16TH ITU ACADEMIC CONFERENCE

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GENEVA2026

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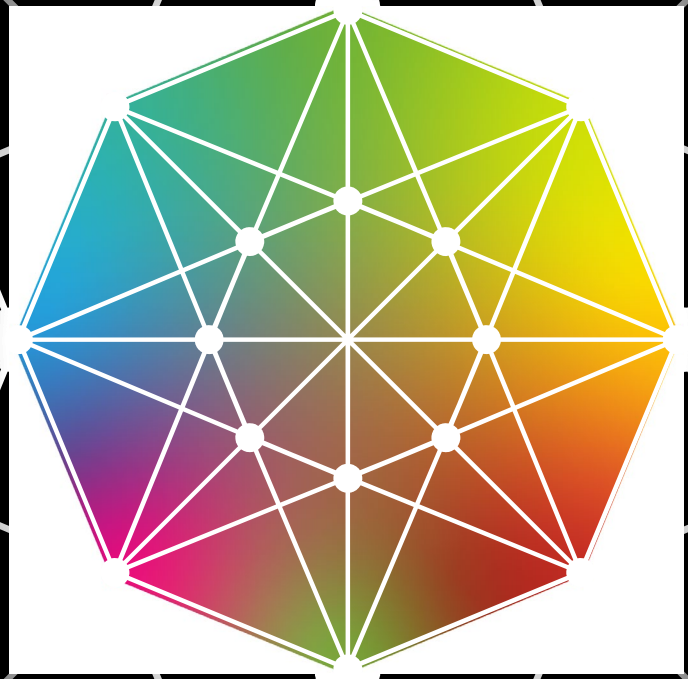
7-9 July 2026
Geneva, Switzerland

Hosted by AI for Good Global Summit



An Innovation Ecosystem Ethics Approach for Quantum Safe Transitions

9 July 2026

Paper Session 7 – Infrastructure, sustainability, and emerging tech ecosystems

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Quantum Safe Transition (QST): From Technical Migration to Ecosystem Redesign

QST is dominantly framed as a technical migration. We argue it is a socio-technical-ecological reconfiguration.

DOMINANT FRAMING

Technical Governance

- Post-Quantum Cryptography (PQC)
- Quantum Key Distribution (QKD)
- Cryptographic agility
- Technical migration roadmaps

→ Under-theorized: the socio-technical, ethical, and ecosystem dimensions of QST

OUR ARGUMENT

QST not just Technical Migration

Quantum-induced vulnerability is:

- Collective
- Intertemporal
- Non-linear
- Value-laden
- Transboundary

→ Ecosystem governance is required

From Technical Governance to Ecosystem Governance

	TECHNICAL GOVERNANCE (Current Focus)	ECOSYSTEM GOVERNANCE (Our Argument)
Key Question	Which cryptographic solution is most secure and efficient?	Who is responsible, for what, according to which values, and for whose benefit?
Stakeholders	Technical experts e.g Cryptographers, engineers, vendors, and standards experts.	Governments, industry, academia, civil society, regulators, infrastructure operators, standards bodies, and end users.
Primary Risks Considered	Algorithm vulnerabilities, interoperability failures, implementation challenges, and system performance.	Quantum divides, accountability gaps, value conflicts, unequal participation, dependency, ethical risks, and governance asymmetries.
Outcome	Quantum-safe cryptographic systems.	A trusted quantum-safe ecosystem characterized by security, accountability, inclusion, resilience, interoperability, legitimacy, and trust.

Key Ethical Challenges for Quantum-Safe Transitions

Temporal uncertainty and multidimensional insecurities

Delayed migration by a single actor can undermine the security and resilience of interconnected and interdependent digital systems

Multi-stakeholder value conflict

- Privacy
- Safety
- Surveillance
- National security
- Strategic autonomy
- International cooperation
- Digital commons
- Human rights

Future-oriented accountability

Who is responsible when today's design choices create harms decades later?

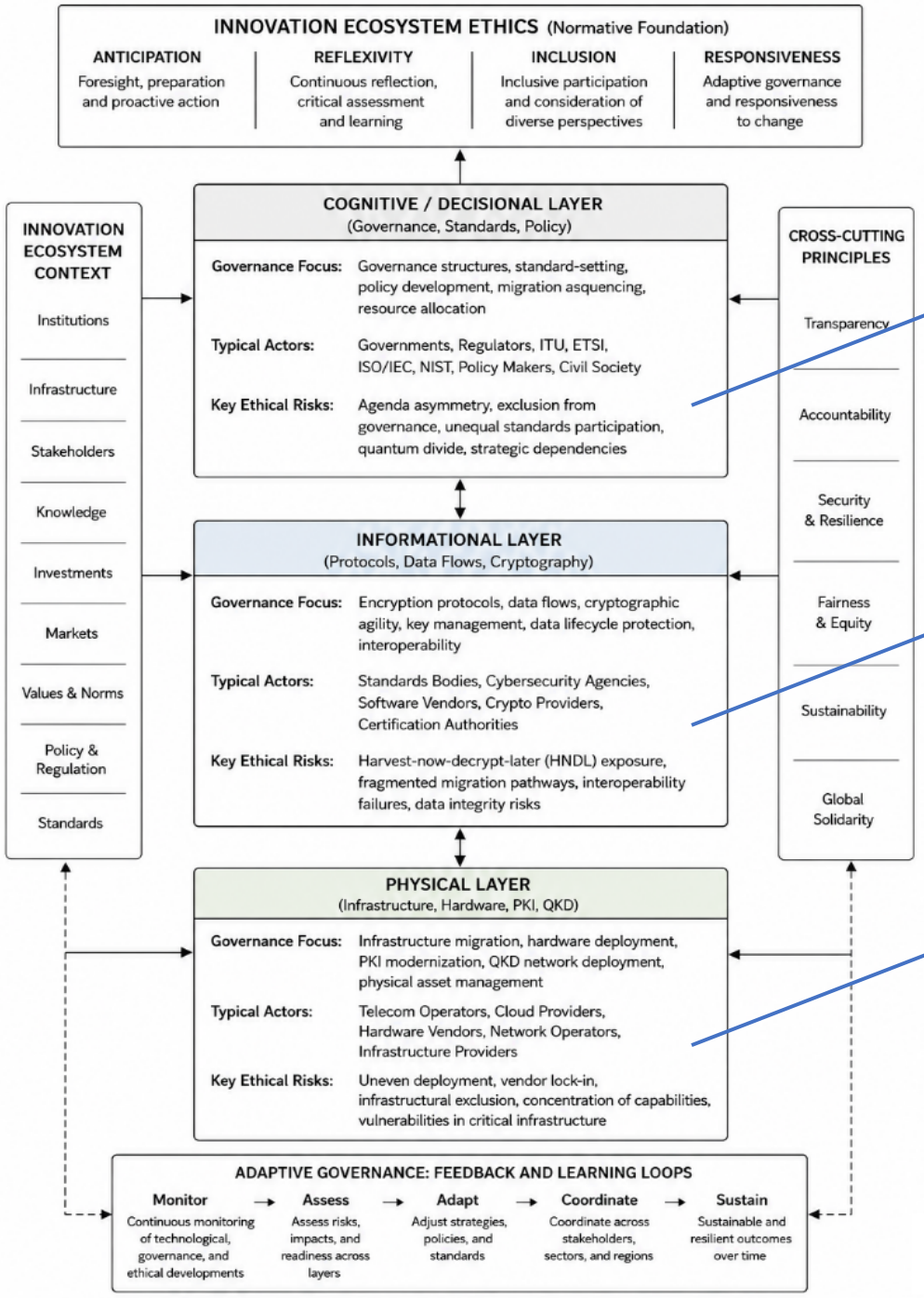
Approach : QST as Socio-Technical Reconfiguration

CONTRIBUTION

- Demonstrate that QST is a **Digital Innovation Ecosystem** transformation.
- Connect **ethical considerations** to practical technical ecosystem dynamics.
- Develop a novel analytical **Integrated Framework** for QST governance.

CORE ARGUMENT

QST constitutes a broader socio-technical-ecological reconfiguration with significant **ethical, legal, societal, and policy implications (ELSPI),** thus interventions should be approached as a whole-of-ecosystem redesign challenge.



INTEGRATED FRAMEWORK

COGNITIVE / DECISIONAL LAYER

Governance, standards & policy

Risks: agenda asymmetry, exclusion, quantum divide..

INFORMATIONAL LAYER

Protocols, data flows, cryptography

Risks: Harvest-now-decrypt-later, fragmented migration pathways..

PHYSICAL LAYER

Infrastructure, hardware, PKI, QKD

Risks: Uneven deployment, vendor lock-in, infrastructural exclusion, concentration of capabilities..

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A three-dimensional matrix to further operationalise the Integrated Framework

ELSPI
×
IE layers
×
unit of analysis
⇨
60 interconnected nodes

A rank 2 tensor is used to visualize the interactions between the three domains or layers of the information environment and the ELSPI dimensions at each unit of analysis

AXIS	DIMENSION	VALUES
X	**ELSPI**	**0** Ethical **1** Legal **2** Societal **3** Policy
Y	**Information Environment**	**0** Physical **1** Informational **2** Cognitive/Decisional
Z	**Unit of analysis**	**0** Individual **1** Organizational **2** National **3** Regional **4** Global
Total Nodes 4x3x5 = 60		

MAIN FINDING

Quantum-Safe Transitions are ecosystem-wide governance transformations rather than discrete technical upgrades

QST require coordinated action across infrastructures, institutions, standards, stakeholders, and governance systems

- **Technical governance** delivers the "how" of quantum-safe migration
- **Innovation ecosystem governance** addresses the "why“, "who" , and "according to whose values" of quantum-safe transitions.

Thank you!