Network eAcademy:

Training for Quantum and Time & Frequency Networks

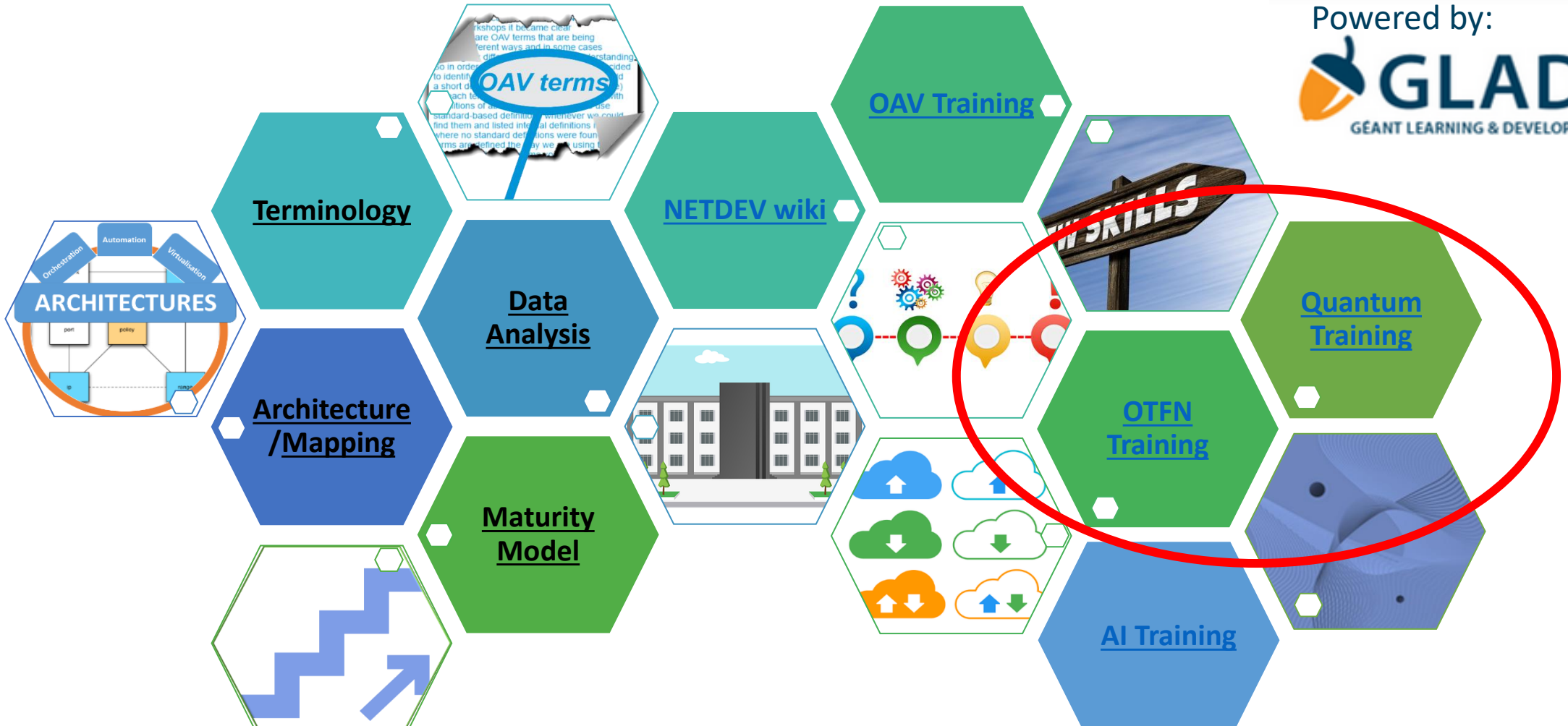
Susanne Naegele-Jackson, FAU

GNA-G Network eAcademy Working Group - Fourth Open Monthly Meeting

February 11, 2026, https://events.geant.org/event/2019/

Network eAcademy, as a Service in GÉANT

To help and support organisations in human capital development in Network-development-related domains, as an umbrella covering several activities



Network e-Academy

Community-driven training platform for advanced networking

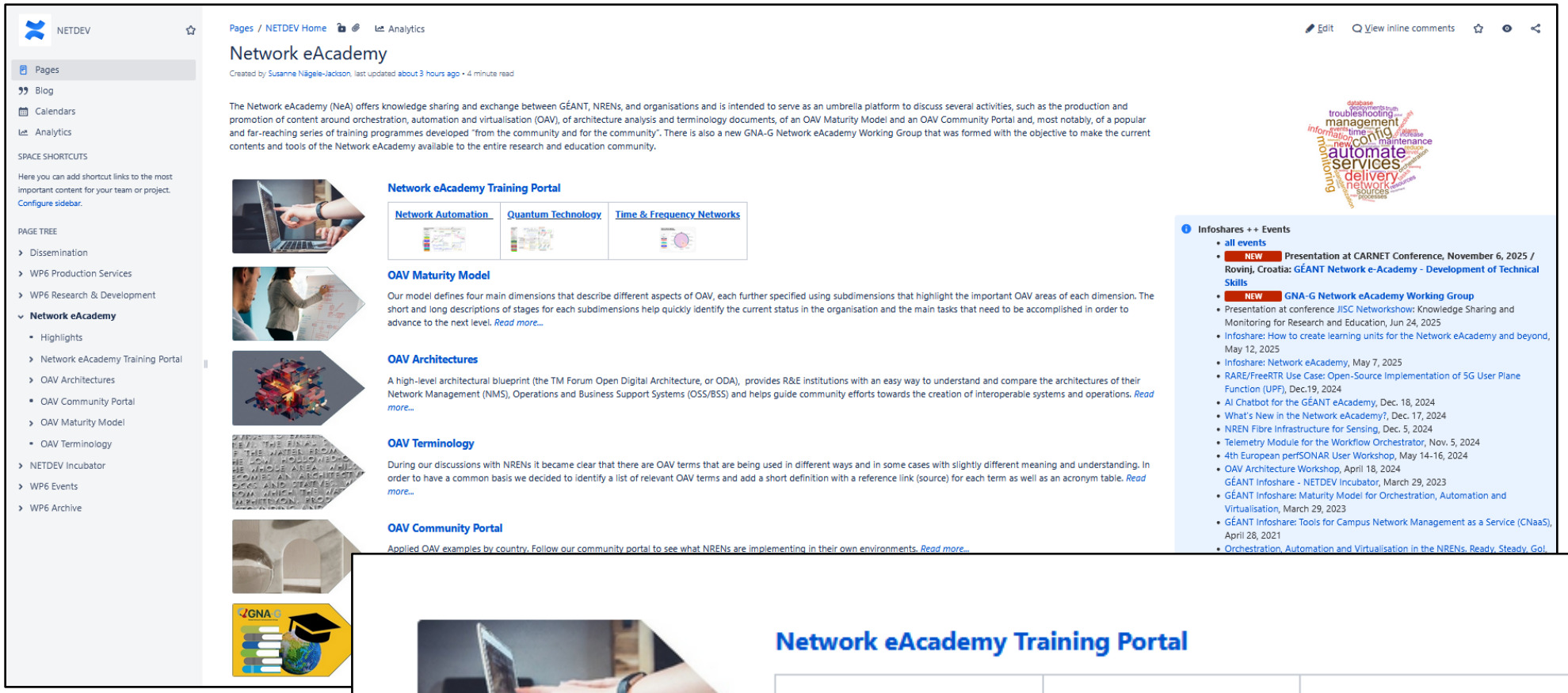
- It offers free courses and learning materials on emerging network technologies
- Intended for NRENs and for the research and education community at large - engineers, managers, researchers, and students
- Mostly short learning units that can be consumed quickly and on-demand
- More than 50 learning units across 3 tracks

Why have different eAcademy areas?

- To cover new emerging technologies that NRENs are exploring
- To upskill existing professionals
- To identify relevant use cases
- For Quantum eAcademy:
  - to raise awareness about Quantum computing potentially threatening to break much of the cryptography we currently use and what to do about it
- For Time & Frequency Networks:
  - To understand network synchronisation which is essential to ensure that distributed network components operate in unison, maintaining precise frequency and time references for reliable, secure, and efficient operations as is needed for many applications

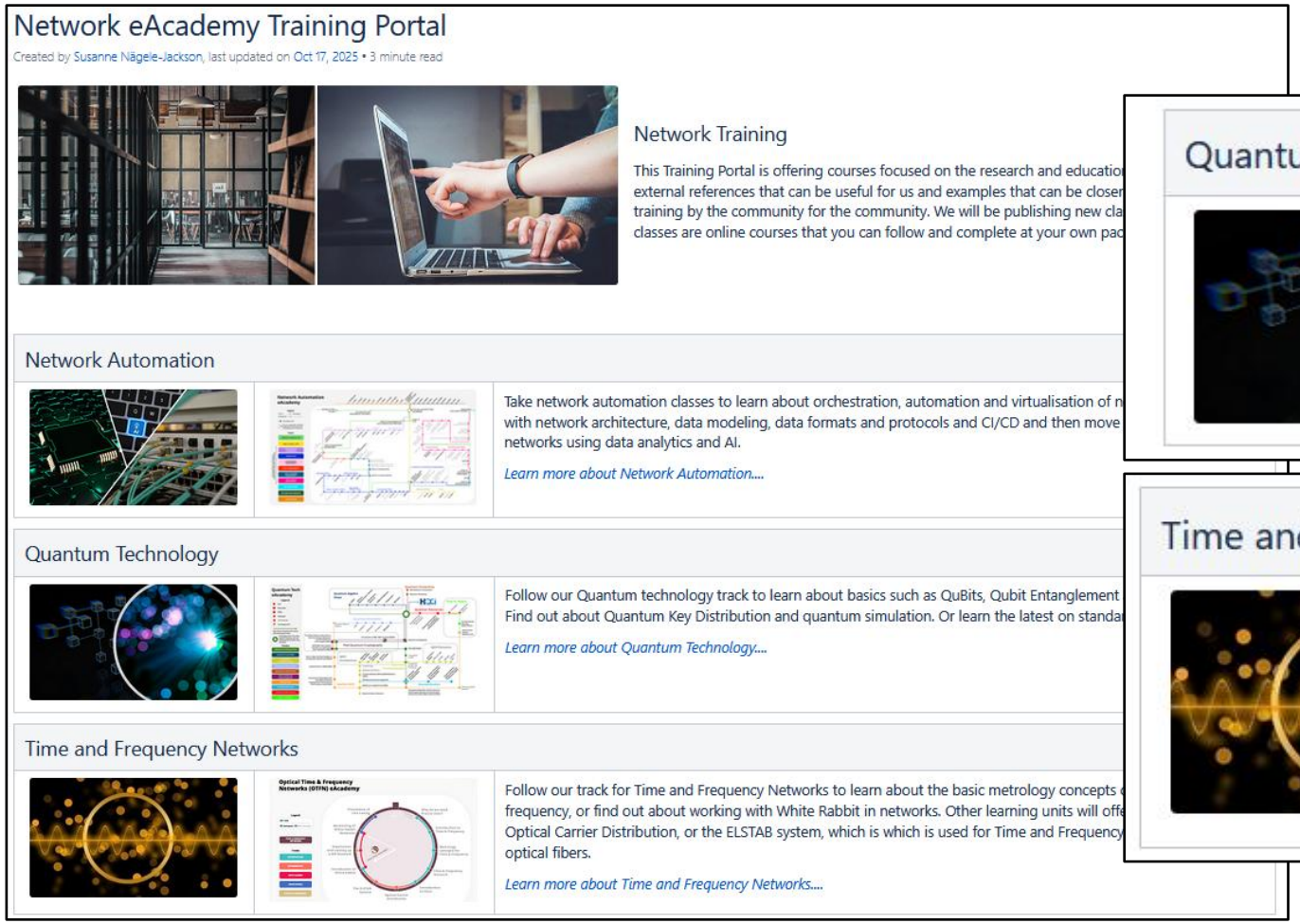
Access to courses through wiki (I)

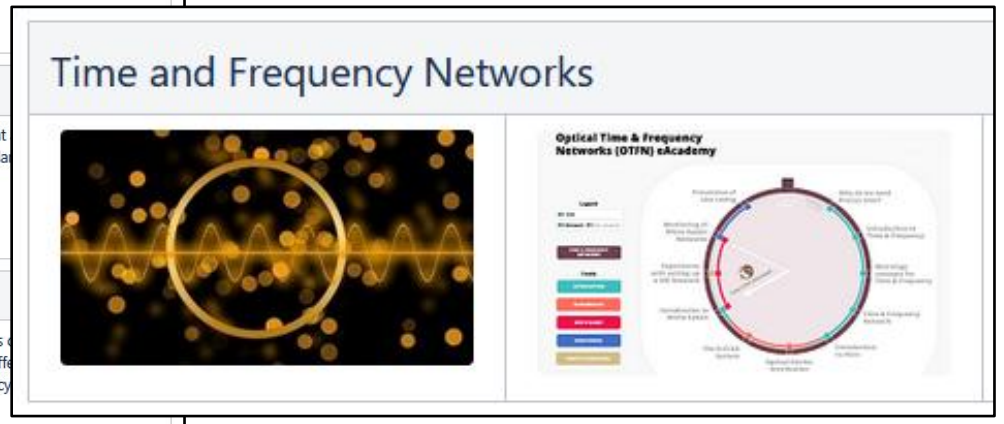
- https://wiki.geant.org/display/NETDEV/Network+eAcademy



Access to courses through wiki (II)

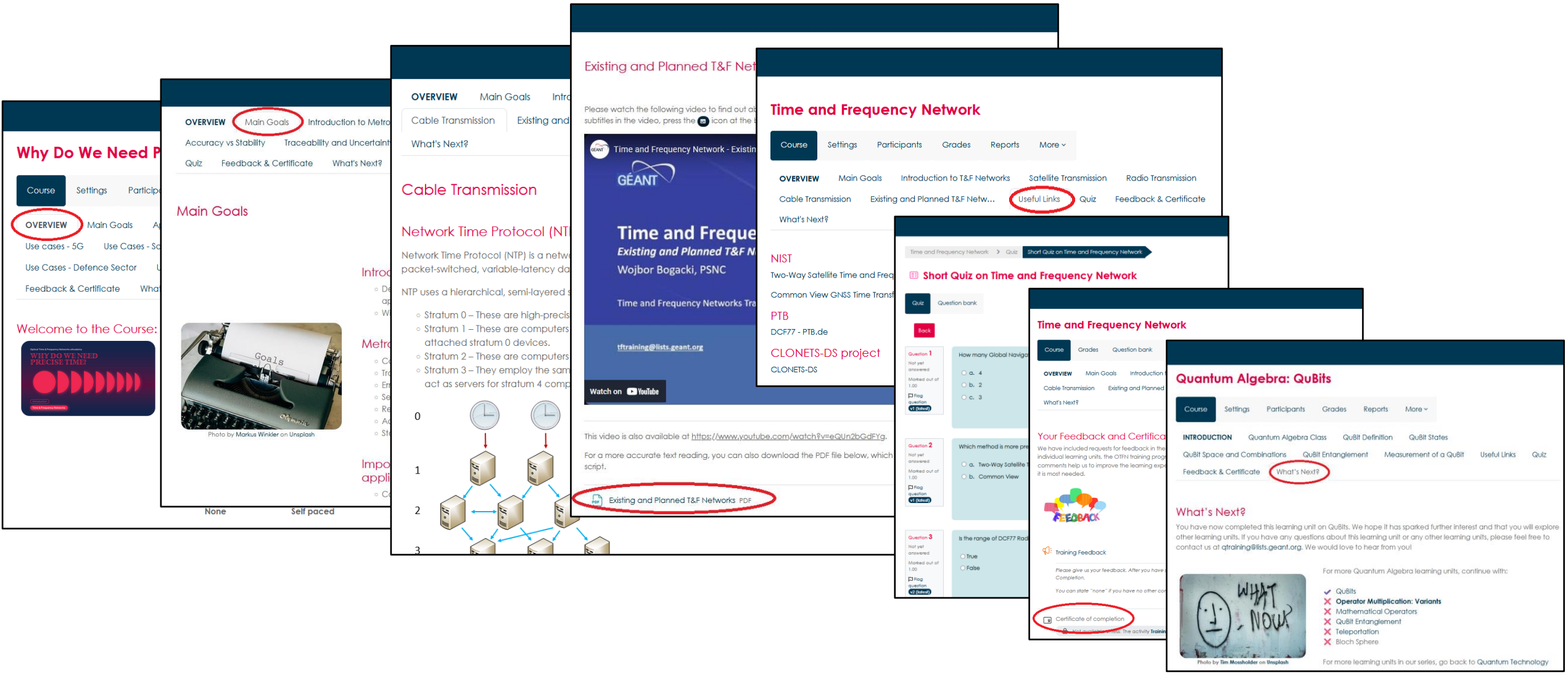
- https://wiki.geant.org/display/NETDEV/Network+eAcademy

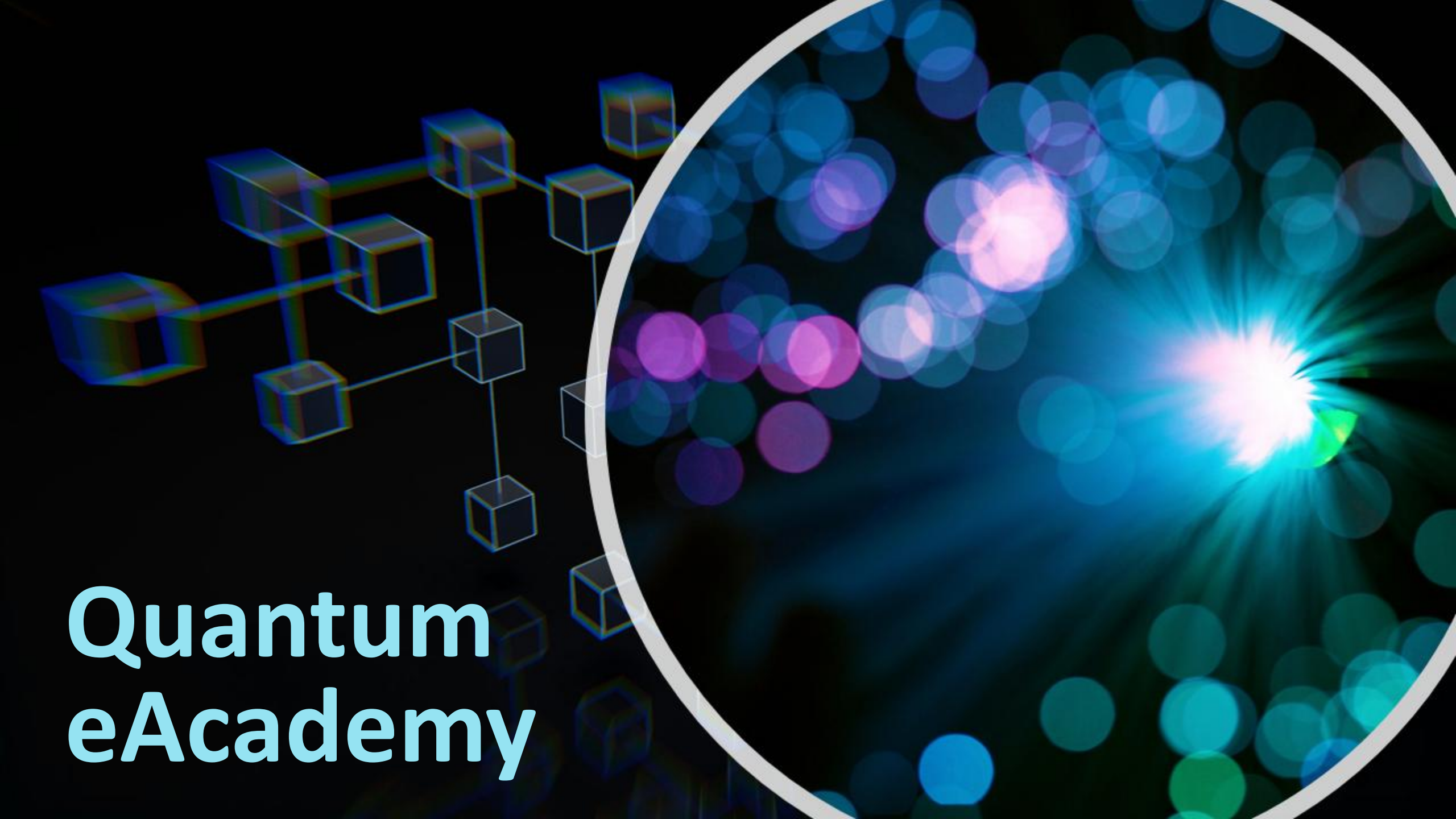




Basic Layout

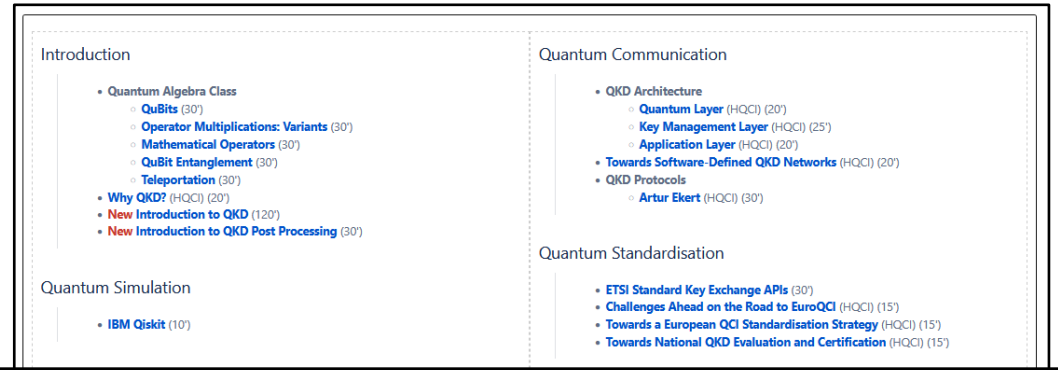
- Similar look and feel as Network Automation eAcademy

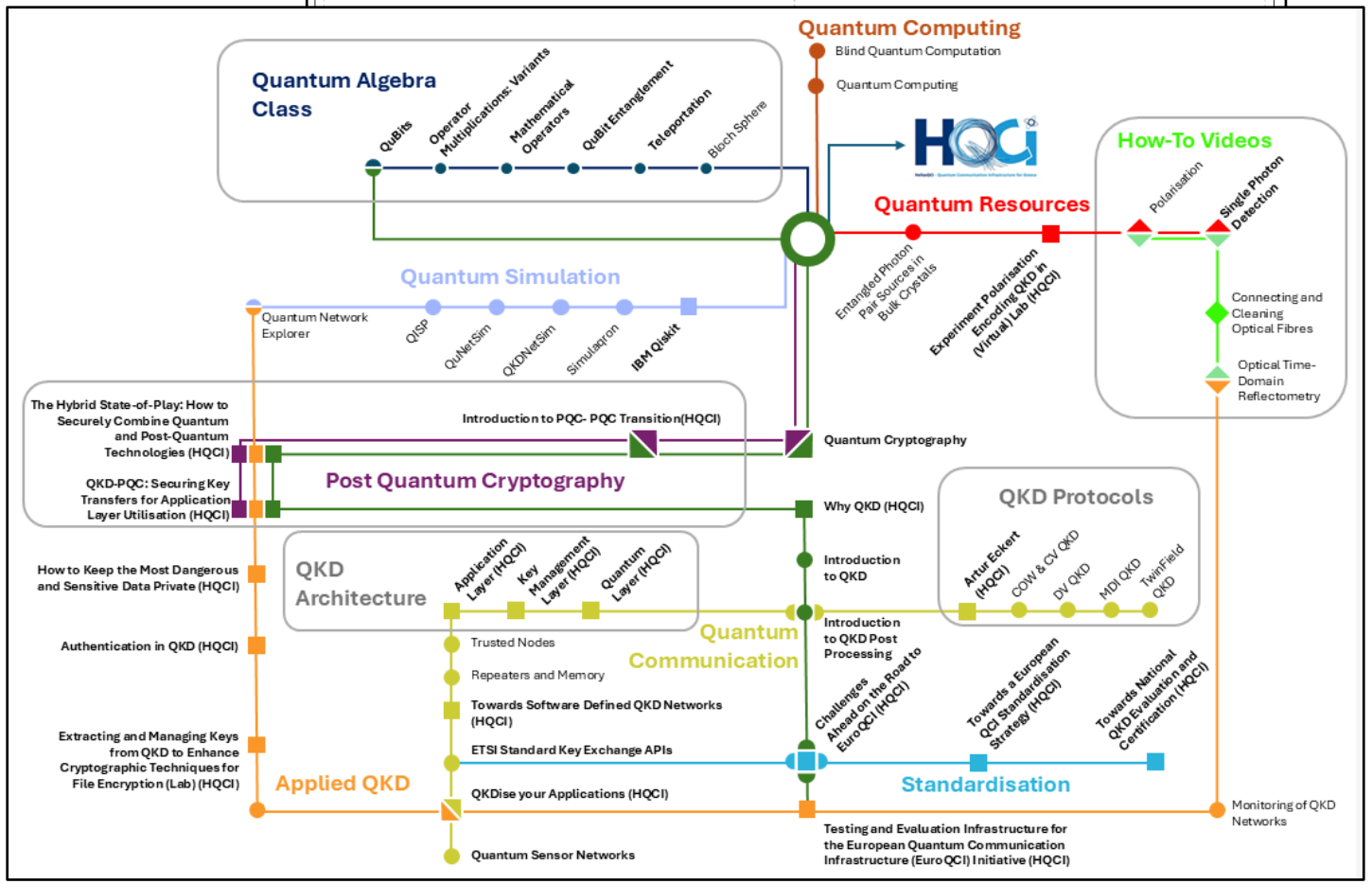



Quantum
eAcademy

Quantum eAcademy (I)

- Classes accessible via links
- Classes also accessible via **metro map**
  - Available classes are clickable on map
  - Circles for classes in Moodle
  - Rectangles for links to documents or external material
  - Various sections and metro lines that cover different topics
  - A green line for introductory courses





Quantum eAcademy (II)

Available lines

- General Introduction
- Quantum Algebra
- Quantum Communication
- Quantum Simulation
- Quantum Computing
- Post Quantum Cryptography
- Applied QKD
- Standardisation
- Quantum Resources
- How-To Videos

Cooperation with

- **Hellas QCI Training Platform**
- https://training.hellasqci.eu/

New in Quantum eAcademy

- How-To Videos
- Concept of whole classes
- HellasQCI Training via Zenodo links
- Direct link to HellasQCI training platform (login required)

New Concept: Quantum Algebra Class (I)

- 5 learning units + 1 addendum

Qubits

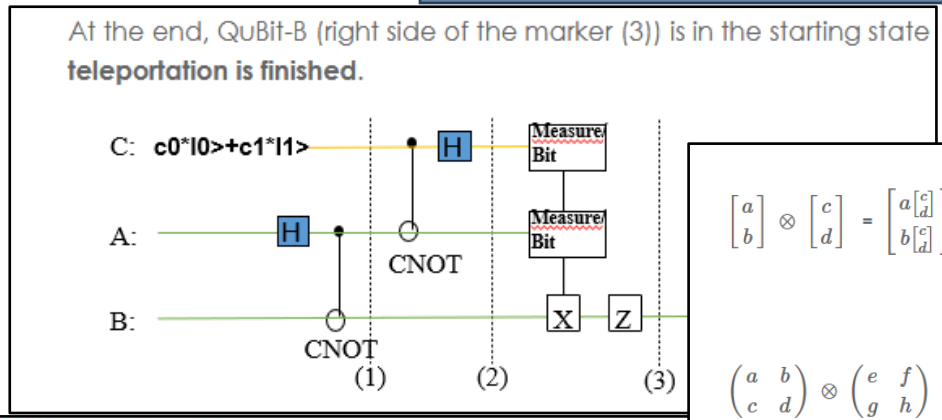
Operator Multiplications: Variants

Mathematical Operators

QuBit Entanglement

Teleportation

Bloch Sphere



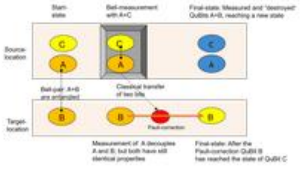
$$\begin{bmatrix} a \\ b \end{bmatrix} \otimes \begin{bmatrix} c \\ d \end{bmatrix} = \begin{bmatrix} a\begin{bmatrix} c \\ d \end{bmatrix} \\ b\begin{bmatrix} c \\ d \end{bmatrix} \end{bmatrix} = \begin{bmatrix} ac \\ ad \\ bc \\ bd \end{bmatrix}$$

$$\begin{pmatrix} a & b \\ c & d \end{pmatrix} \otimes \begin{pmatrix} e & f \\ g & h \end{pmatrix} = \begin{pmatrix} a\begin{pmatrix} e & f \\ g & h \end{pmatrix} & b\begin{pmatrix} e & f \\ g & h \end{pmatrix} \\ c\begin{pmatrix} e & f \\ g & h \end{pmatrix} & d\begin{pmatrix} e & f \\ g & h \end{pmatrix} \end{pmatrix} = \begin{pmatrix} ae & af & be & bf \\ ag & ah & bg & bh \\ ce & cf & de & df \\ cg & ch & dg & dh \end{pmatrix}$$

Wait a minute . . .

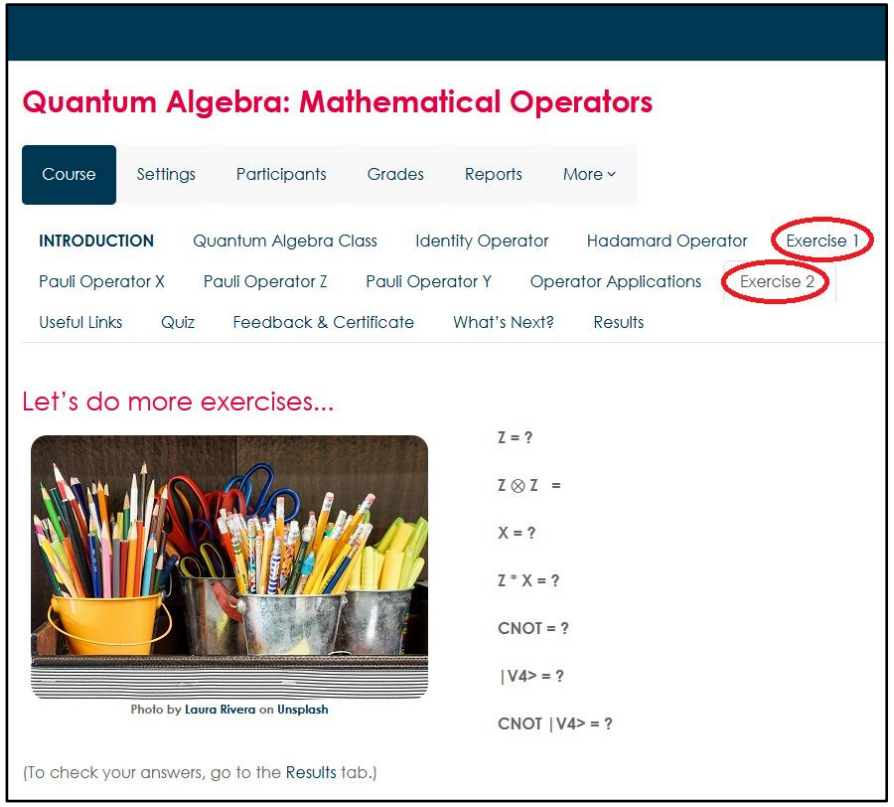
Did I get this right?

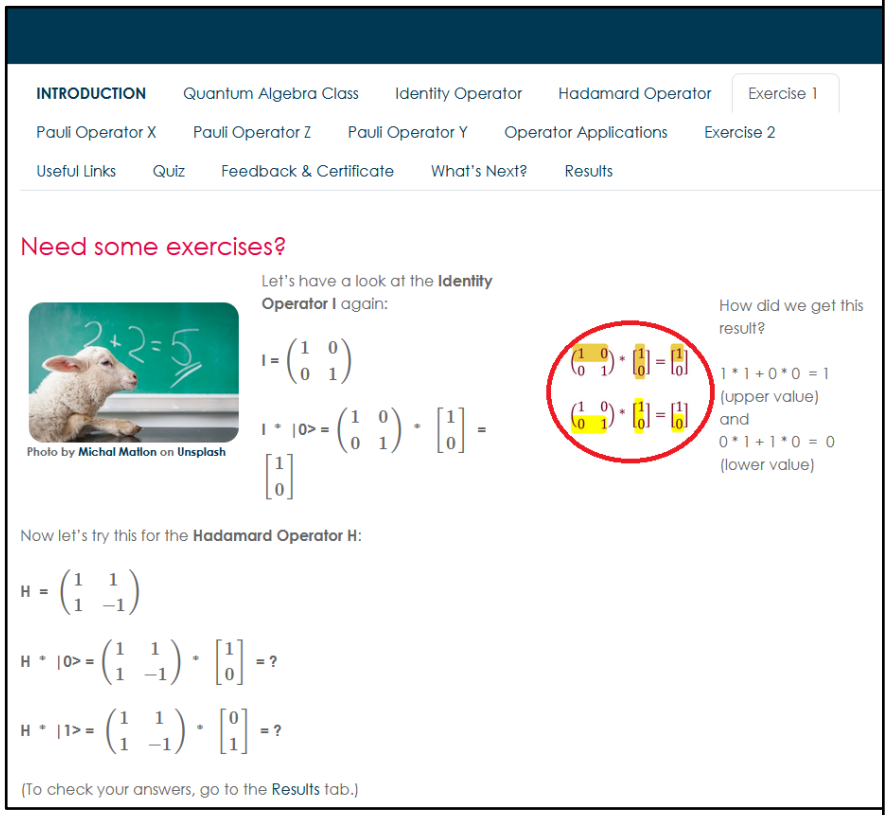
- QuBit-A and QuBit C ***ARE*** at the source location and they never move to the target location???
- Only two classical bits from the measurement at the source location are moved classically to

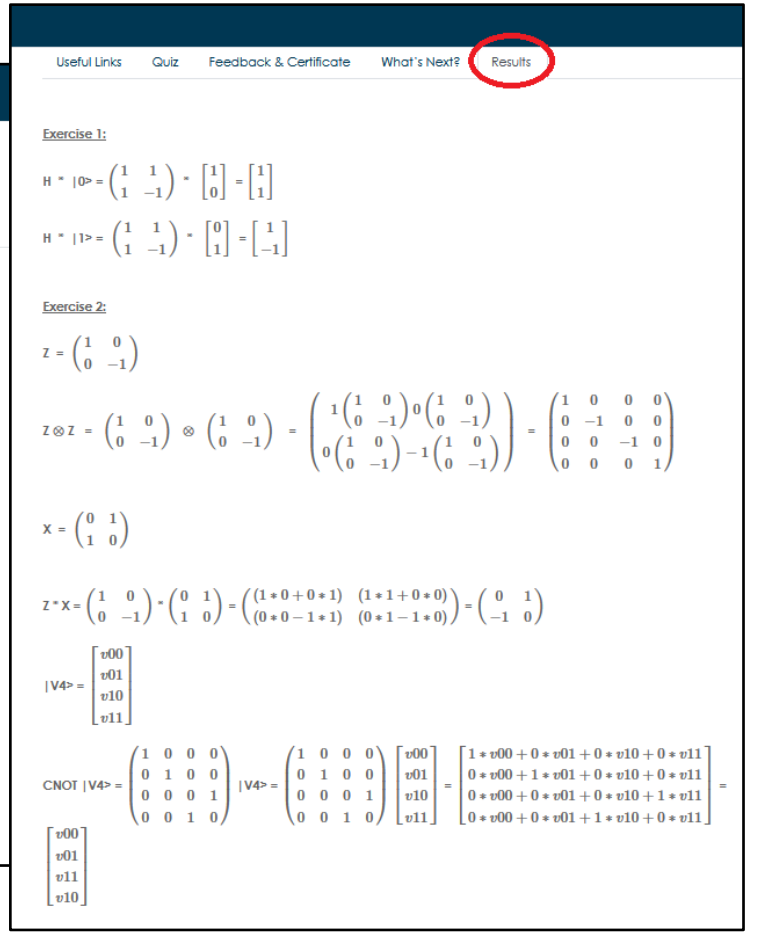


New Concept: Quantum Algebra Class (II)

- Most learning units of the class contain exercises
- Exercises ≠ Quizzes; Results tabs are available

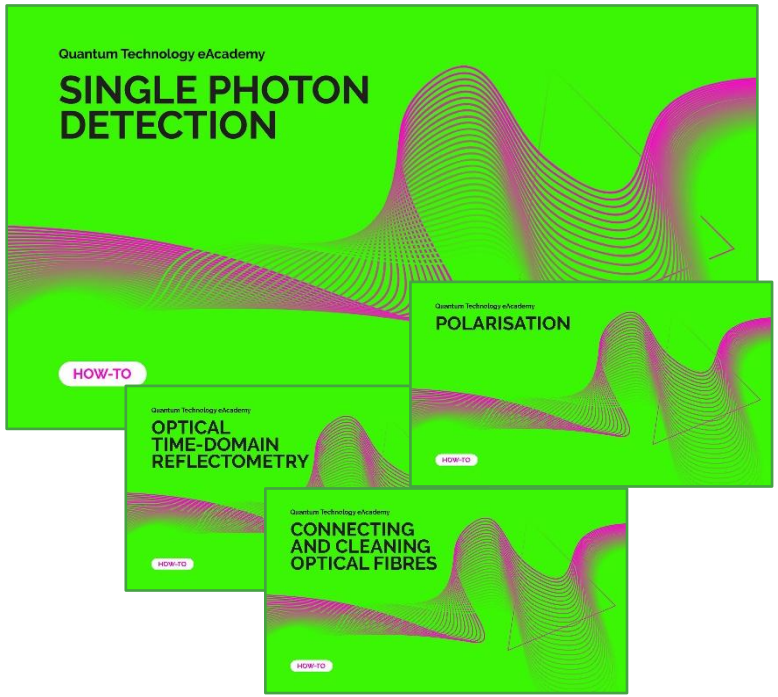


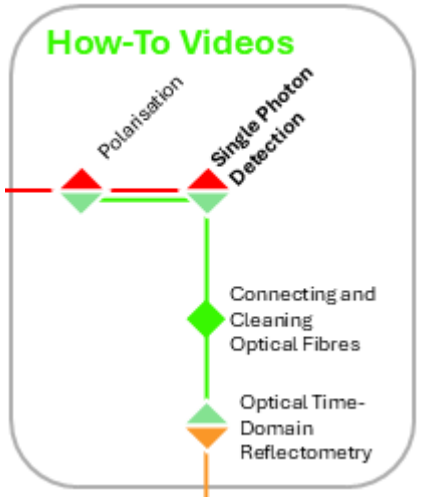


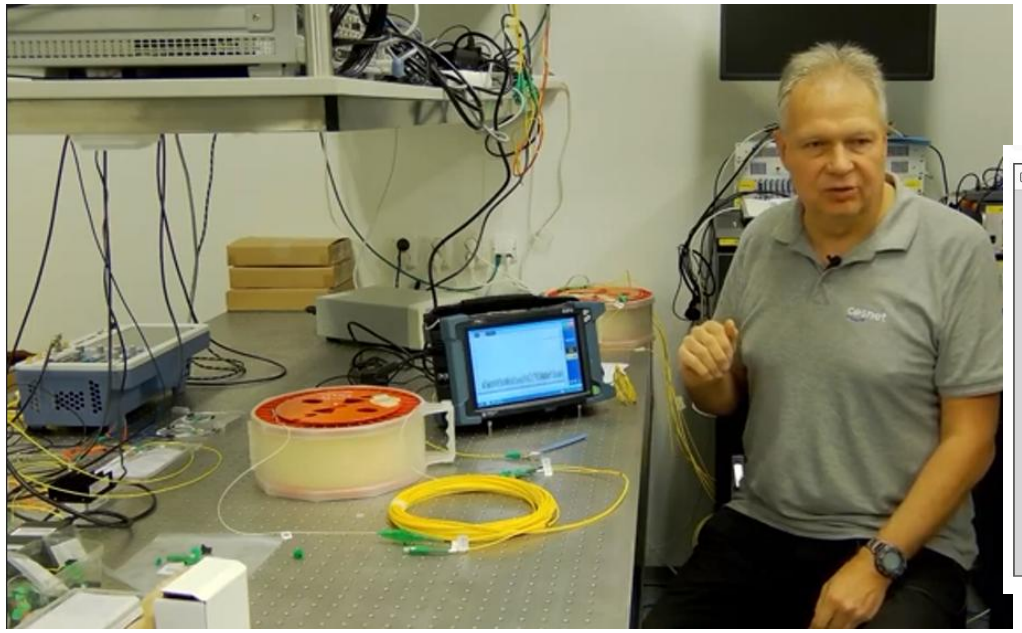


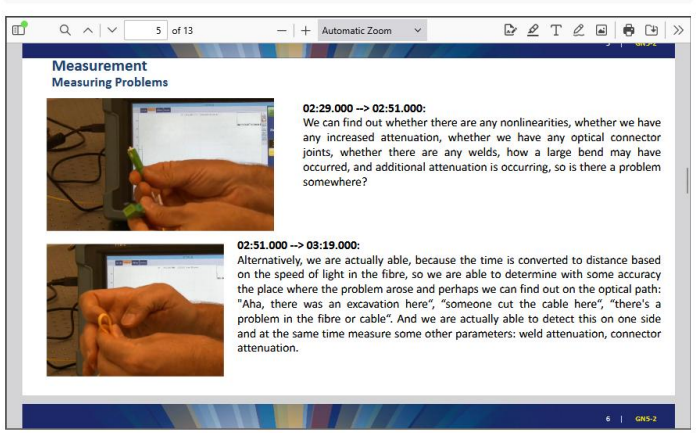
New Concept: Hands-on Videos

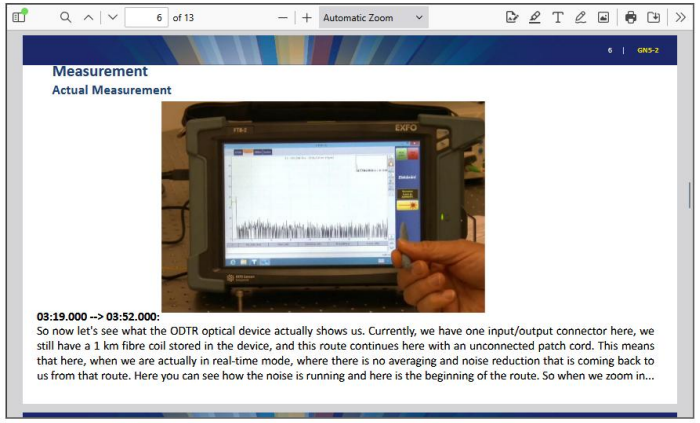
- Short demonstrations
- Includes script with screenshots and timestamps
- Includes useful links, but no quiz





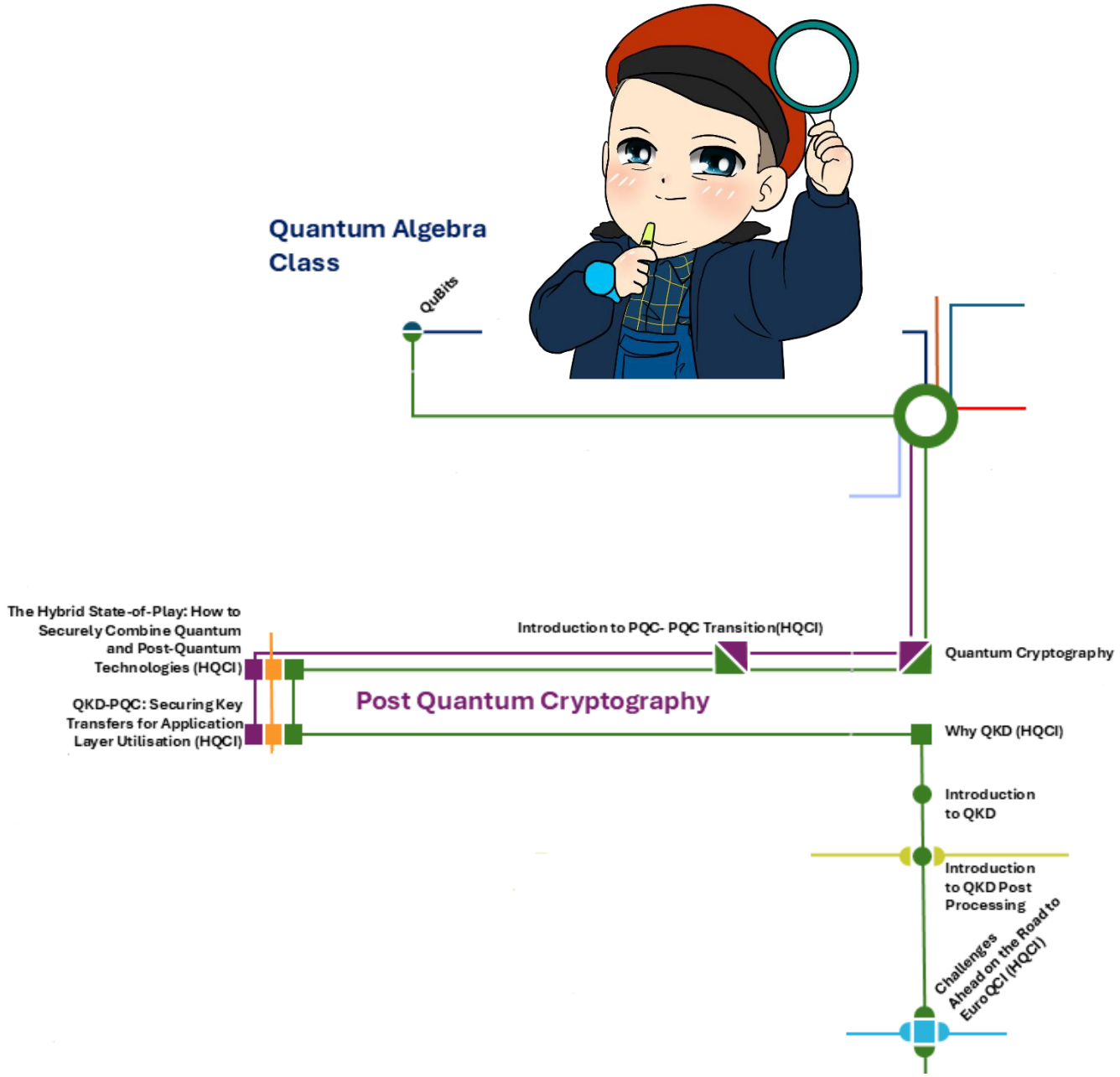






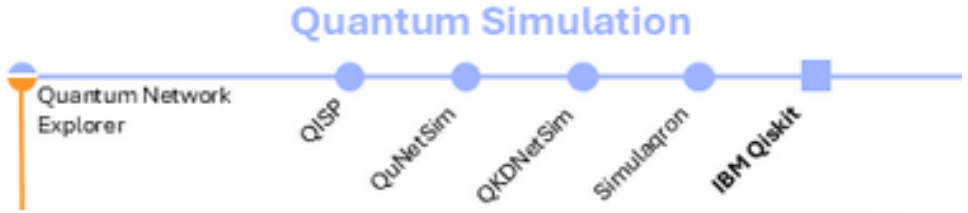
The green metro line: Introduction

- QuBits (30’)
- Quantum Cryptography (HQCI) (45’)
- Introduction to PQC - PQC transition (HQCI) (30')
- The Hybrid State-of-Play: How to Securely Combine Quantum and Post-Quantum Technologies (HQCI) (15')
- QKD-PQC: Securing Key Transfers for Application Layer Utilisation (HQCI) (35')
- Why QKD? (HQCI) (20’)
- Introduction to QKD (120’)
- Introduction to QKD Post Processing (30’)
- Challenges Ahead on the Road to EuroQCI (HQCI) (15')



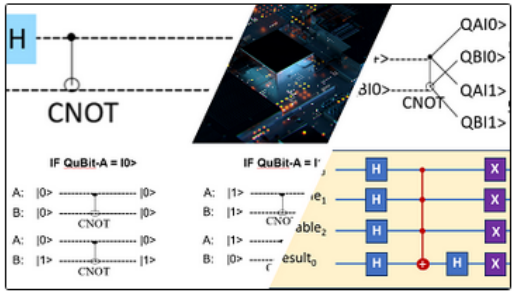
The lavender metro line: Quantum simulation

- Available learning units
  - IBM Qiskit (wiki)
- In preparation
  - Simulaqron
  - QKDNetSim



Qiskit

Created by Susanne Nägele-Jackson, last updated on Feb 06, 2026 • 1 minute read



IBM Qiskit is an open-source toolkit that helps users schedule and run quantum programs either in the cloud on a variety of simulators and quantum processors or in their local Python environment. Users have the option to build their own circuits or select some pre-built circuits from an extensive circuit library. More information including tutorials, Youtube videos and user exchange platforms are available under the following links:

- https://qiskit.org/
- http://qiskit.slack.com/
- https://www.youtube.com/@qiskit
- https://qiskit.org/documentation/
- https://github.com/Qiskit
- Qiskit Foundations - Coding with Qiskit Season 1, https://www.youtube.com/playlist?list=PLOFEBzvs-VvrgHZt3exM_NNiNKtZlHvZi
- Qiskit Textbook, https://qiskit.org/learn/
- Qiskit Runtime Service, https://www.ibm.com/quantum/qiskit-runtime
- https://medium.com/qiskit
- Microsoft Quickstart: Submit a circuit with Qiskit to Azure Quantum, https://learn.microsoft.com/en-us/azure/quantum/quickstart-microsoft-qiskit?pivots=platform-ionq
- James L. Weaver, Frank J. Harkins, Qiskit Pocket Guide, Released June 2022, Publisher(s): O'Reilly Media, Inc., ISBN: 9781098112479
- Marouen Helali, Introduction to Quantum Computing using Qiskit and IBM Q, March 31, 2019
- qiskit Discord Servers, https://discords.com/servers/tags/qiskit

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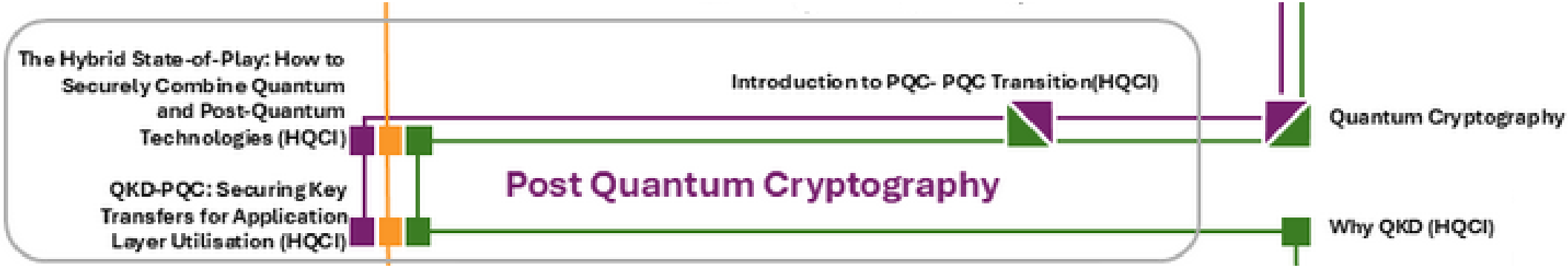
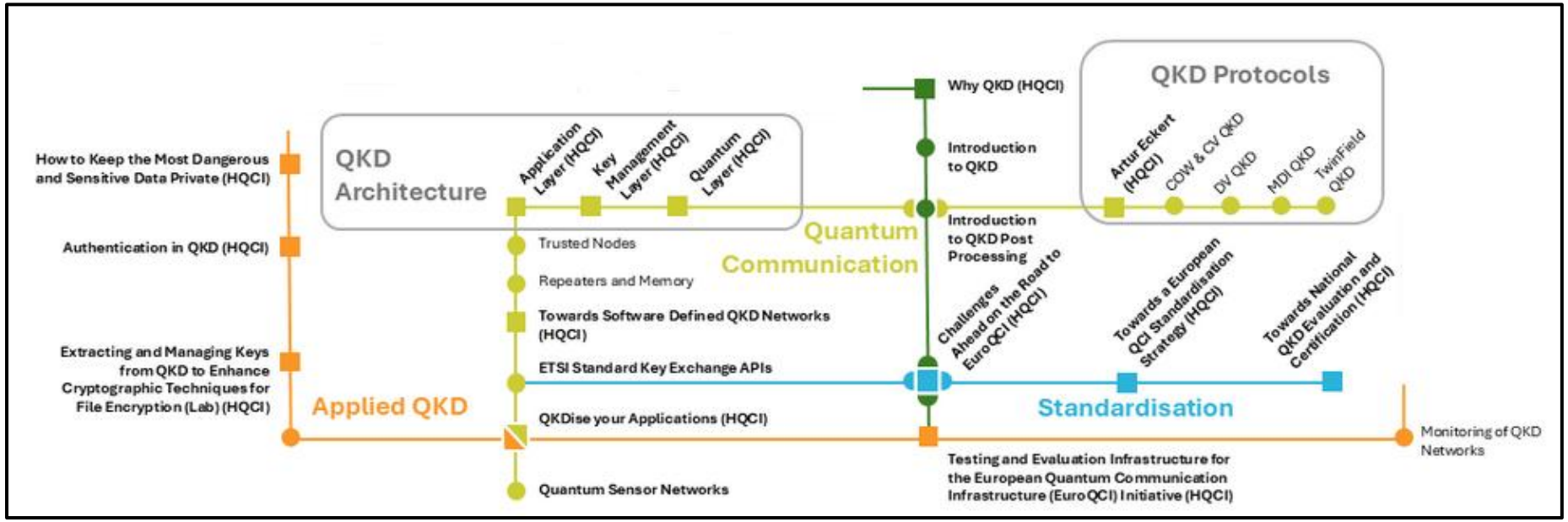
The dark purple metro line: Post Quantum Cryptography (PQC)

- Available learning units
  - Quantum Cryptography (HQCI) (45')
  - Introduction to PQC - PQC transition (HQCI) (30')
  - The Hybrid State-of-Play: How to Securely Combine Quantum and Post-Quantum Technologies (HQCI) (15‘)
  - QKD-PQC: Securing Key Transfers for Application Layer Utilisation (HQCI) (35')



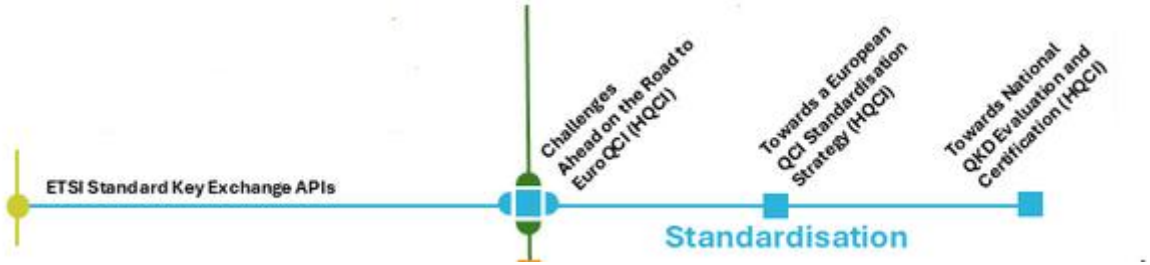
The dark yellow and orange metro lines: QKD and Applied QKD

- Available dark yellow learning units
  - About QKD technology
  - QKD Protocols
  - QKD Architecture
  - Coming soon: Trusted Nodes
- Available orange learning units
  - Dealing with use cases, tests

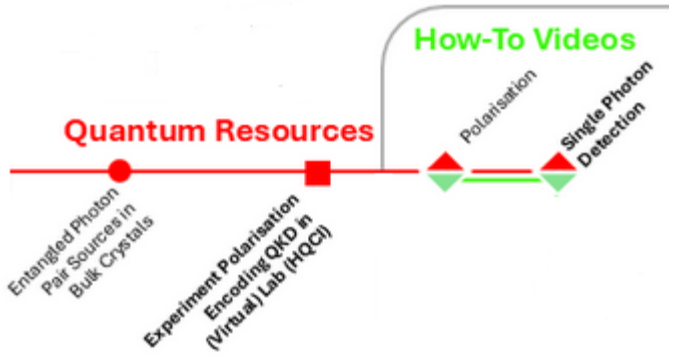


Other Quantum metro lines

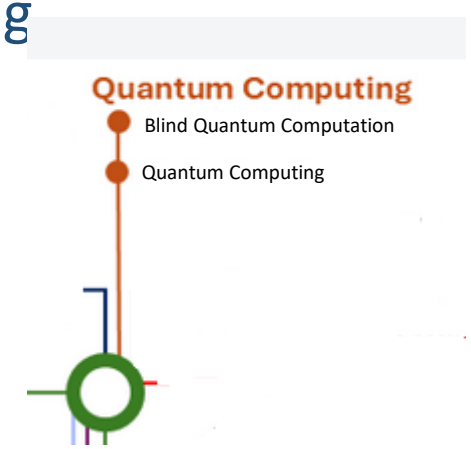
- The light blue metro line: Standardisation



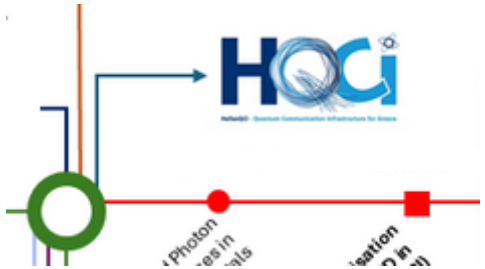
- The red metro line: Quantum Resources



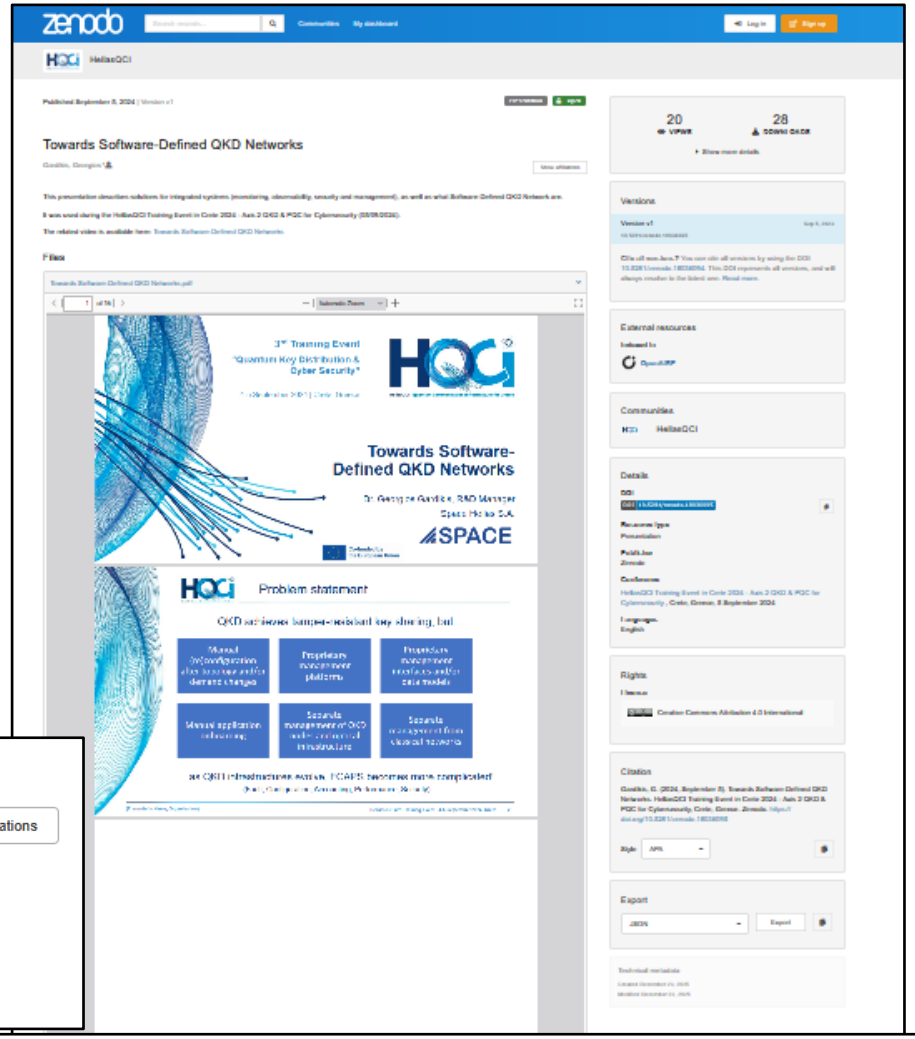
- The brown metro line: Quantum Computing



The HellasQCI Training Platform



- Classes marked with “HQCI” were made available by the HellasQCI Training Platform
- Also marked with rectangle for station icon on map
- Video and accompanying pdf available via zenodo



Towards Software-Defined QKD Networks

Gardikis, Georgios[1]

Show affiliations

This presentation describes solutions for integrated systems (monotoring, observability, security and management), as well as what Software-Defined QKD Network are.

It was used during the HellasQCI Training Event in Crete 2024 - Axis 2 QKD & PQC for Cybersecurity (05/09/2024).

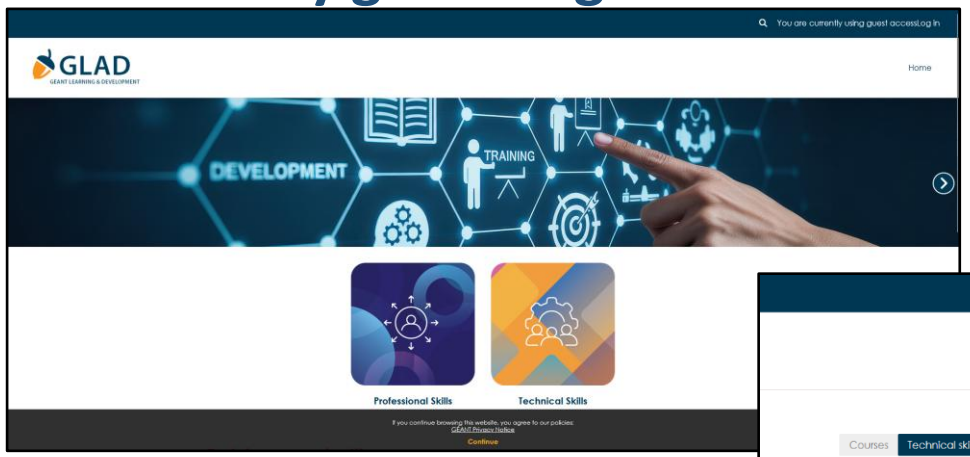
The related video is available here: Towards Software-Defined QKD Networks

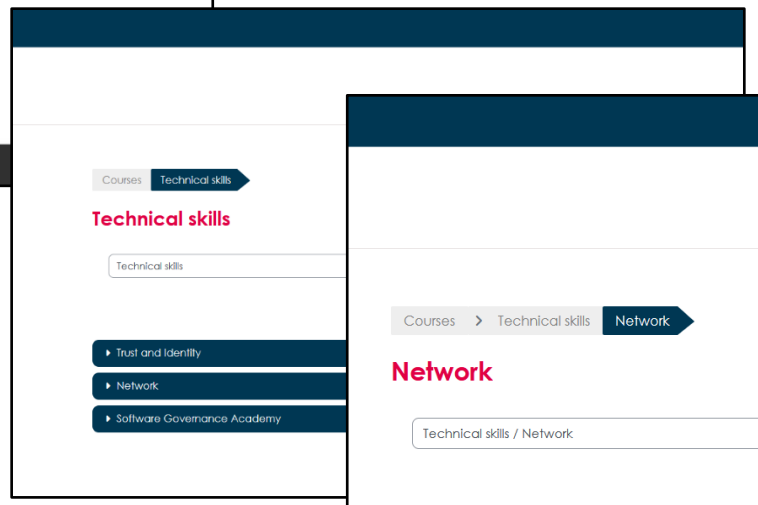
Files (2.4 MB)

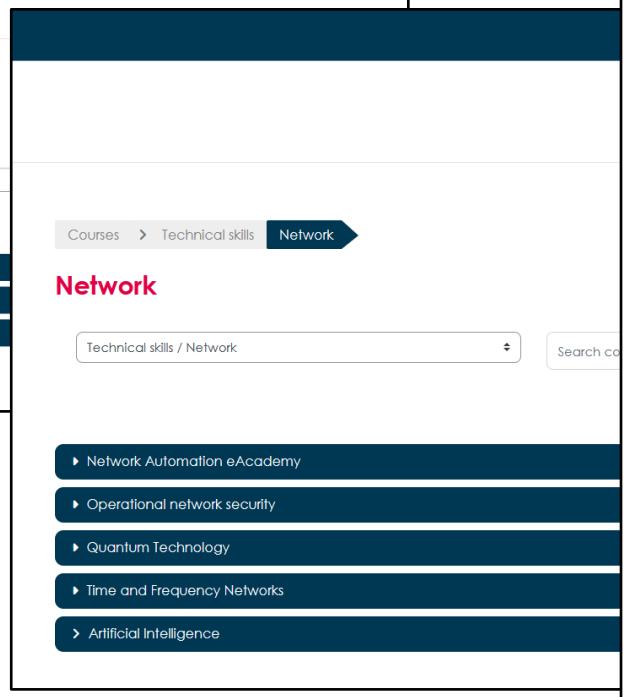
Name	Size	Download all
Towards Software-Defined QKD Networks.pdf md5:7355d3f92d0159c4e259d2081732b90e	2.4 MB	Preview Download

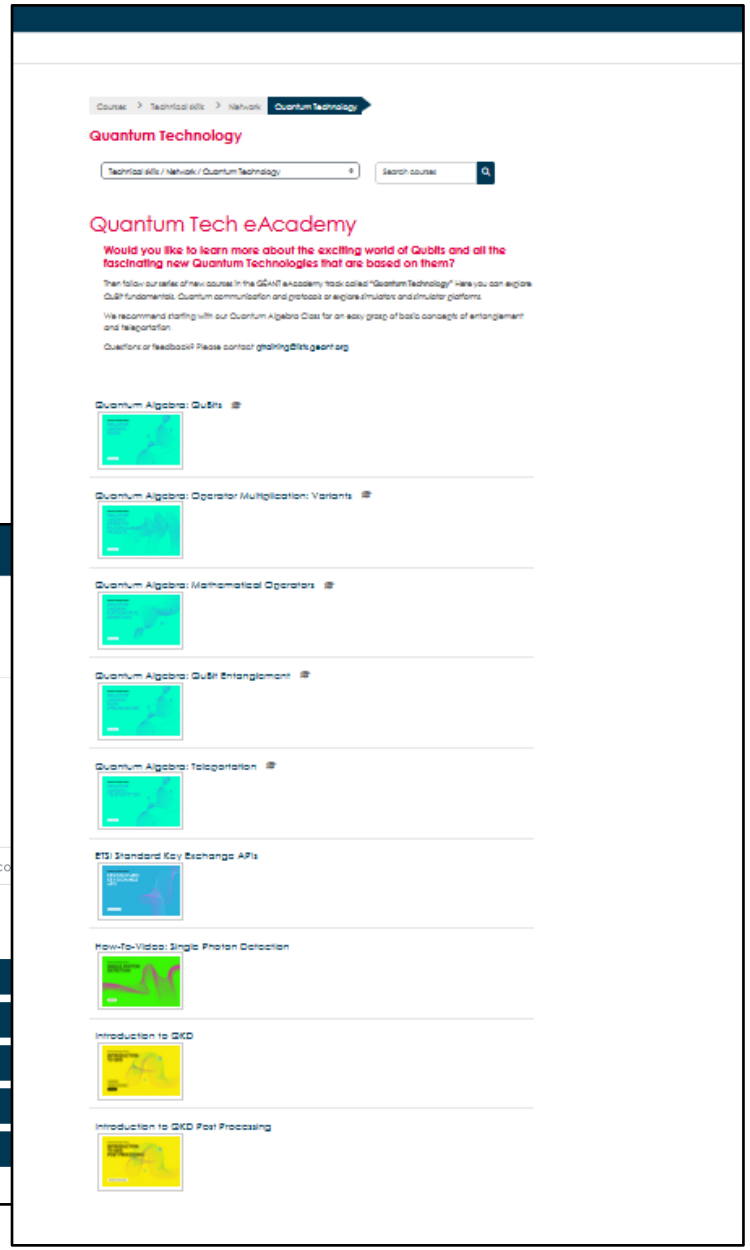
Access to courses via GÉANT Moodle platform

- e-academy.geant.org









- No access to HQCI through Moodle

Time & Frequency Networks

T&F eAcademy

T&F eAcademy

Introduction

- **Why Do We Need Precise Time?** (30')
- **Introduction to Time & Frequency** (30')
- **Metrology Concepts for Time & Frequency** (30')
- **Time and Frequency Network** (30')
- **Introduction to Fibre** (30')
- Network Time Services

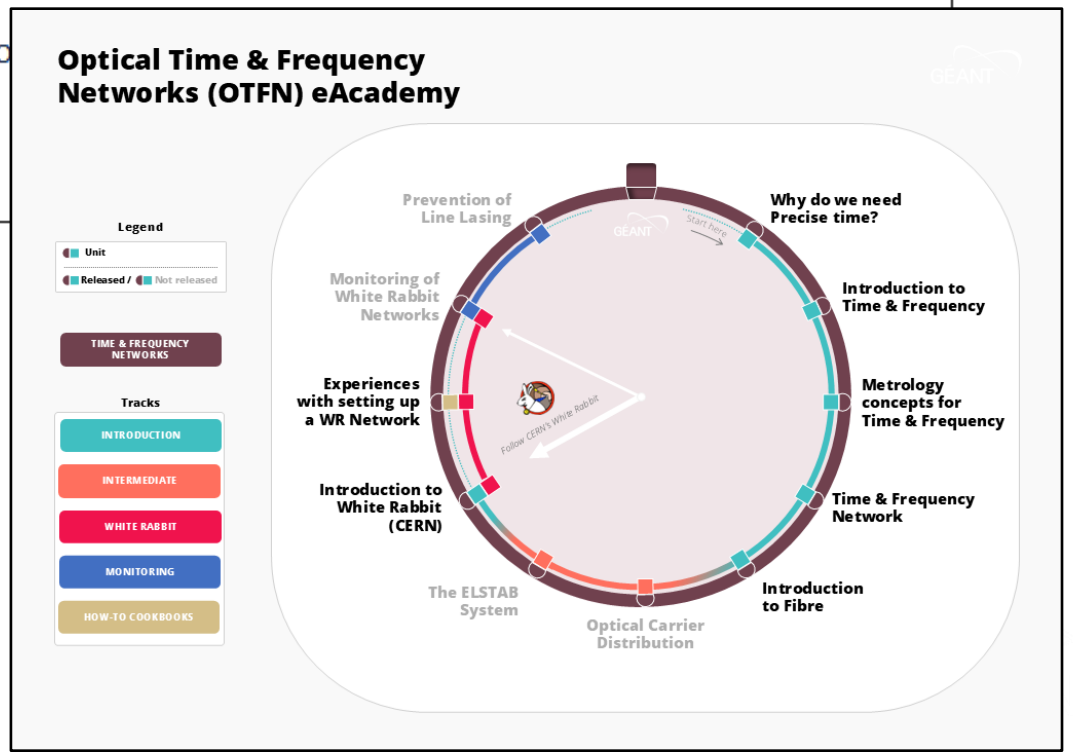
White Rabbit (WR)

- Network Time Services
- **Introduction to White Rabbit** (50') - *From CERN White Rabbit training*
- **Experiences with Setting Up a WR Network** (30')
- Monitoring of White Rabbit Networks (30')
- Follow ***CERN's White Rabbit Project training***
- And read more on **CERN's official White Rabbit website**

Advanced Level

- Optical Carrier Distribution (30')
- The ELSTAB System (30')

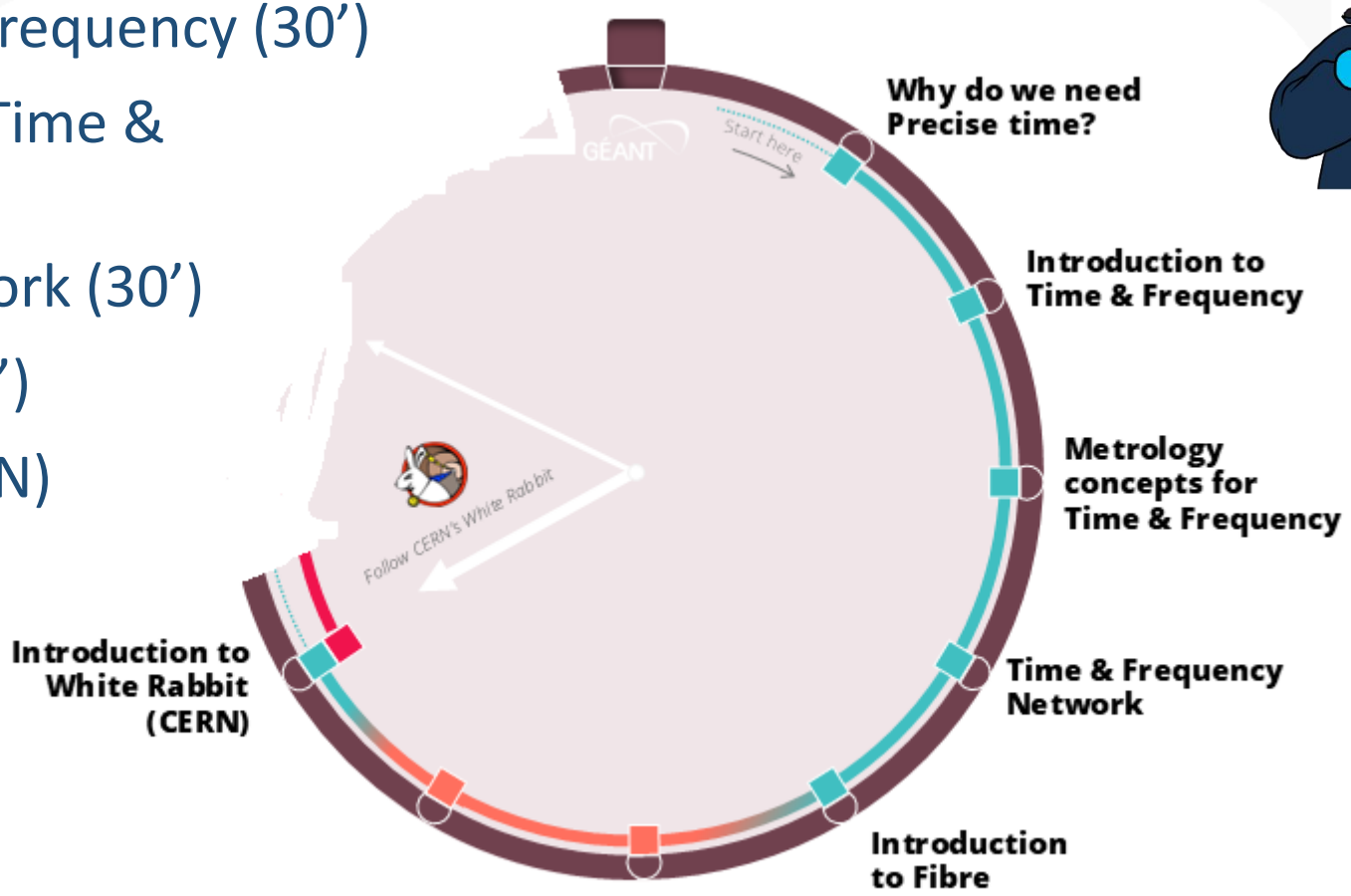
Monito



- Five metro lines:
  - Introduction
  - Intermediate Level
  - White Rabbit (WR)
  - How-to Cookbooks
  - Monitoring
- No circle stations, all access is denoted by rectangles

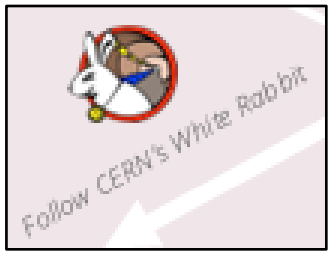
The green metro line: Introduction

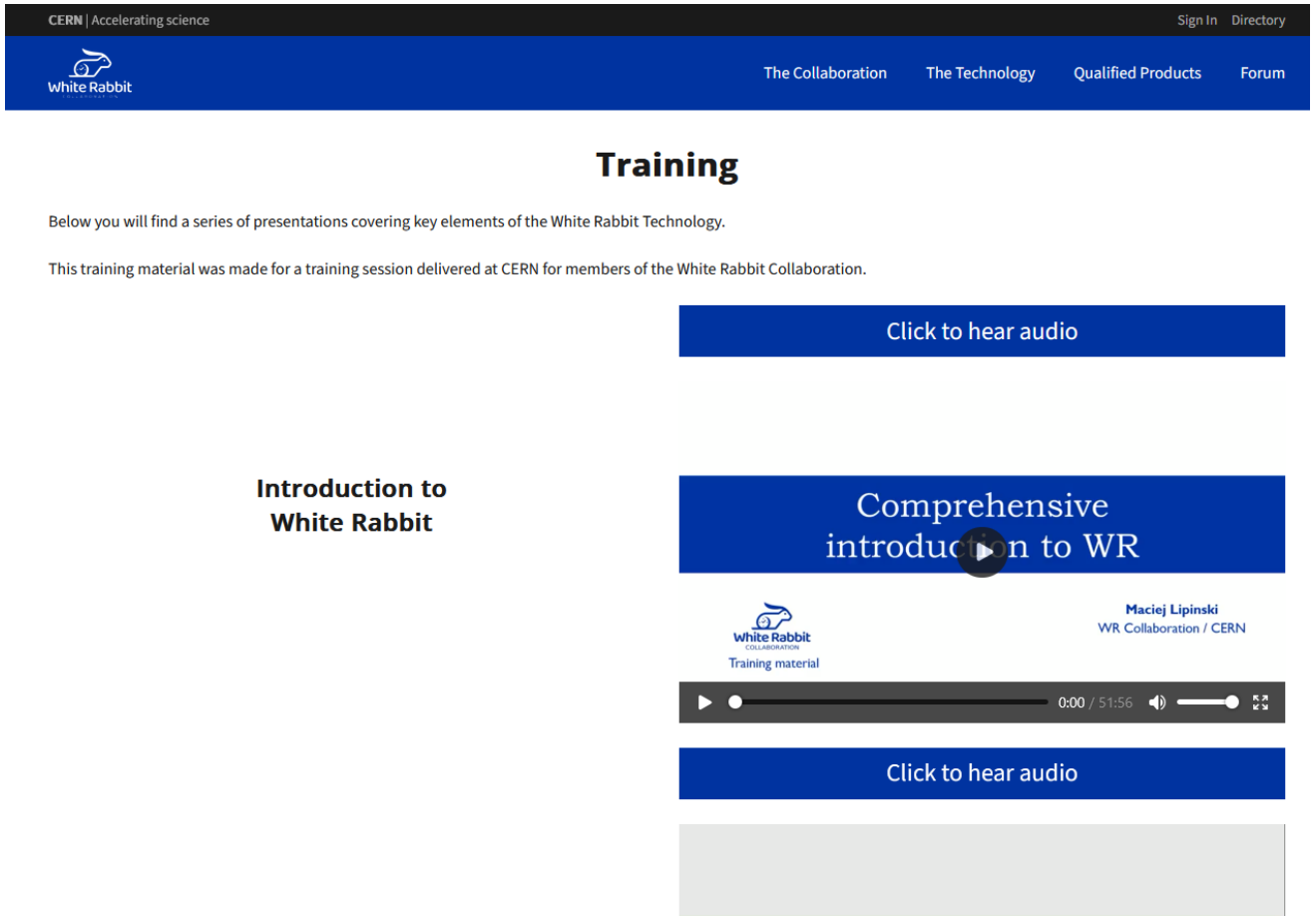
- Why do we need precise time? (30’)
- Introduction to Time & Frequency (30’)
- Metrology concepts for Time & Frequency (30’)
- Time & Frequency Network (30’)
- Introduction to Fibre (30’)
- Introduction to WR (CERN)



Collaboration with CERN

- Introduction to WR
- White Rabbit Switch - The Basics
- White Rabbit Switch - Advanced Topics
- White Rabbit Node (WR PTP Core)
- White Rabbit PTP Core Integration into a White Rabbit Node
- White Rabbit Calibration
- Oscillators - An Introduction



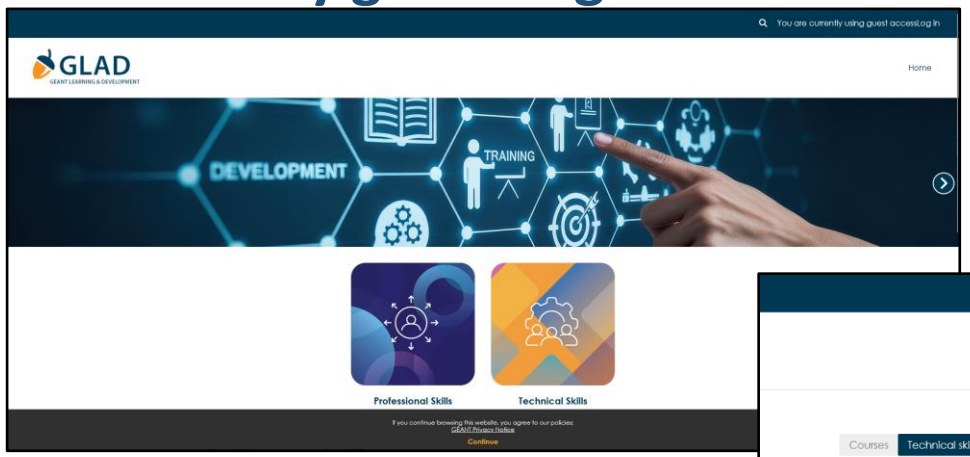


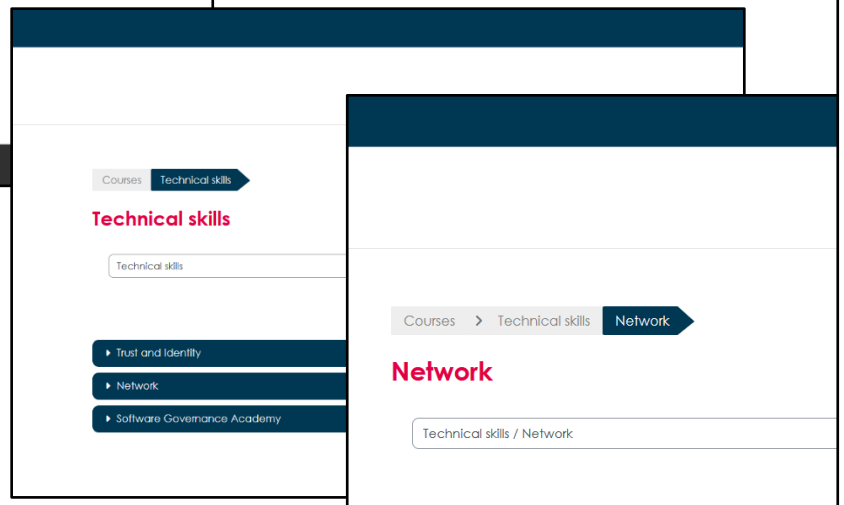
Orange, gold and blue metro lines

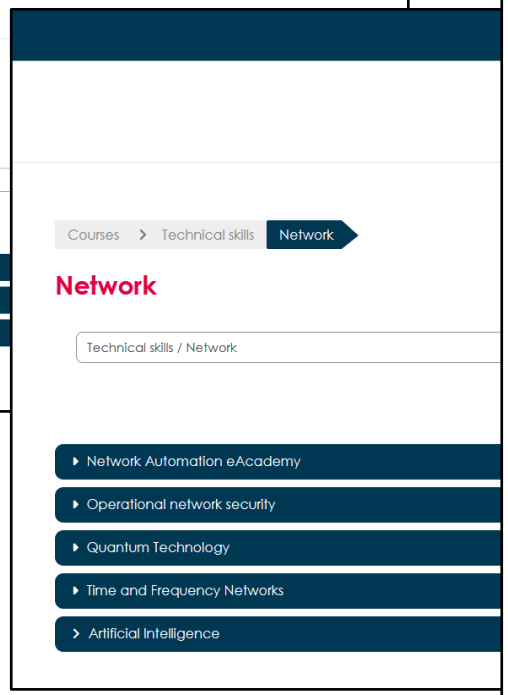
- **Intermediate Level**
  - Optical Carrier Distribution (30')
  - The ELSTAB System (30')
- **How-to Cookbooks**
  - Experiences with Setting Up a WR Network (30')
- **Monitoring**
  - Monitoring of WR Networks
  - Prevention of Line Lasing

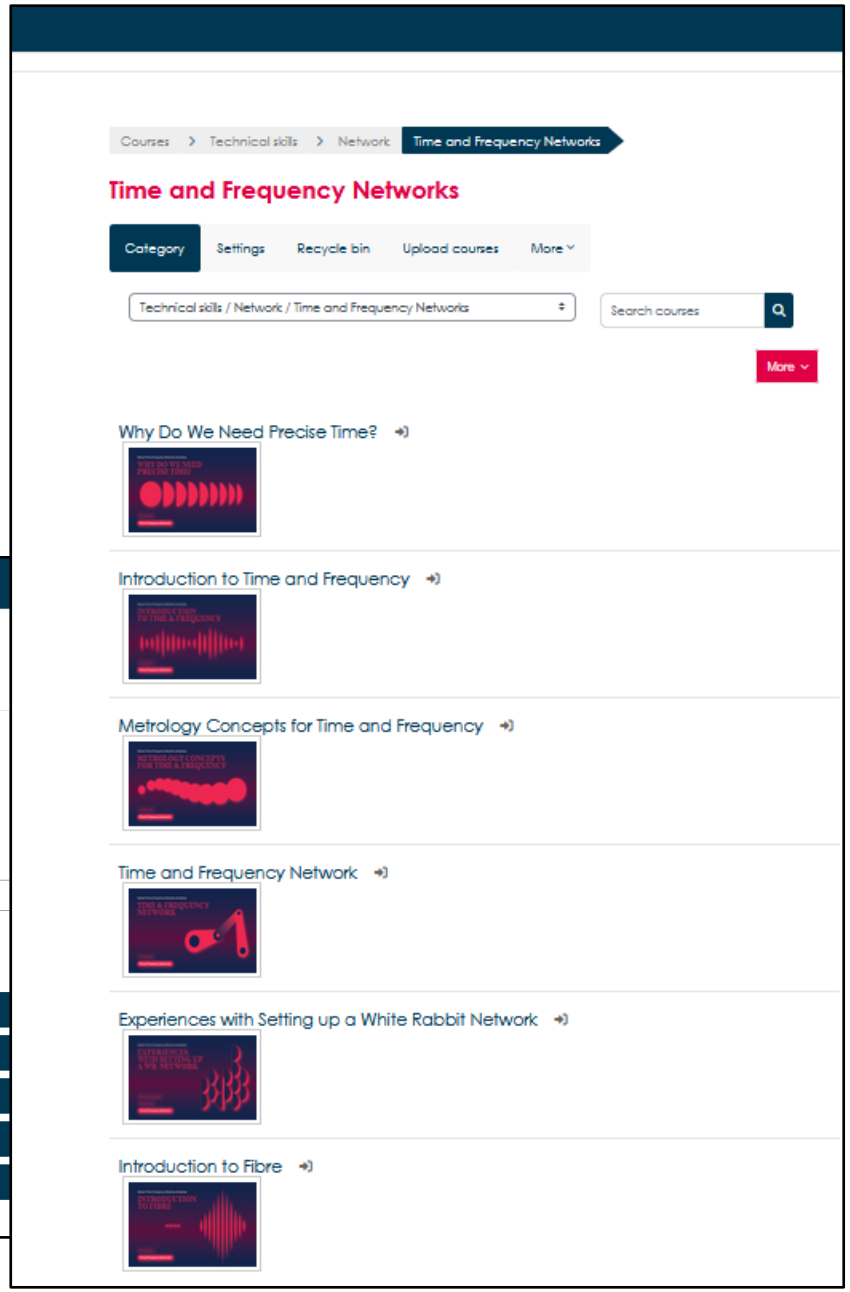
Access to courses via GÉANT Moodle platform

- e-academy.geant.org



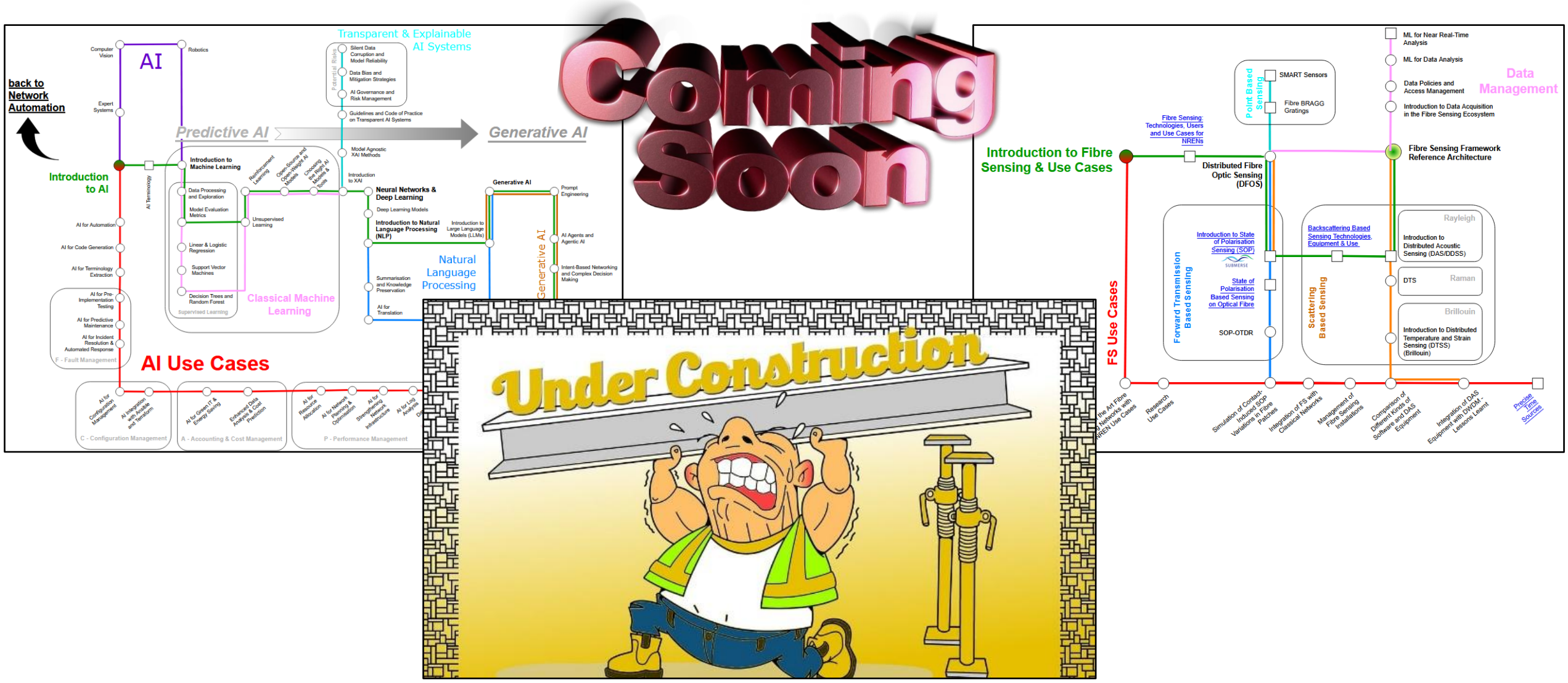






- No access to CERN through Moodle

Coming Soon: AI and Fibre Sensing Metro Maps



Thank You

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