

## Services Across Multi-tenant Quantum Communication Infrastructures

### Lessons Learned from Real Deployments

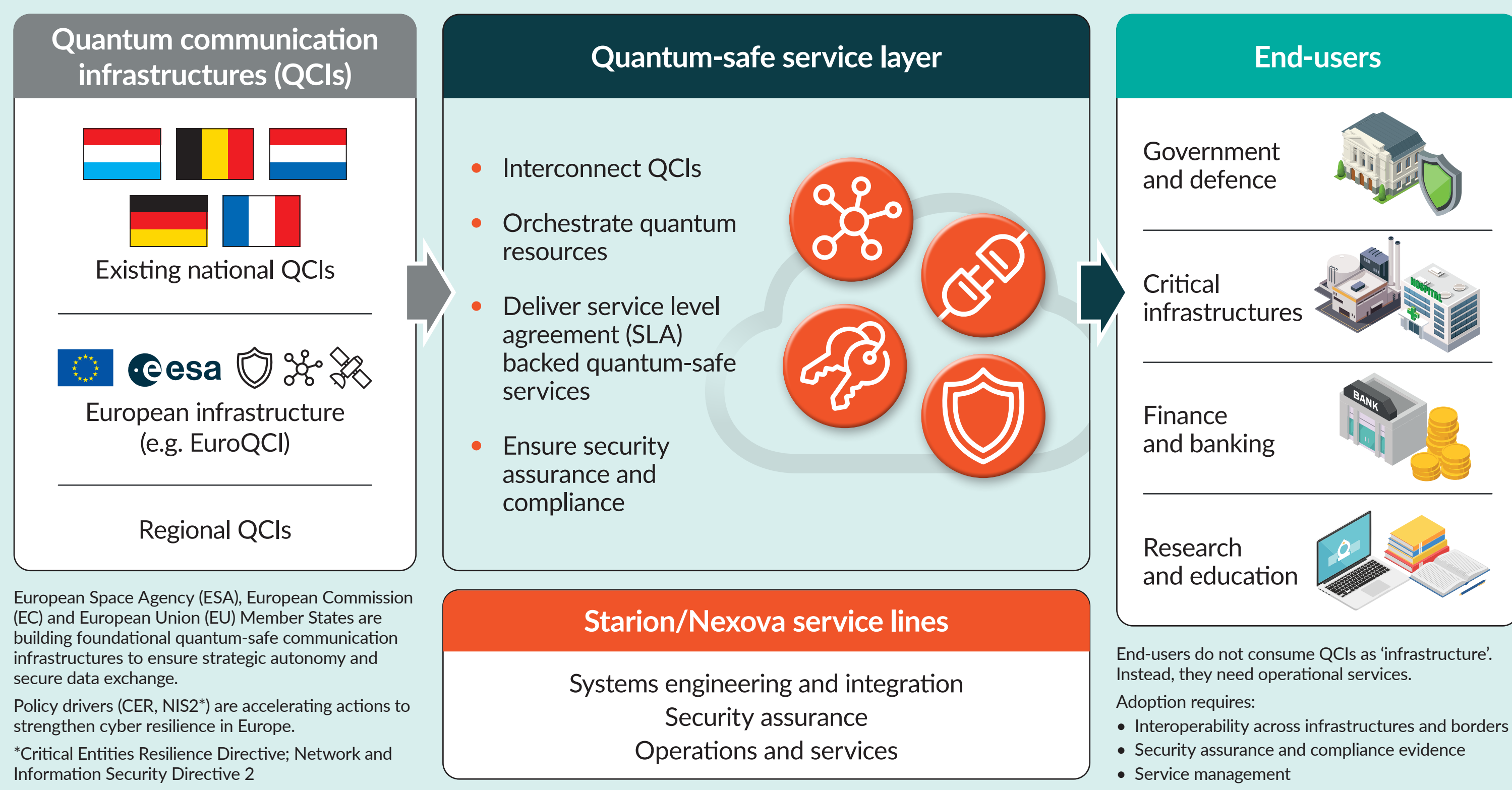


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#### 1. Services bridging quantum infrastructures and end-users

End-users consume operational services with explicit service levels, security assurance and cross-border continuity.

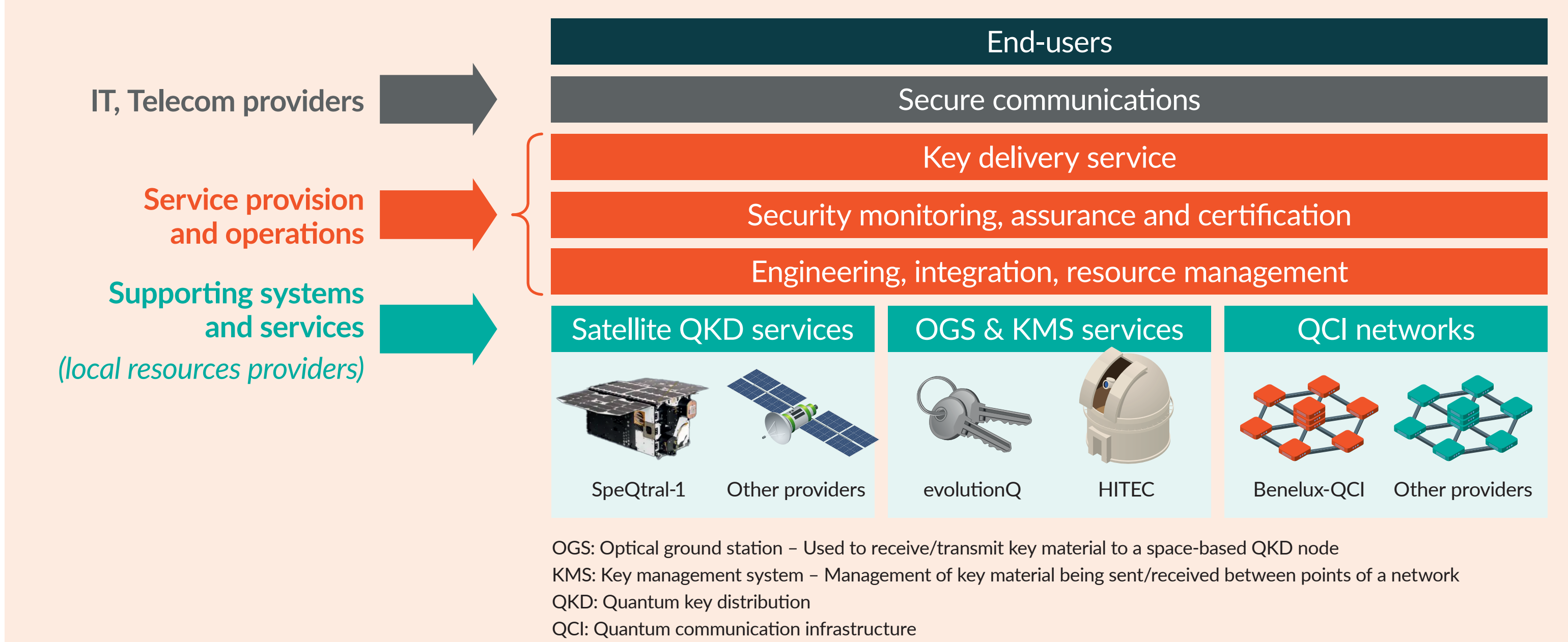


#### 2. Enabling adoption with a service-focused approach

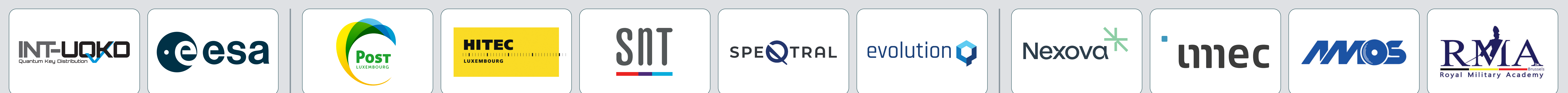
**Service focused:** Enabling secure point-to-point end-users' business applications via their cloud/network providers.

**Infrastructure agnostic:** Exploiting existing QCIs – not deploying our own.

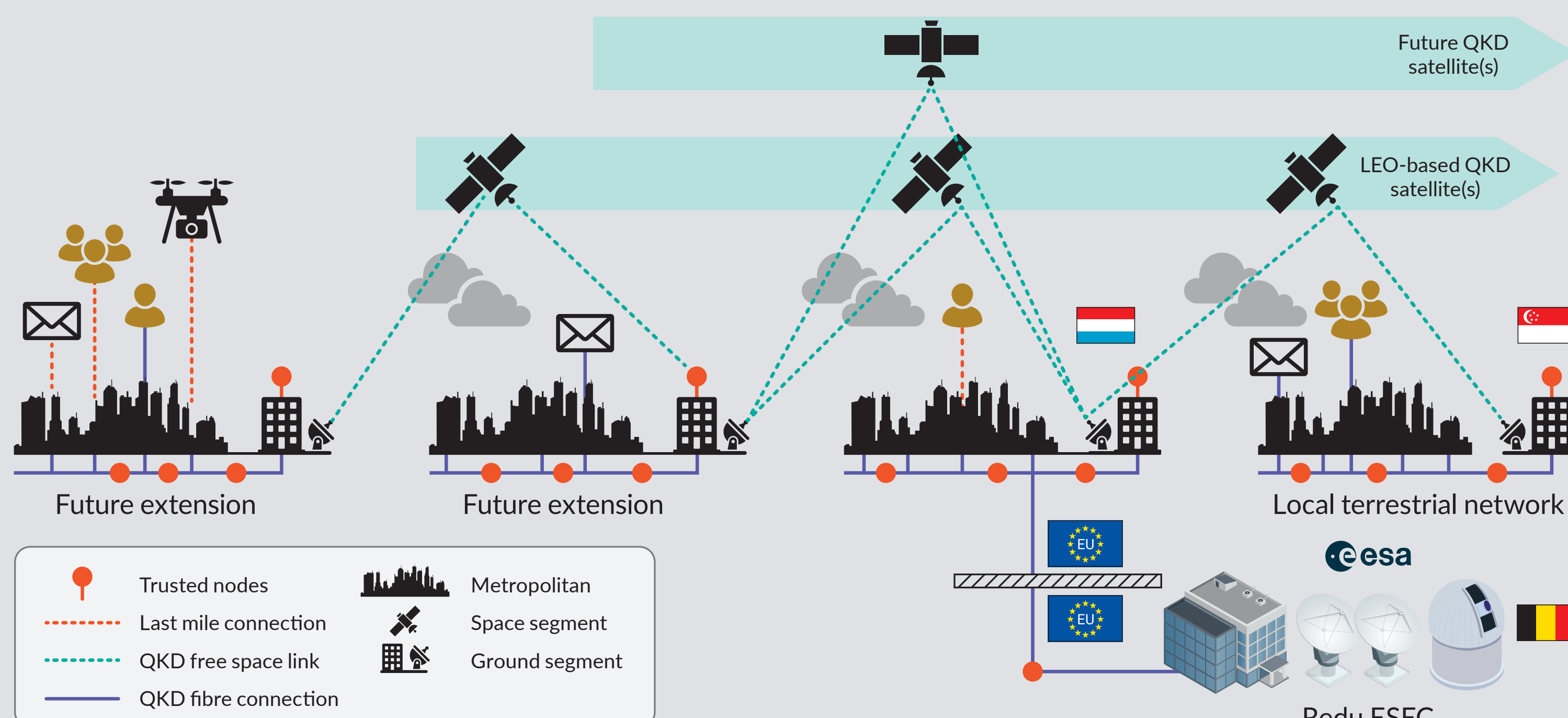
**Complementary:** Providing complementary capabilities to ongoing European Space Agency (ESA) and European Union (EU) infrastructure-focused deployments.



#### 3. INT-UQKD: International Use Cases for Operational Quantum Key Distribution Applications and Services



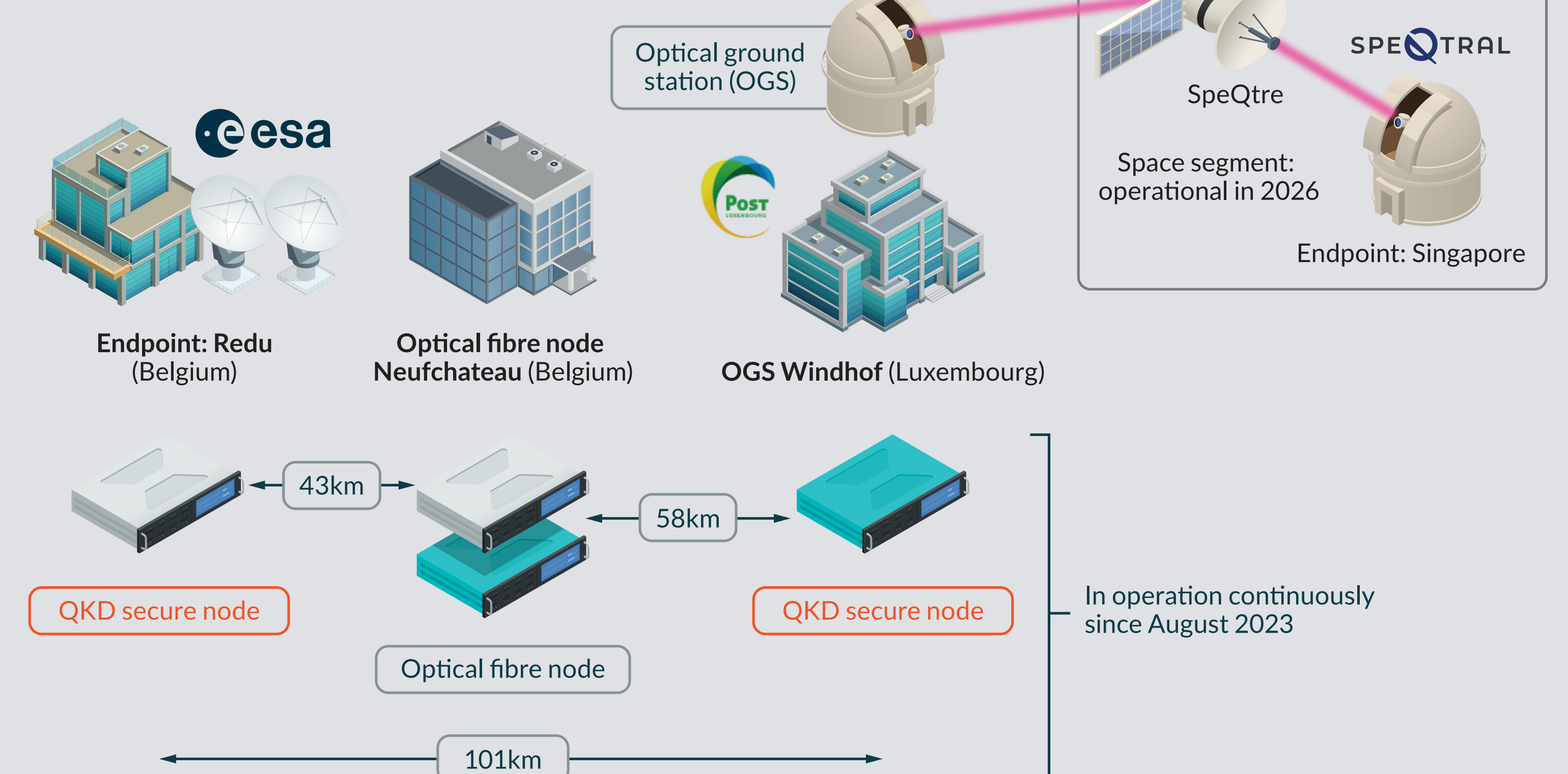
##### 3a. INT-UQKD network architecture



- QKD connectivity between core customer sites that become the backbone of the network. They can be either:
  - Terrestrial, over optical fibre communication networks
  - Space-based, via low Earth orbit (LEO) or geostationary satellites
- Last-mile connectivity to remote endpoints, using classical communication channels (e.g. 5G/6G, RF link, ethernet).

The system architecture is infrastructure agnostic, allowing future quantum-safe extensions to enhance technical capabilities and expand the network geographically.

##### 3b. Current network in Europe



**Current status:** Operational terrestrial network deployed in Luxembourg and Belgium.

**Next step (by end 2026):** Quantum-secure communications established between ESA's European Space Security and Education Centre (ESEC) in Belgium and Singapore, routed via Luxembourg using terrestrial fibre optic and satellite QKD links.

##### 3c. Ongoing developments: network extensions to enact QCI interoperability

**Timeline:** Planned operational capability in 2028

**Fundamental capabilities:**

- Demonstrate **interoperability** with a third party QCI
- QCI resource management
- Operations and business admin
- Develop a **formal security proof** of INT-UQKD architecture and user key delivery services

- Demonstrate a **SIEM** (security information and event management) service for QCIs
- Demonstrate **new technologies** (post-quantum cryptography (PQC) / QKD key establishment, continuous variable (CV)-QKD for space applications)

