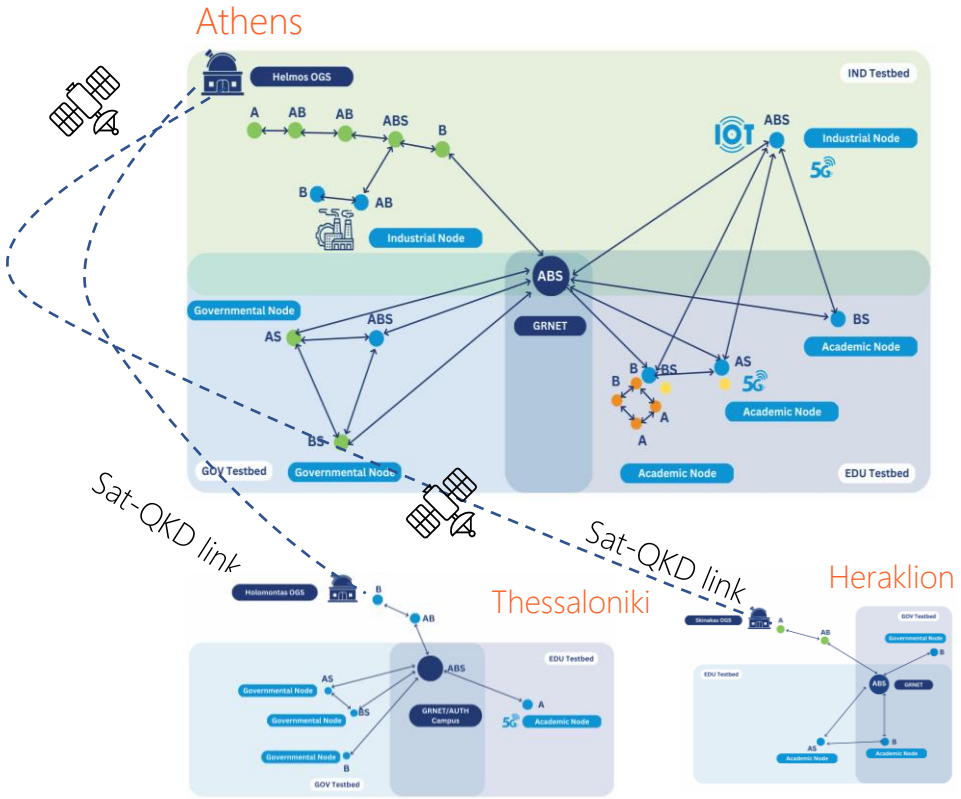
EuroQCI → part of the Digital Transformation Strategy of Greece (2020-2025 and 2026-2030)

GRNET was appointed by GSTP to participate in EuroQCI and coordinate Greece's DEP–CEF national proposals (2021)

1st Phase NatQCIs: The HellasQCI project was submitted in 2022 and started in 2023 → EuroQCI DEP

2nd Phase Cross-border: The SEEWQCI, TransEuroOGS projects were submitted in 2025 and will start in 2026 → EuroQCI CEF

HellasQCI National QCI terrestrial backbone networks



Deploy the national pilot quantum networks as part of the EuroQCI	• **3 national MAN test-sites (240km)**: Athens, Thessaloniki, Heraklion-Crete • Connecting geostrategic locations in Greece • **Terrestrial connectivity to 3 Observatories** (OGSs) to the closest MAN QKD network **(410km)**
Powerful MAN test-beds	• **3 domains:** GOV (NSAs), EDU, IND • **27 dedicated fiber links** for the HellasQCI Networks • **22 Permanent QKD nodes:** 16 GOV and 6 EDU • **2 Quantum Internet nodes** for the entanglement distribution network (EPPSs & SNSPDs)

HellasQCI Space segment connectivity

HellasQCI - Quantum Communication Infrastructure for Greece

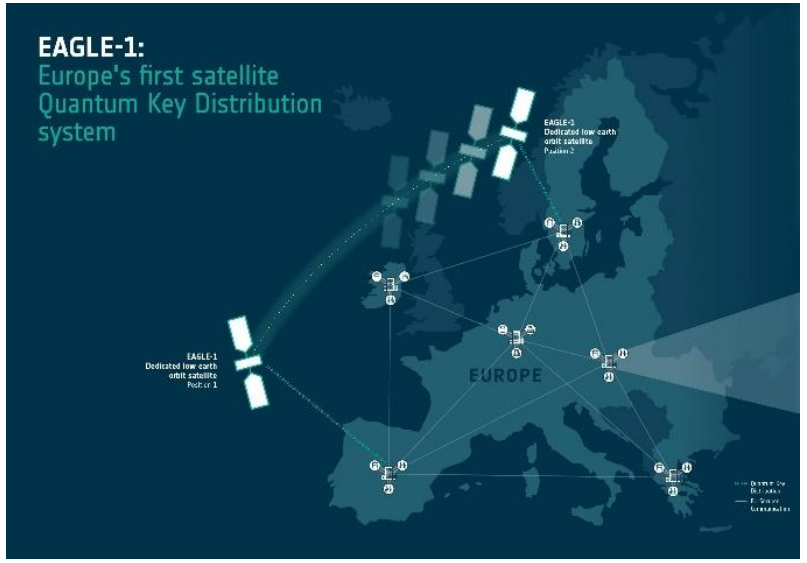
Space segment connectivity

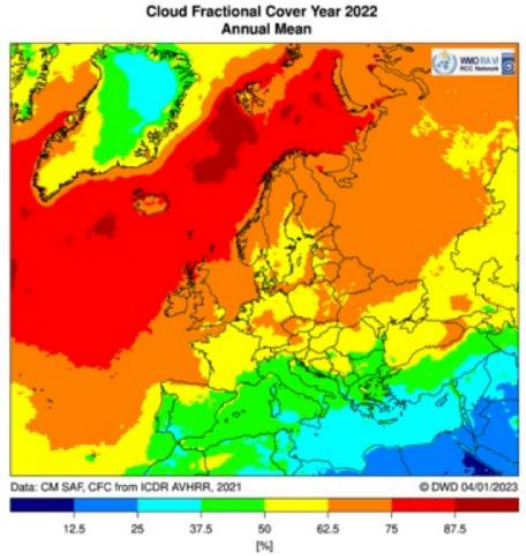
- HellasQCI provides interconnection to 3 Observatories – transformed to OGSs:
  - ✓ Helmos → Athens (270km)
  - ✓ Holomontas → Thessaloniki (80km)
  - ✓ Skinakas → Heraklion, Crete (60km)
- All Observatories are part of **ESA programmes:** Scylight, Hydron, SAGA and Greek Obs2OGS
- Upon the availability **of Eagle-1**, Greece aims to be among the 1st countries to validate & test EuroQCI both segments.
- Greece has the advantage (3 OGSs) and the ideal location (clear skies) to serve as **a hub for EuroQCI for the SEE.**
- Synergy with **OBS2OGS** project for smooth integration of terrestrial and satellite segment

Helmos Observatory
Altitude: 2340 m
2.3m Aristarchos optical telescope

Holomontas Observatory
Altitude: 861 m
1m optical telescope

Skinakas Observatory
Altitude: 1750 m
1.3m optical telescope





HellasQCI e-infra implementation Phases

Phase 0 (2023-2024)

Preparatory Phase

- In-kind equipment & fibers
- Procurements preparation
- **Athens PoC Quantum Network:**
  - ✓ 2-physical links (45km)
  - ✓ 3-node setup

Phase 1 (2025 - Present)

Implementation Phase

- HQCI equipment & fibers
- **Athens Quantum Network:**
  - ✓ 5-physical links (120km)
  - ✓ 8- node setup

Large International Demos

QCI Days 2025 Demo in GR
April 2025

15-node network: GR, AT, ES

ECOC 2025 Petrus Demo in DK
September/October 2025

7-interconnected domains EU member states: GR, ML, IT, ES, DE, AT, and LX

Currently implementing and completing the HQCI 17 Use Cases

Phase 2 (2026-end)

Final Deployment Phase

- QKD systems deployed at their permanent destinations
- Control and management of the HellasQCI network.

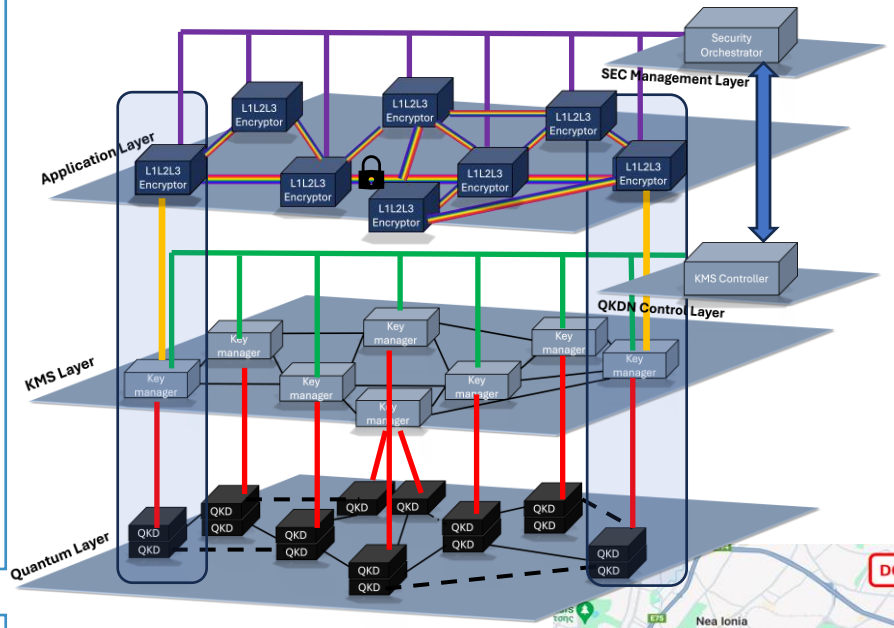
HellasQCI Phase 0

→ HellasQCI Architecture 3-layer format

QKD layer
Support relayed DV-QKD, switched QKD, support partial mesh deployment for optimized usage

KMS layer
Link with Application Layer (ETSI-QKD-18)
Perform advanced QKD-SDN controls (ETSI-QKD-15)
Transparency with QKD vendors (ETSI-QKD-14)

Application (Service) layer
L1, L2, L3 encryption + Maintain backwards compatibility with classical encryption schemes



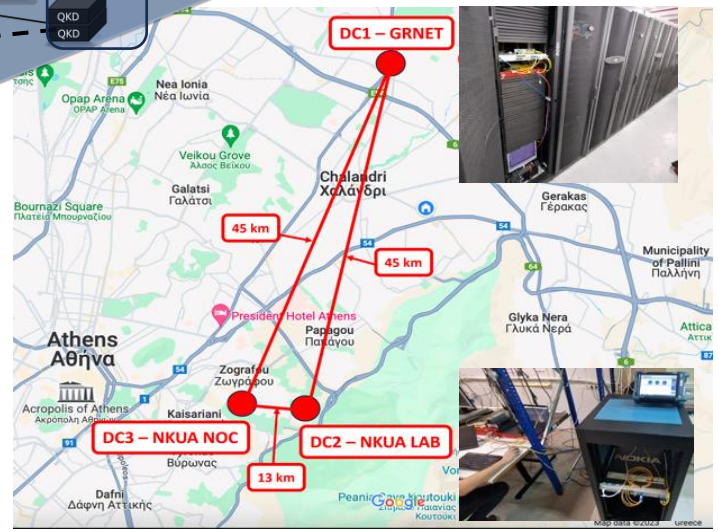
→ PoC validation (45km)

PoC to validate HellasQCI Architecture in a real field deploy testbed (L1-OTN): Complex topology of a 3-node full ring configuration GRNET- NKUA.

PoC key features and innovations: Hybrid operation – SMS orchestrates quantum and classical keys, Supports optimized QKD resources - requires less QKD pairs.

ECOC2024 FRANKFURT — Link

Forbes — Link



Phase 0→1 E-Infra deployment - major procurements completed

Dark fibers	QKD devices	Trusted nodes network equipment *	Quantum Internet equipment
27 links - 650km: 3 long-distance and 24 MAN → 20 links for the GOV sector and 7 links for the EDU Contracted: June 2024 Completed: September 2025	**11 x DV-QKDs:** 9x IDQ Clavis XG 30db & 2xThinkquantum QuKY 20db Contracted: April 2024 Estimated Completion: February 2026	**16 x Micro-DC racks:** APC NetShelter SX Contracted: January 2025 Completed: July 2025 **4 x Encryptors L1:** 1830 PSI-M + 1x SMS Contracted: June 2025 Estimated Completion: December 2025 **10 x Encryptors L3:** FortiGate 120 G Contracted: November 2025 Estimated Completion: February 2026	**16 x SNSPDs** SSPD-1550-80 Contracted: May 2024 Completed: December 2024 **2 x EPPSs** Contracted: December 2024 Completed: October 2025

*HellasQCI Trusted Nodes requirements

HellasQCI **comprehensive framework** for auditing and securing the GOV trusted nodes (NSAs and SAB agreement):

1. **The National Industrial Security Regulation (NISR):** The applicable legislative framework in Greece for classified information.
2. **ISO/IEC 27001** for information security and
3. **Information Technology Infrastructure Library (ITIL)**
4. **HellasQCI Audit methodology:** crucial role in ensuring the security of trusted nodes that host sensitive equipment and classified information.

→ *Trusted nodes (end and relay) into governmental and NSA premises and **Micro-DC racks** featuring biometric access and unified management controls.*

HellasQCI Phase 1

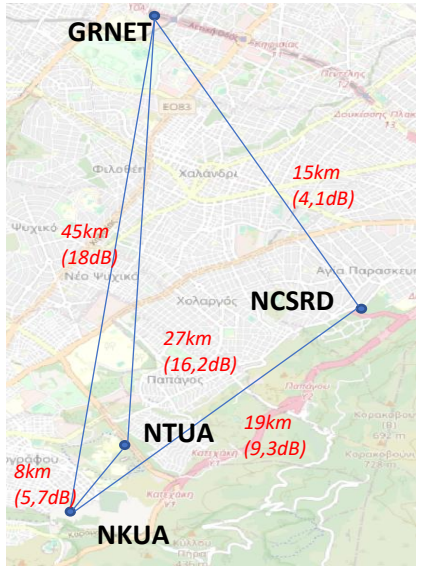
Athens Quantum Network setup - 120km

1st large scale QCI networks deployment in Greece

Extension of the Athens PoC with HellasQCI QKD devices and fibers

- From 45km to 120km,
- From 2 to 5 physical links,
- From 3 to 8 physical nodes

✓ To test & accept delivery of the HellasQCI QKDs
✓ Perform use-cases & prepare the ground for the large scale deployment
✓ Mirror the GOV and NSAs network in Athens
✓ EDU testbed → a pilot platform bridging research, innovation & industry



GRNET - NKUA
Total length: 45km (18db)

NTUA - GRNET
Total length: 27km (16,2db)

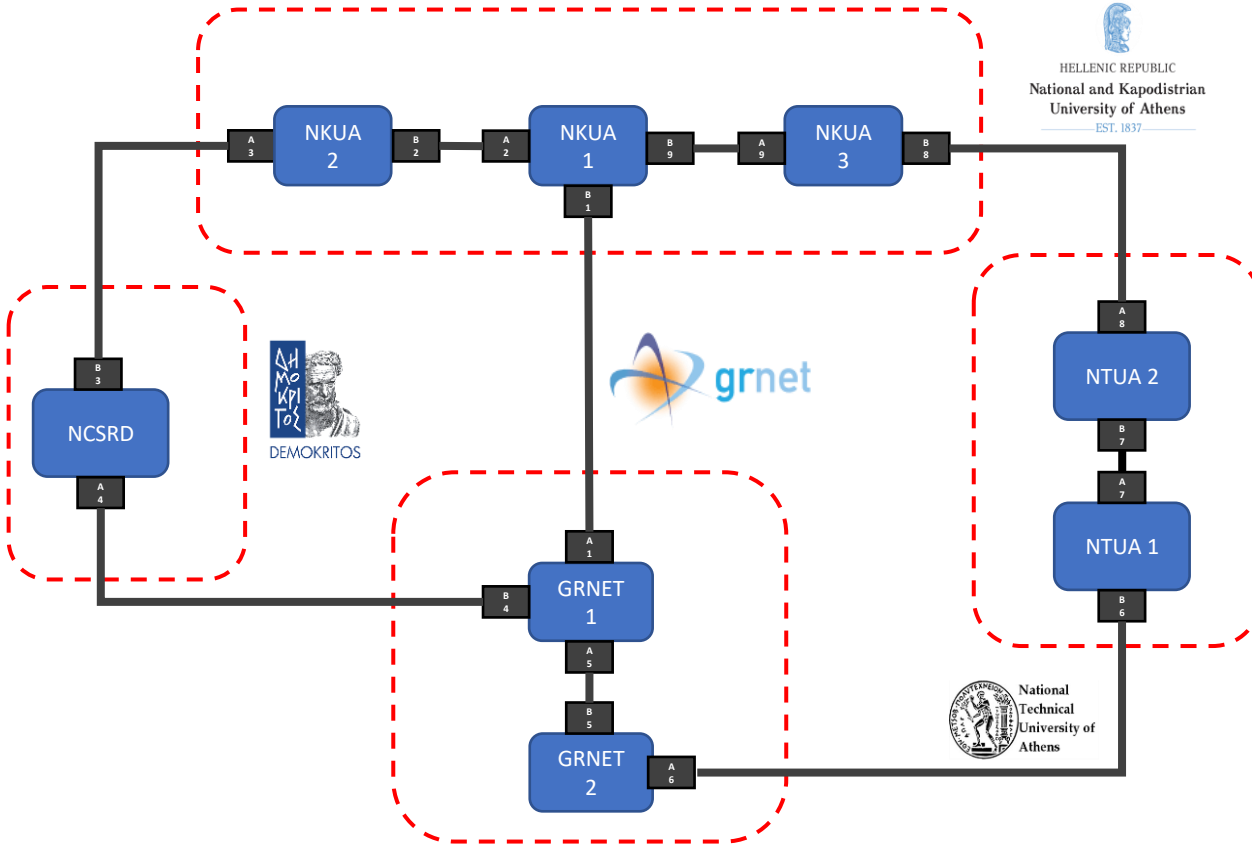
GRNET - NCSRD
Total length: 15 km (4,1db)

NSCRD - NKUA
Total length: 19km (9,3db)

NKUA - NTUA
Total length: 8km (5,7db)

5 physical links

Total fiber length=120km



HellasQCI Use Cases

17 Multidisciplinary Use cases

Advanced use cases in different application scenarios

- 7 National Security and Governmental nodes connected
- 6 Critical infrastructures, health sector and ICT industry nodes connected
- 6 Research and Innovation nodes connected
- Entanglement distribution network 16 receivers – 4 users

National Security

Use Case 1 — QKD for National Security
Use Case 2 — Enhanced QKD resilience for National Security Links
Use Case 3 — Satellite QKD connectivity for remote National Security Nodes
Use case 16 — HellasQCI space and terrestrial segments
Use case 17 — Quantum-secured OGS connection and satellite data delivery

Public Health

Use Case 4 — Secure communications for Public Safety applications
Use Case 5 — Quantum Secure technologies for cloud Health Applications
Use Case 6 — Secure transmission of medical imaging data for Public Hospitals
Use Case 7 — QKD for secure connectivity to supercomputing infrastructure

Industry | Critical Infrastructures

Use Case 8 — Quantum cryptography to secure communication links
Use Case 9 — ICT sector | Secure storage in cloud data centres
Use case 10 — ICT sector | QKD over 5G
Use case 11 — ICT sector |Next Generation Quantum Secured FTTH services
Use case 15 — Preparation of a quantum encrypted software application

Research

Use case 12 — Preparing for the quantum internet
Use Case 13 — Advanced quantum network controls
Use case 14 — PUF-based hybrid authentication for switched QKD

HellasQCI Use Cases | Highlights 1/3

→ PUF/PQC authentication of QKD

UBITECH quantum supremacy

FORTH

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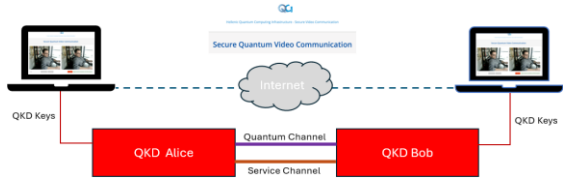
→ Quantum Secure video conference software



UBITECH quantum supremacy

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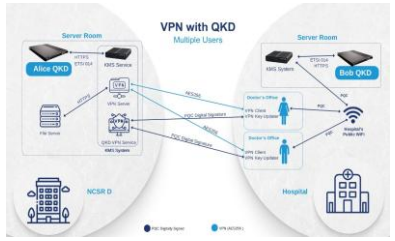
→ QKD/PQC integration in healthcare applications

Secure messaging and secure file-transmission (VPN with QKD) between end users.

Fiber line 8km between NCSRD and Alexandra Hospital in Athens.



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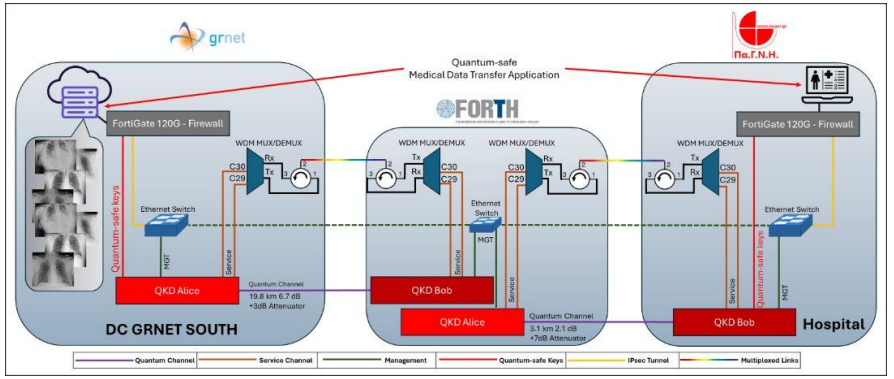
ΔΗΜΟΚΡΙΤΟΣ
DEMOKRITOS

→ Secure transmission of medical imaging data for public hospitals



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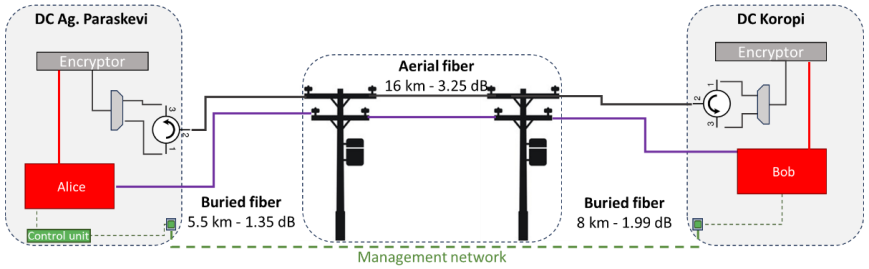
IP-secured medical data transfer from PAGNI University Hospital to GRNET DC in Heraklion.

→ Secure storage in cloud data centers



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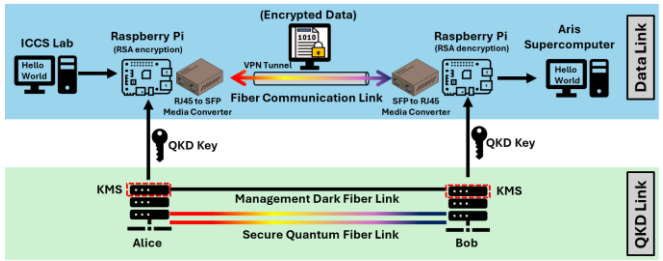
DC-DC secure QKD connectivity through ~30km long fiber pair link with 16km aerial fiber.

HellasQCI Use Cases | Highlights 2/3

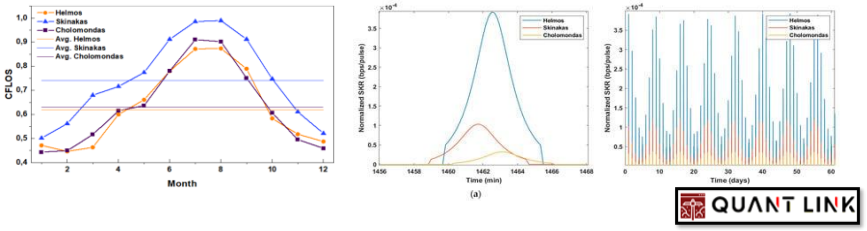
→ QKD for secure connectivity to HPC infrastructure



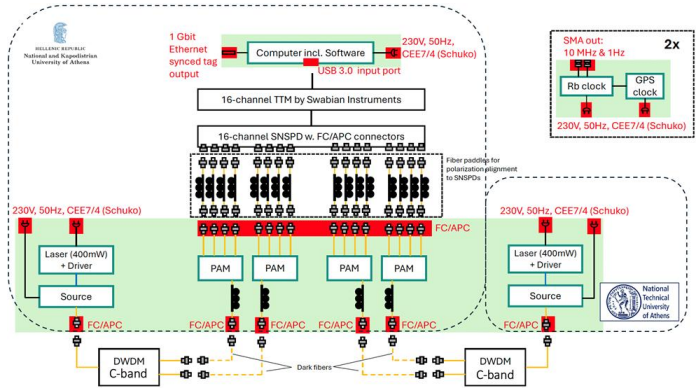
Establish a secure connection between the ICCS Lab in NTUA and the ARIS HPC system in GRNET.

→ Software tool for modelling satellite-QKD downlinks

Simulator that provides design requirements for the EuroQCI space-seg., estimate key rates and link availability.



→ Preparing for the quantum internet



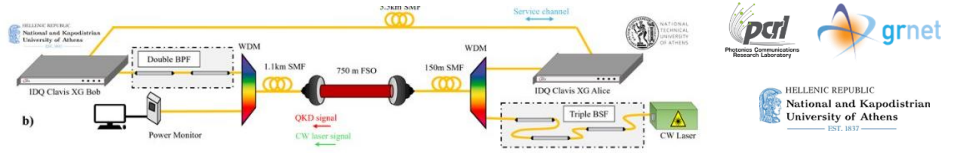
HellasQCI implements a state-of-the-art active entanglement distribution network using 2x EPPSs and 16x SNSPDs @1550nm.

Experimental scenarios identified including Bell-state measurement experiments and entanglement swapping.

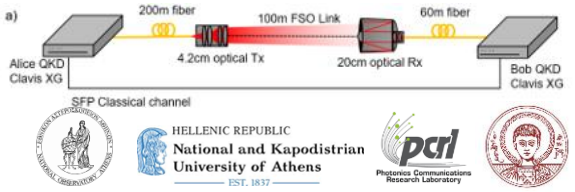
Selective routing and manipulation of entangled photon pairs based on wavelength.

Dynamic control of the entangled photon pair within the network.

→ FSO-QKD over 0.75km Intercampus Link



→QKD over 100m FSO with small telescope



HellasQCI Scientific Publications

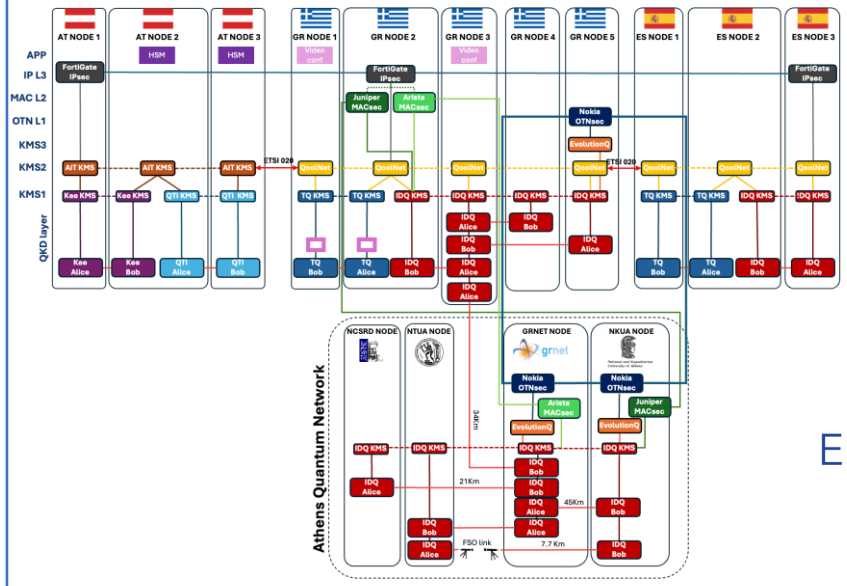
HellasQCI Use Cases | Highlights 3/3

→International Demo in Athens

QCI Days Athens 2025 Demo setup
600 participants from 30 countries, 20 Exhibitors, *3 days*
Enable real time cross-border demonstrations: ES-GR-AT

Key Features and innovations:

- **Multi node:** 15 nodes
- **Multi-domain** interoperability: interdomain operation ETSI-QKD-20
- **Multi-service** encryption (L1, L2, L3): First ever 4-node Quantum Secure video conference & 7 Quantum Encrypted applications
- **Multi Vendor QKD**: IDQ, TQ, KQ, QTI
- **Field deployed network:** 131 km in Athens

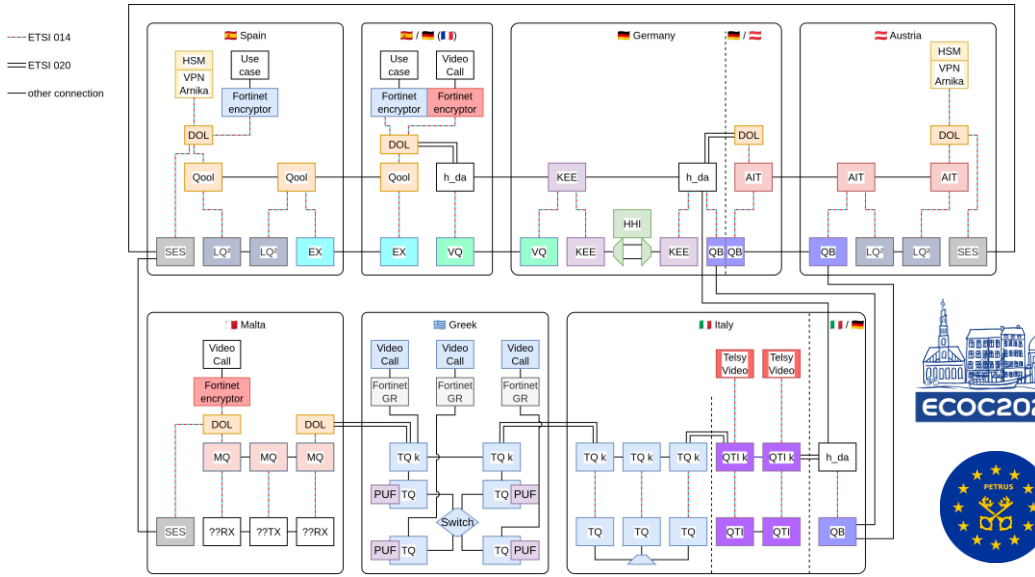


→International Demo in Denmark

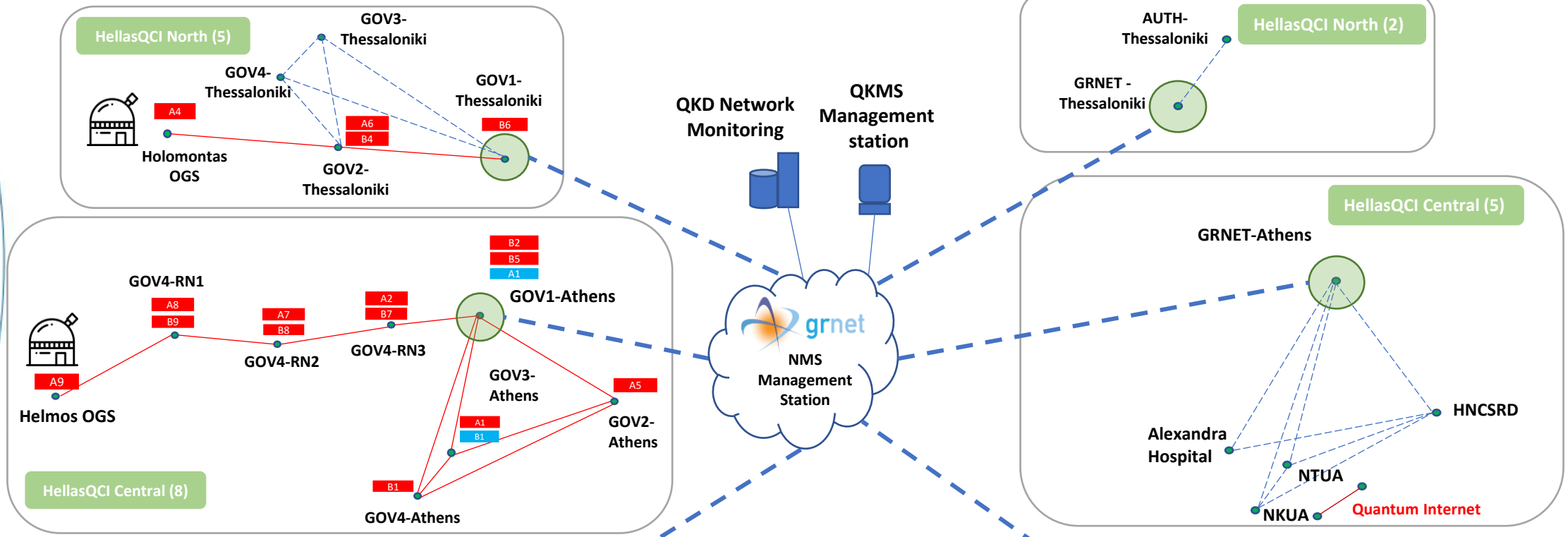
51st ECOC Demo setup by Petrus
8,300 participants from 73 countries, 350 Exhibitors, *4 days*
Enable real time cross-border demonstrations: GR, ML, IT, ES, DE, AT-LX

Key Features and innovations:

- **Interconnected domains:** 7
- **Key management Systems (KMS):** 8
- **QKD Providers (CV, DV, MDI – QKD)**: 9
- **Simulated space links:** 2
- Real-world use cases: secure video call, sensitive data backup, VPN encryption
- Advanced features: optical switching and PUF-base authentication at the QKD



HellasQCI Phase 2 | Final Setup



HellasQCI - GOV Networks

- 16 permanent nodes (including NSAs)
- 19 permanent fiber links
- 3 OGS connected

HellasQCI - EDU Networks

- 9 nodes in total (6 unique nodes)
- 10 permanent fiber links
- 2 Quantum Internet nodes

HellasQCI Training environment

HellasQCI training methodology

Addresses the needs in three pillars of users:
a. academic/research staff,
b. experts in digital security and
c. end users from public and private sector

ATTENTION PLEASE

HellasQCI Training event in Athens (9/2023)

Workshop on Quantum Key Distribution (QKD) Systems

Workshop on Cybersecurity with QKD and PQC

- ✓ 20 Lessons performed, 4 Labs took place, 375 attendees, 4 days
- ✓ Hybrid format (livestreamed and recorded) in EN
- ✓ PETRUS CSA and 4 NatQCIs presented their activities.

HellasQCI Training event in Crete (9/2024)

Workshop on EuroQCI Deployments & Cooperation

Workshop on Cybersecurity with QKD and PQC

- ✓ 30 lessons performed, 2 Labs took place, 415 attendees, 2 days
- ✓ 40 Speakers from 14 countries
- ✓ Hybrid format (livestreamed and recorded) in EN
- ✓ PETRUS CSA, Nostradamus and 10 NatQCIs presented.
- ✓ Visit to Skinakas Observatory → 1750 m

HellasQCI Training event in Thessaloniki (11/2025)

Workshop on EuroQCI Cooperation

Focus on Space-based QKD

- ✓ 25 lessons performed, 3 Labs, 250 attendees (100 physical and 150 online)
- ✓ 40 Speakers from 15 countries
- ✓ Hybrid format (livestreamed and recorded) in EN
- ✓ PETRUS CSA, Nostradamus and 11 NatQCIs presented their activities.

HellasQCI 4-day Training event in Athens

HellasQCI 2-day Training event in Crete

HellasQCI 3-day Training event in Thessaloniki

HellasQCI Training environment

GÉANT eAcademy

Six (6) end-user training workshops took place

ThinkQuantum (18-19 September 2024)

107 online and physical participants, 3 Trainers.

ID Quantique (1-2 October 2024)

75 online and physical participants, 1 Trainer.

Single Quantum (6 February 2025)

35 online and physical participants, 3 Trainers.

Zero3 (22 October 2025)

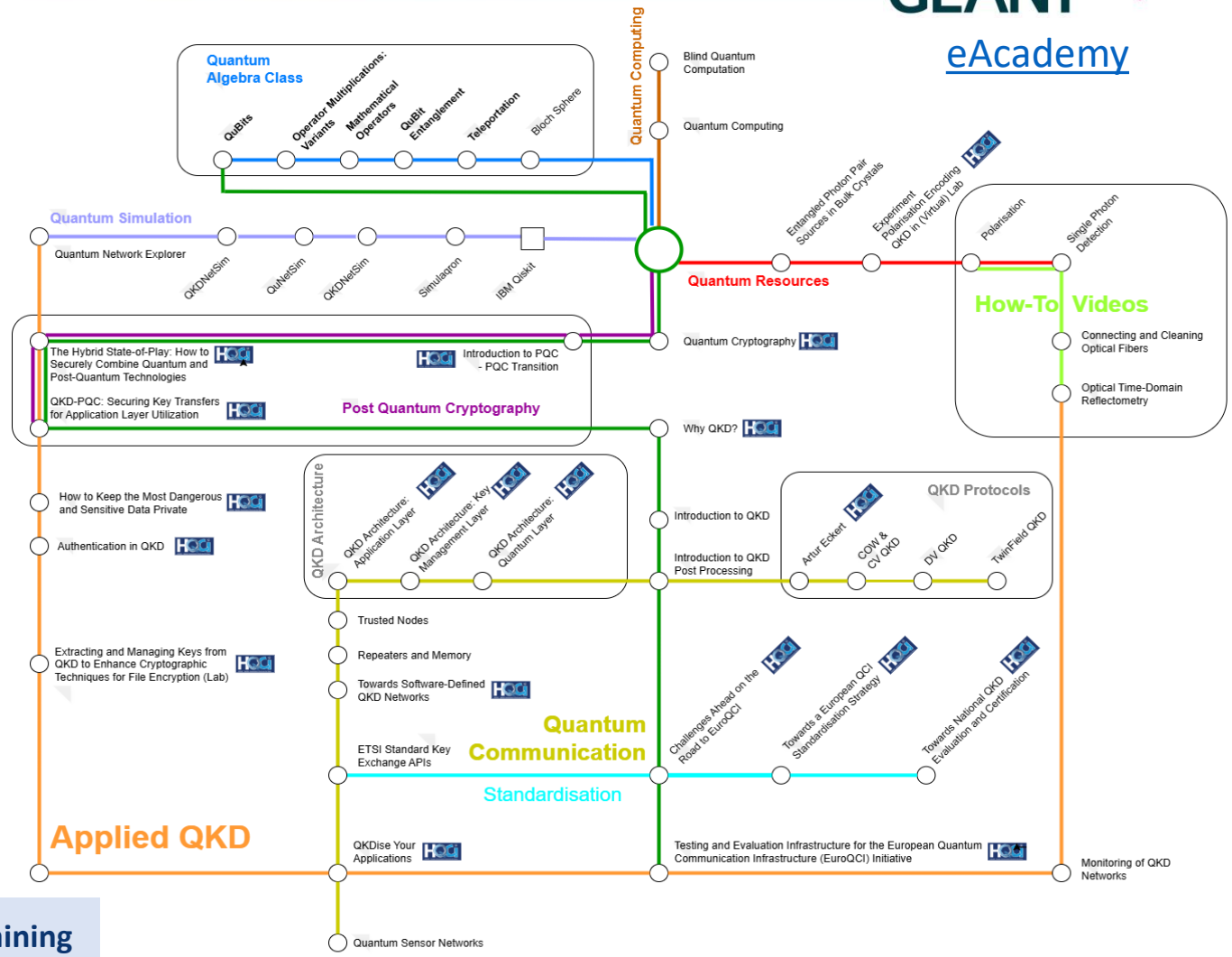
22 online and physical participants, 2 Trainers.

NOKIA (3-6 November 2025)

35 online and physical participants, 1 Trainer.

Hellenic Armed Forces Training (31 October 2025)

25 physical participants, 4 Trainers.



- Organized: **9 training events** | Delivered: **24 full days of training**
- Trained **> 1000 people** | HellasQCI Training Platform users: **124**

HellasQCI Community- QKD standards and certifications

HellasQCI Community

- **Establishment of the HellasQCI community from all national stakeholders** that can benefit and support the HellasQCI networks, gather expertise and share knowhow.
- More than **37 organizations registered (GOV,EDU,IND)** have been attracted in the HellasQCI community registry
- A dedicated session, chaired by GSTP in QCI Days 2025, focused on the preparation of the **National Quantum Strategy**
- All stakeholders from Greece are invited to participate in the HellasQCI Community

Alignment QKD standards and certifications

- **a. Cen/Cenelec JTC 22**
  WG2: Entangled Photon Pair Sources.
  WG4: Large scale QKD networks best cases & SatQKD standards.
- **b. QuIC (European Quantum Industry Consortium)** Standardisation Working Group 4.
- **c. Petrus Thematic Working Group (ETWG)** on Interoperability and Standards and to **Nostradamus** project.
- **d. Supported the creation of Greece's National Mirroring Committee on Quantum Standards** *(ELOT: Hellenic Organization for Standardization)* → Ensures Greece has a formal voice in shaping the quantum standardization

HellasQCI Synergies with EuroQCI ecosystem and Raise Awareness

HellasQCI - Quantum Communication Infrastructure for Greece

Overall Achievements

January 2023 - November 2025

- **15** EVENTS ORGANISED BY HELLASQCI
- **9** TRAINING EVENTS HELLASQCI LED (OF WHICH)
- **2.612** ATTENDEES (PHYSICAL & ONLINE)
- **24** DAYS OF TRAINING WORKSHOPS
- **36** EVENTS REPRESENTING THE PROJECT
- **1000+** OVERALL TRAINED
- **650km** QKD NETWORKS
- **27** DEDICATED FIBER LINKS
- **22** Permanent QKD nodes
- **16** GOV nodes
- **6** EDU nodes
- **17** USE CASES COMPLETED & ONGOING
- **37** COMMUNITY REGISTRY MEMBERS
- **259** TRADITIONAL MEDIA & ONLINE PRESS
- **27** SCIENTIFIC PUBLICATIONS
- **20** PUBLISHED PROCUREMENTS
- **1.272** SOCIAL MEDIA FOLLOWERS
- **247+K** KEY AUDIENCES REACHED
- **24.280** WEBSITE UNIQUE VISITORS

QCI Days Athens 2025, 28–30 April 2025 (Family photo)

Mr. Dimitris Papastergiou
Minister of Digital Governance

National QCI.DK Workshop, 5/11/2024

National EstQCI Event, 16/9/2025

RoNaQCI Workshop Iași, 20-21/6/2024

HellasQCI at the ETWG Workshop, 26-28/11/2024, Brussels

GEANT TNC25, 9-13/6/2025

2024 Digital Governance Awards

DIGITAL GOV AWARDS

Winner - 1st place

"Best New Idea" Category

HellasQCI - Quantum Communication Infrastructure for Greece

Co-funded by the European Union

HELLENIC REPUBLIC
Ministry of Digital Governance

HELLENIC REPUBLIC
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NATIONAL CENTRE FOR SCIENTIFIC RESEARCH "DEMOKRITOS"

UBITECH quantum supremacy

SPACE

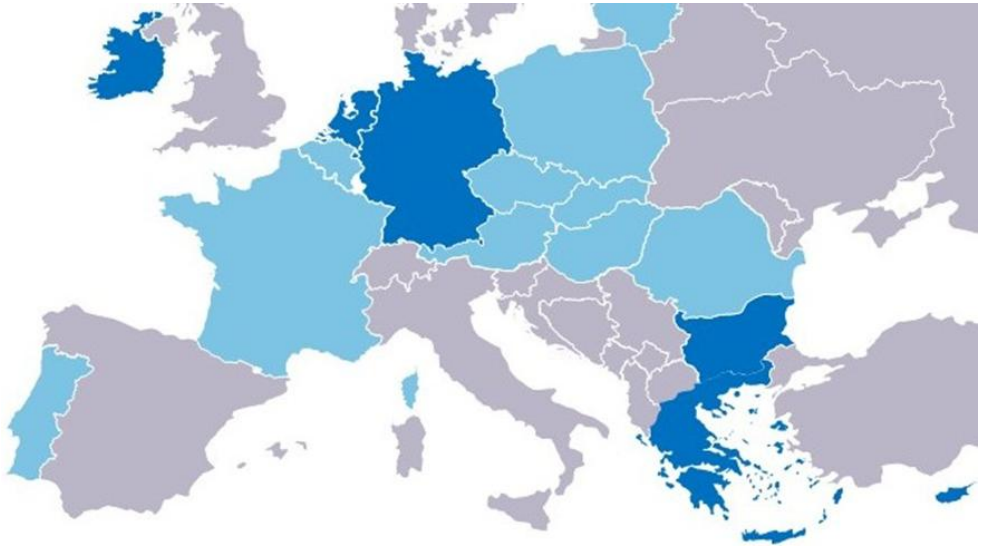
WALTON Institute for Information and Communication Systems Science

Coordination grnet

Looking Ahead: Next steps on the HellasQCI infrastructure

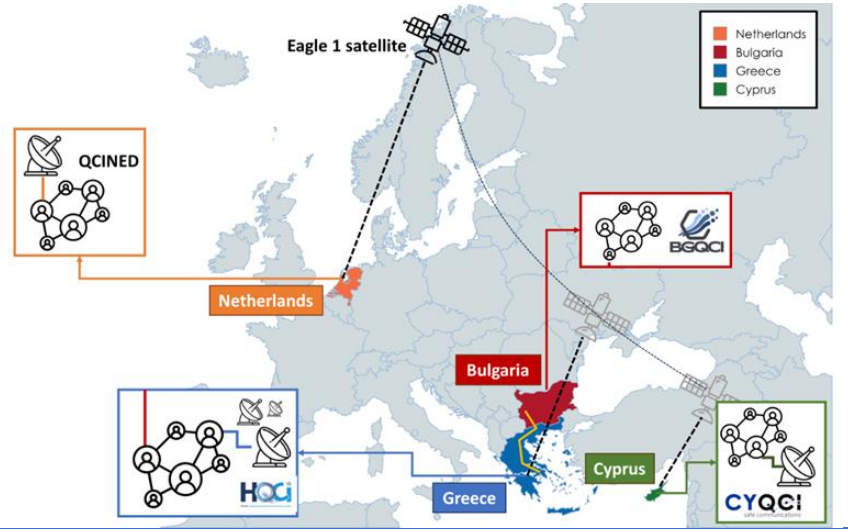
Greece at the EuroQCI CEF call (2nd Phase of the EuroQCI)

- ✓ **Greece** participated in call with **spectacular results** → Top-Ranked and Highest-Scoring among the EuroQCI CEF proposals.
- ✓ **SEEWQCI** South-East Europe to Western Europe Quantum Communication Infrastructure → **GR, NL, CY, BG**
- ✓ **TransEuroOGS** Trans-European Optical Ground Stations → **DE, IR, GR, LX**
- ✓ Collaboration with **18 National QCIs** and **11 EuroQCI CEF** proposals
- ✓ Secured strong **political** and **institutional** support: from Ministries, NSAs and SOCs across the participating Member States



SEEWQCI (Coordinated by GR)

- ✓ Deploy a **1,100 km terrestrial QKD network** from Greece to Bulgaria → Balkan Corridor connecting 3 MSs: GR-BG-RO
- ✓ Establish **5 OGSs** across Greece, Cyprus, and the Netherlands
- ✓ **6 cross-border** quantum links between MS: GR-BG (terr.), GR-NL (sat.), GR-CY (sat.), CY-NL (sat.), CY-BG via GR (terr-sat.), NL-BG via GR (terr-sat.)
- ✓ Demonstrate **29 cross-border quantum connections** using diverse terrestrial and space scenarios



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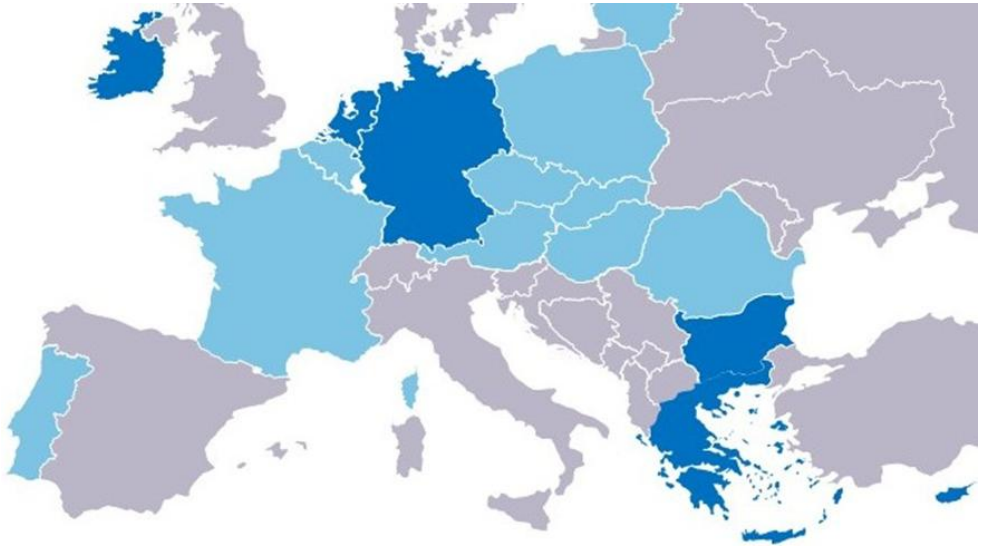

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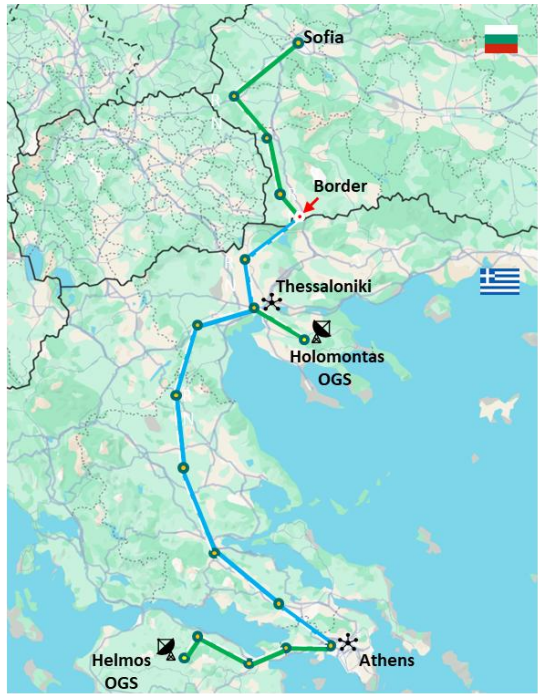

Key takeaways

- Europe is moving decisively to address the emerging quantum threat.
- The EuroQCI vision to interconnect national-scale QKD networks is highly ambitious and presents several technical and organisational challenges.
- Important milestones have already been achieved in the network architecture, establishing an operational layer hierarchy aligned with international standards.
- Further critical developments are needed in policy frameworks and in the operational management of the networks.
- Within the Quantum Coordination Strategy Group, a landscape exercise will be conducted to gain a clearer understanding of NREN activities.

Thank you

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HellasQCI.eu

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EuroQCI

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