Lighting up NREN Spectrum

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Trieste TNC22

15 June 2022

Outline

- Motivation
- What is Spectrum
- SCS team in GN4-3
- GEANT Trials
- User Pilots and Requirements
- Next Steps

Spectrum Service Team and GEANT field trials

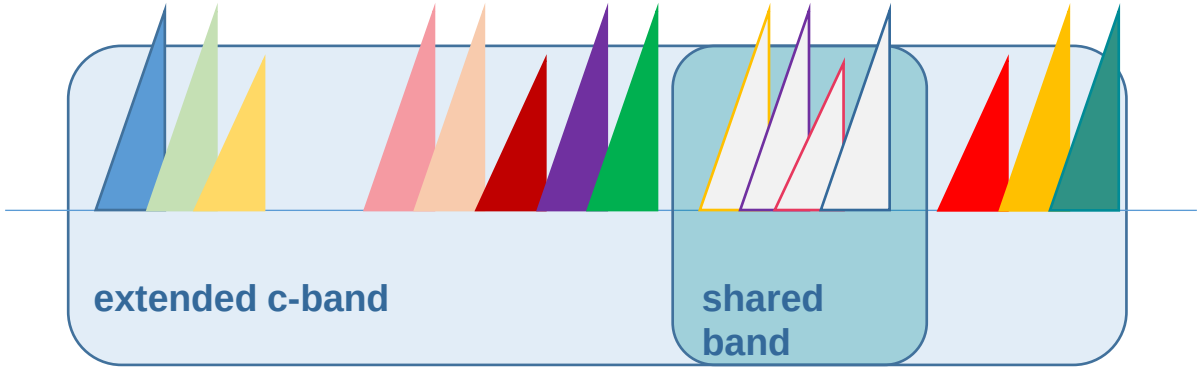
- **Speaker: Guy Roberts (GEANT)**

Spectrum Sharing Motivation

- NREN Technical capabilities allow spectrum sharing their network
- Technology such as ZR+ pluggables allow for easy lighting of spectrum
- Spectrum saves money and increases user's control over their transmission network
- Provides easy scaling up and IRU on spectrum gives good financial model and certainty for planning
- In 2020 GEANT set up the Spectrum Connection Service team to develop a new service
- GEANT has been trialling spectrum in GN4-3 with good results

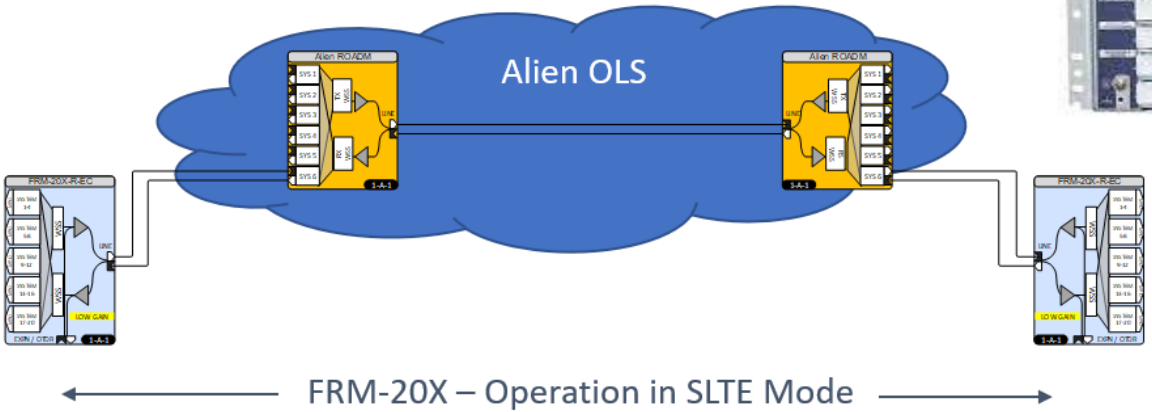
Spectrum is now being deployed widely in commercial providers and NRENs and is here to stay

Spectrum Sharing at a glance



- Extended C-Band has 4.8THz of spectrum, but this is typically not fully utilized
- Open Line Systems with FlexGrid allows spectrum to be managed in slices (6.25GHz)
- Each slice of spectrum can be ‘owned’ and operated by a separate network provider

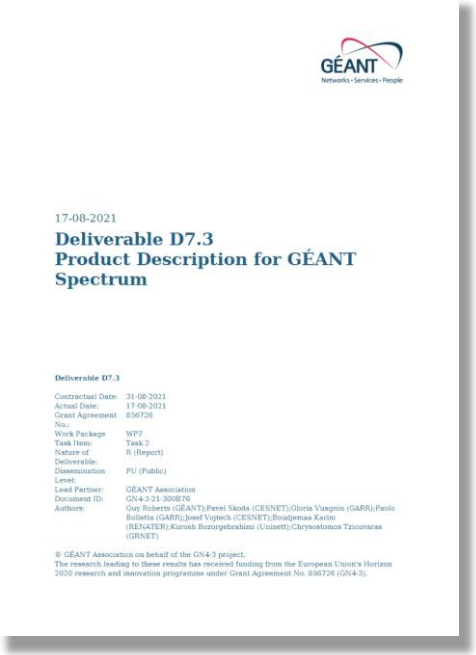
GEANT – FlexILS enabling spectrum



- GÉANT uses the FlexILS, this is a flexgrid ROADM from Infinera
- System designed to be Open Line to support 3rd party transponders
- Flexible Add Drop of scalable slice of spectrum

GEANT project and The Spectrum Connection Service (SCS) team

- GÉANT network is being upgraded and will be completed in 2023.
- A new Spectrum Connection Service (SCS) has been proposed in the GÉANT Network Evolution Plan
- The service development team in GN4-3 is WP7-T2
- The SCS team
  - has defined a service description
  - is running field trials
  - engages Users to run service pilots
- The participating NRENs are:


17-08-2021

Deliverable D7.3
Product Description for GÉANT Spectrum

Deliverable D7.3

Contractual Date:	31-08-2021
Actual Date:	17-08-2021
Grant Agreement No.:	856726
Work Package	WP7
Task Item:	Task 2
Nature of Deliverable:	R (Report)
Dissemination Level:	PU (Public)
Lead Partner:	GÉANT Association
Document ID:	GN4-3-21-300B76
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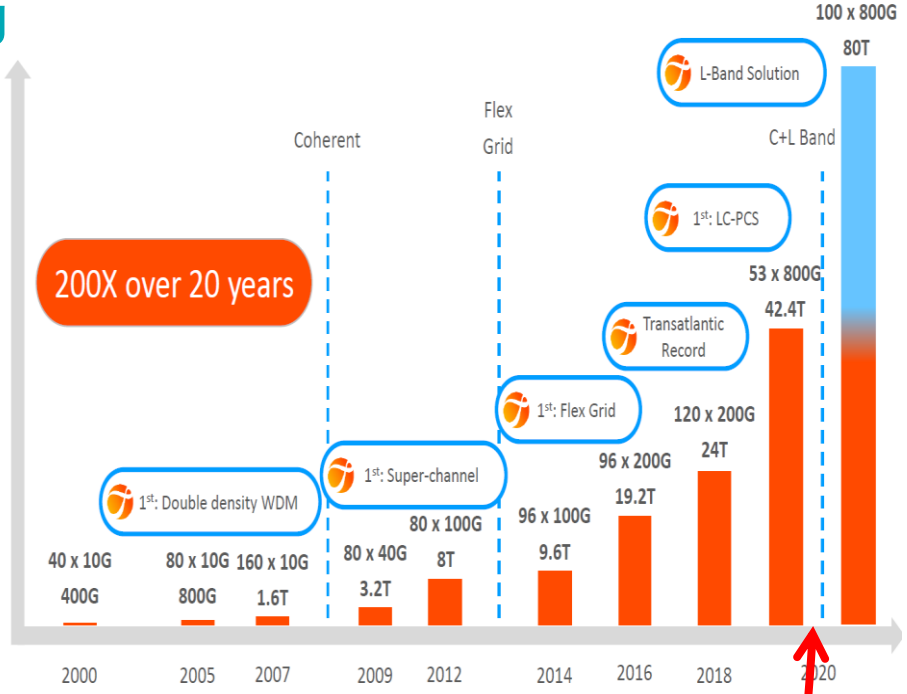
Fibre Capacity – Technology Scaling

- Next generation of DCI and pluggable optics increasing fibre capacity
- DCI and pluggable form factors are current trend
- Up to 80Tbps on a fibre pair

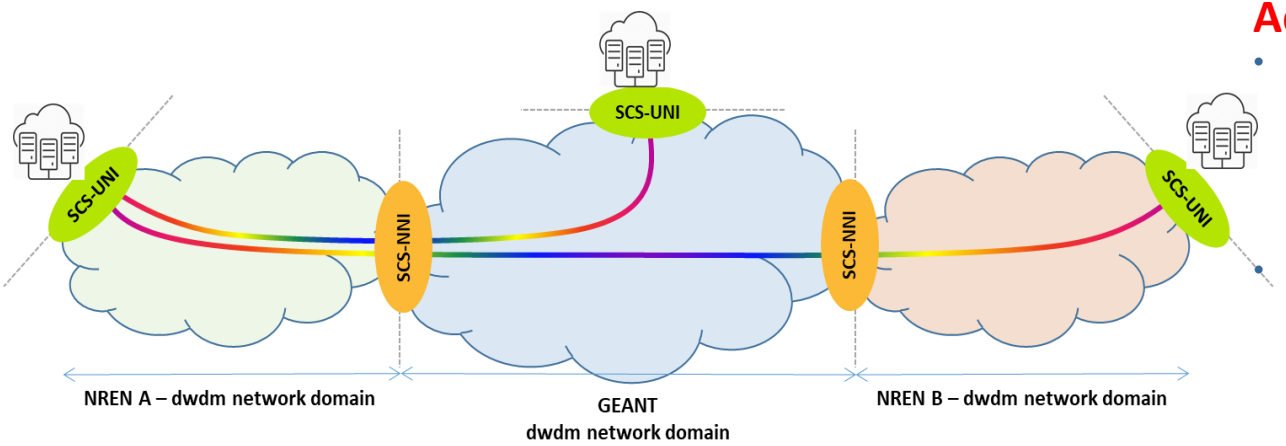
Infinera Groove

400 ZR Pluggable



Field Trial 2021:
800G Direct Detect
800G per λ, 42T per fiber

SCS Reference Model



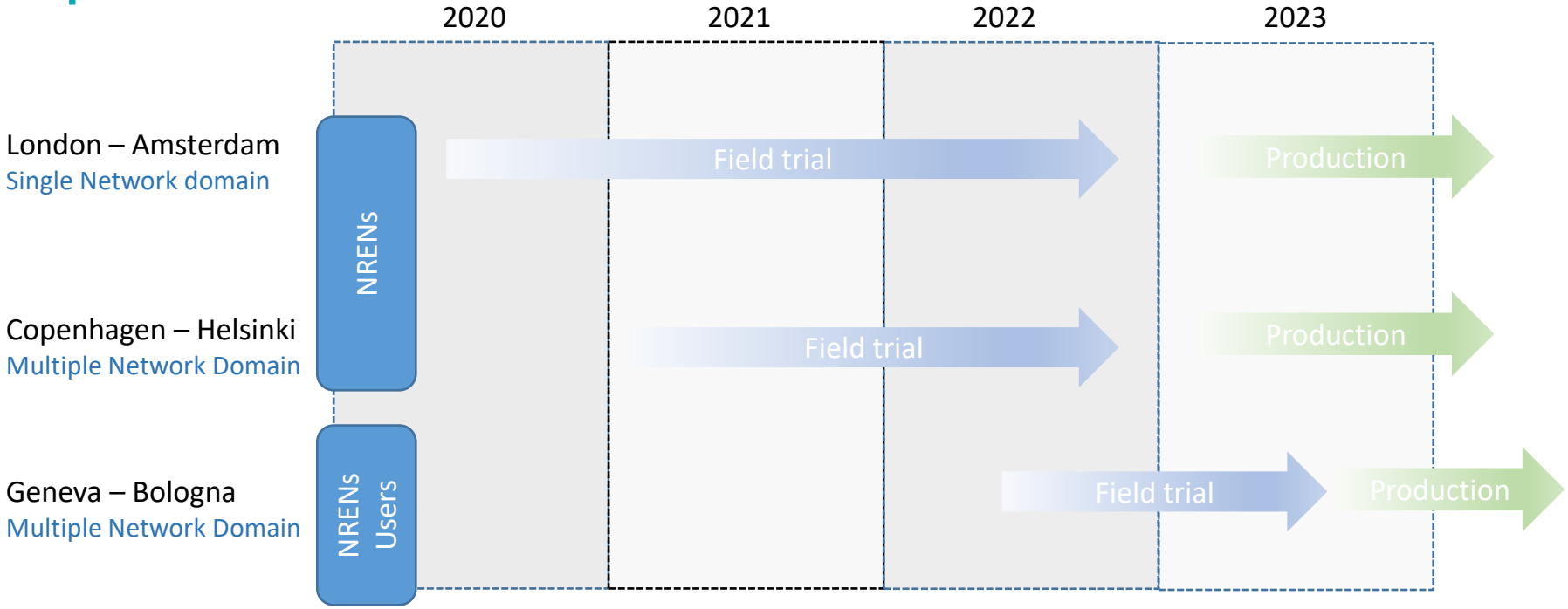
Actors:

- **Spectrum Service Users- Consumers**
  Own the equipment that generates the coloured, coherent optical signals, behind the SCS-UNI
- **Spectrum Service providers**
  Own and operate the DWDM line system in their domain

Interfaces:

- **SCS-UNI: The User-Network Interface.**
  - It defines the ‘end’ of the SCS service region. Beyond is the customer’s network outside of the region controlled by the SCS service
- **SCS-NNI: The Network-Network Interface.**
  - It defines the boundary between two networks that are participating in the SCS service

Spectrum Service Field trials

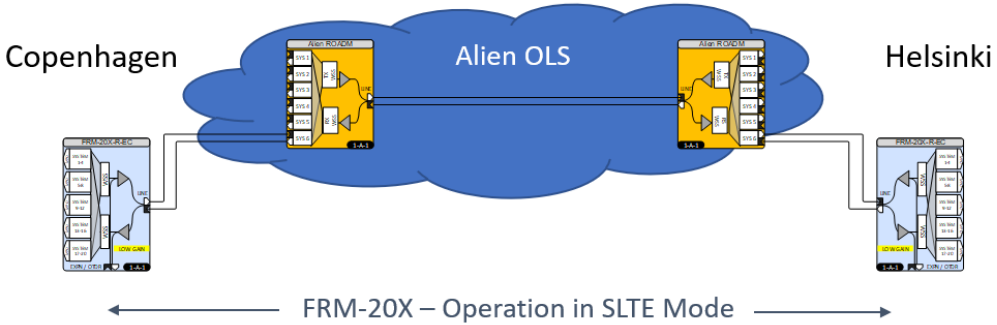


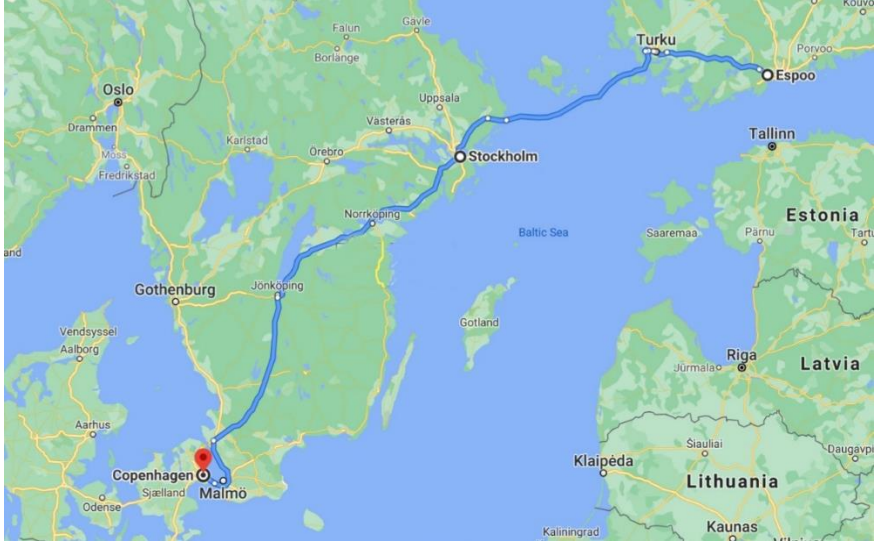
Amsterdam-London

- In 2020 SURF required a solution to replace their dark fibre between London and Amsterdam
- As SURF and GÉANT are collocated at both ends of the GÉANT fibre it was agree that GEANT would provide spectrum to SURF
- The Infinera system was built in September and in October 2021 the SURF spectrum service trail began

- The system has been stable and carrying SURF traffic for more than 6 months
- The system will go into production in 2023 once the GEANT Spectrum Service is launched

Helsinki-Copenhagen



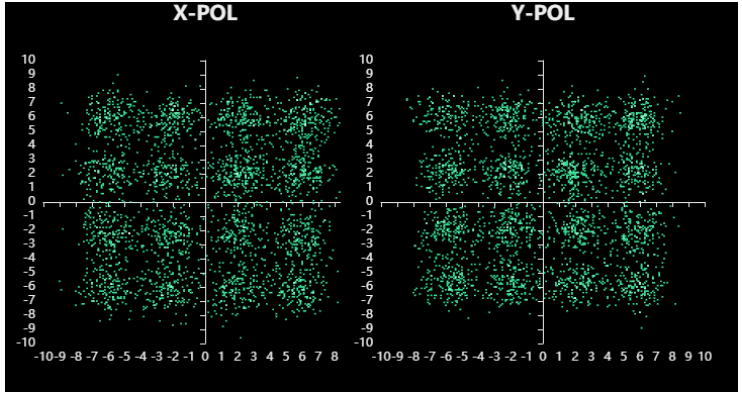


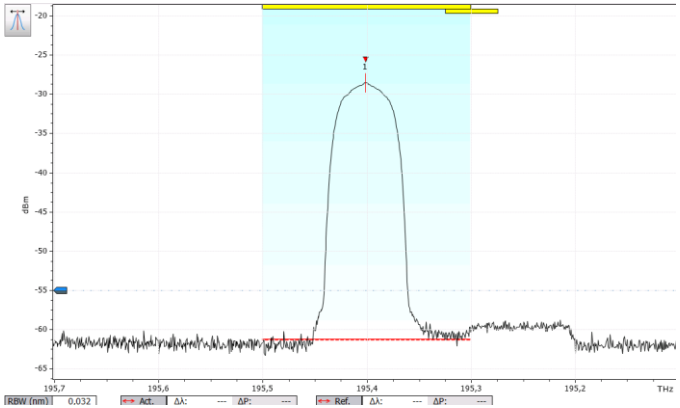
- SUNET and FUNET have provided GEANT with1200GHz of spectrum between Copenhagen and Helsinki in two bands:
  - 600GHz: 191,575THz – 192,175THz
  - 600GHz: 195,075THz – 195,675THz
- Field trials have been successful

Helsinki-Copenhagen

- When running 200Gbps 16QAM with 69Gbaud in a 100GHz channel the system runs error free with 20.1dB of OSNR
- CHM1, 16QAM/200Gbps at 100GHz and 34.7GBaud

DGD (ps)	4
Q-Factor (dB)	6.5
OSNR (dB)	20.1
CD (ps/nm)	22369
Pre Fec Ber	0.016163326800000
CD Range Low	-45000
CD Range High	45000



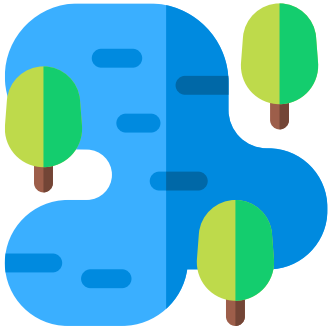


User Pilots and Applications

- **Speaker: Paolo Bolletta (GARR)**

Back to Use Cases

Data explosion

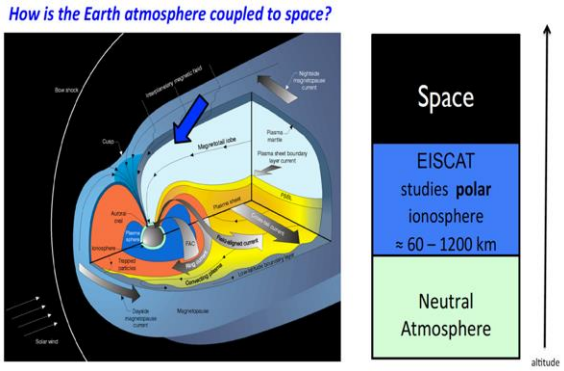


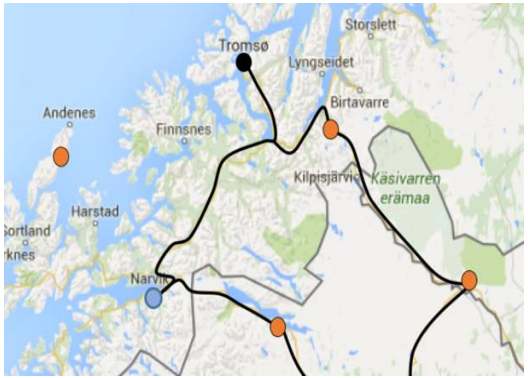
User Access to the Optical Layer
Dynamic DCI for Data Lakes for Science

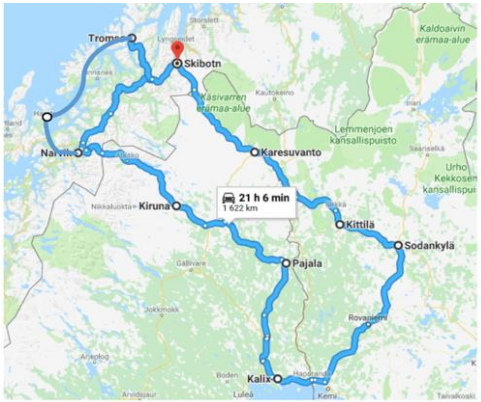
NREN to share infrastructure
Spectrum Sharing at European Level

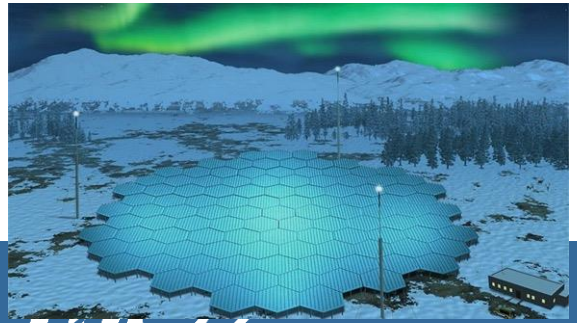
EISCAT Antenna

- EISCAT and EISCAT3 project in Norden Nordic area: studies of the atmosphere and near-Earth space environment



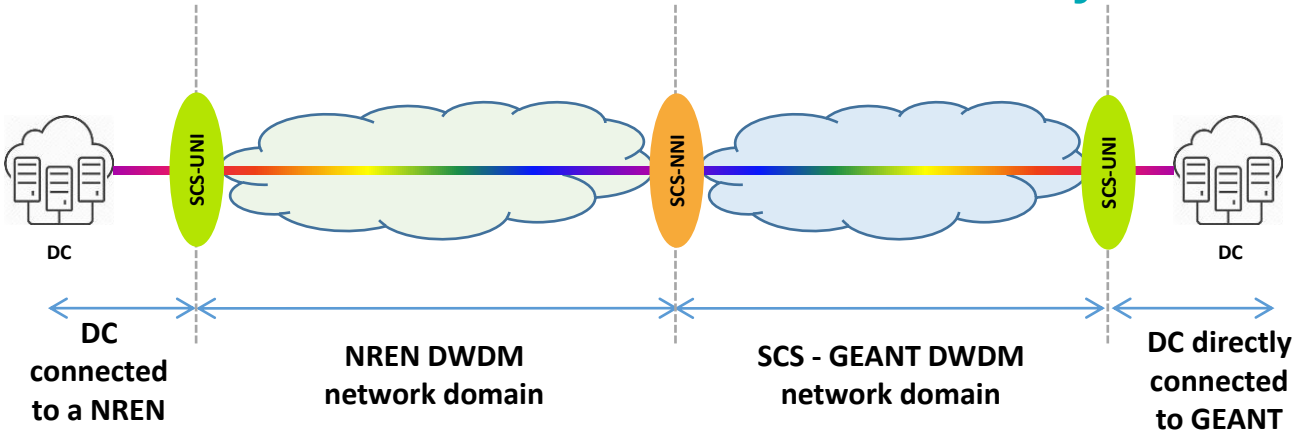






- Three antenna site, each needs 2x4Tbit/s of constant data stream to the storage/computation site (DC).
- 2THZ shared spectrum crossing three domain (NO-SE, SE-FI and FI-NO)

Generic Use Case: Data Centers Interconnection by SCS

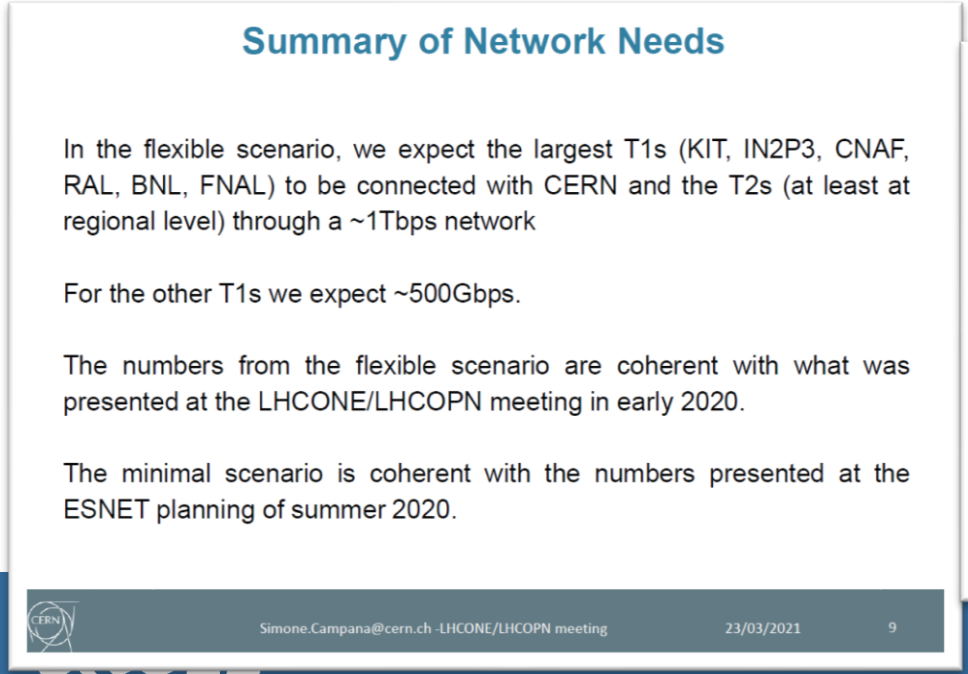


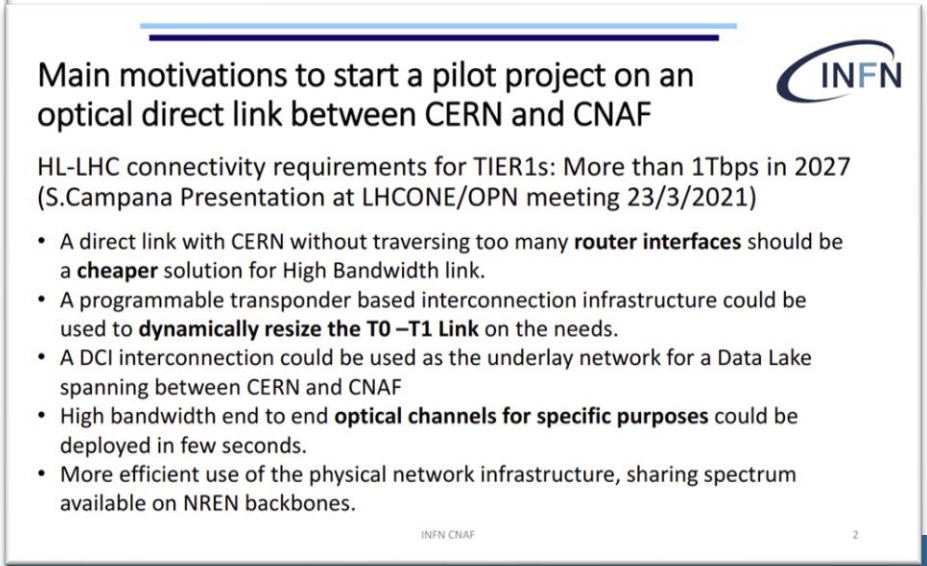
- End user interconnection over two photonic domains: one NREN and Géant
- Two Data Center as end-sites, providing DCI boxes to generate optical signal
- No 3R regeneration -> approximately 1000km path.
- Focus on APIs to provision, manage and monitor the connection
- Simulation tools test
- **Use Case**: CNAF (IT) Tier1 to CERN Tier0, through GARR and Géant SCS service providers

CNAF – CERN Data Center Interconnection

- LHCOPN-LHCONE meeting #46
- S.Campana (CERN) - link

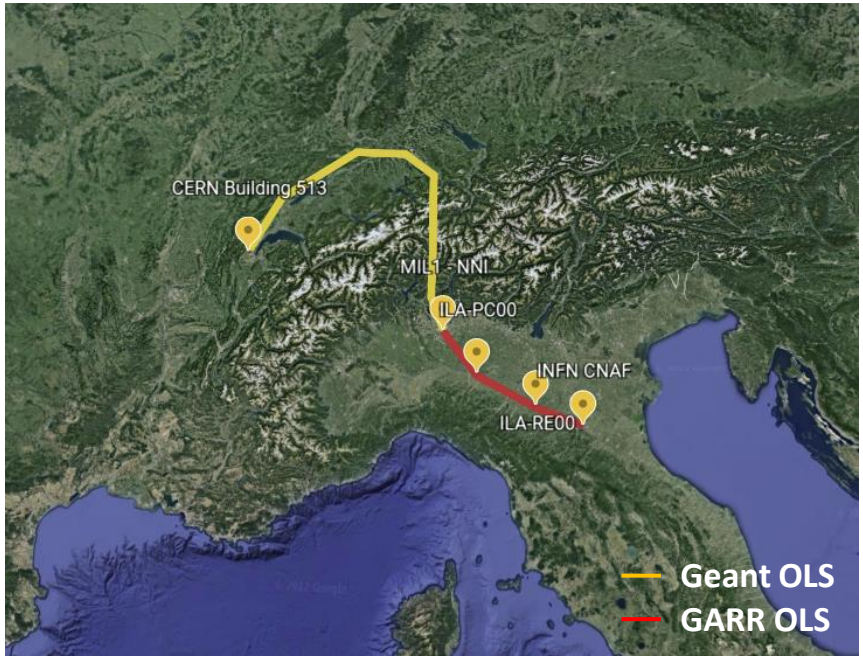
- LHCOPN-LHCONE meeting #48
- S.Zani (INFN) - link





CNAF-CERN DCI over SCS

- Direct Interconnection between DC to scale up with network traffic demands
- Approximately 1000km
- CNAF DC collocated with GARR optical core node BO01
- CERN DC collocated with GEANT optical node GVA
- GARR GEANT optical network collocated in Milan
  - Node Architecture in MIL1 allows to evaluate different interconnection schemas



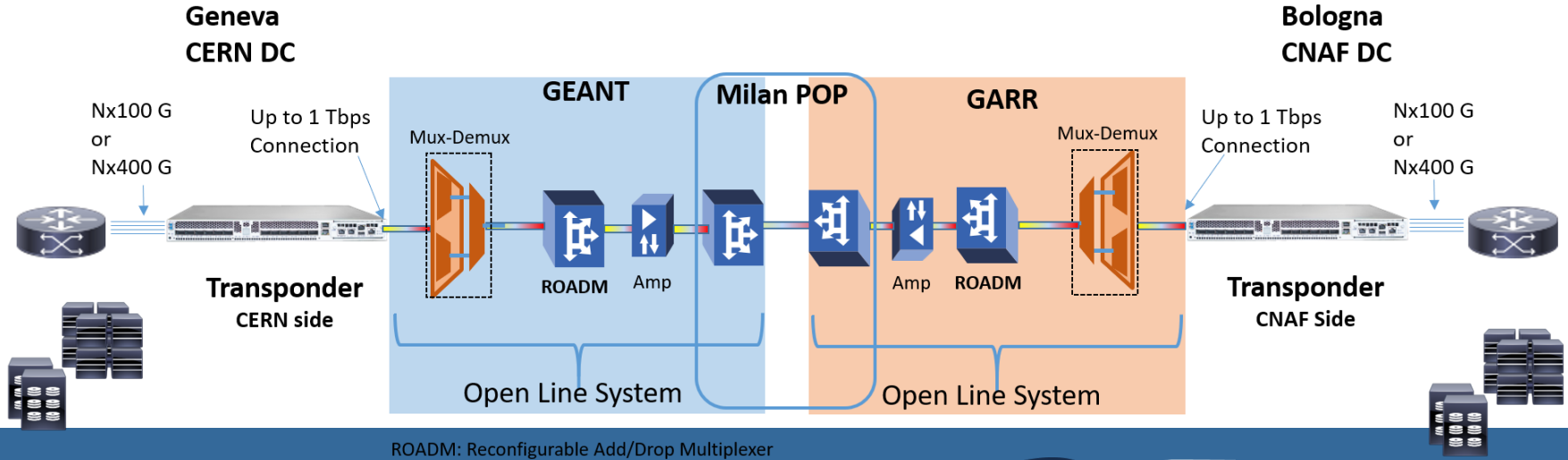
Pilot Activity

Service Main Features

- e2e transparent optical interconnection
- neither restoration nor protection
- flexible DCI ownership

Areas of investigation

- End Points (DC, L2/L3 interconnections)
- UNI
- NNI
- Reliability
- Monitoring and Control
- Impact on Optical Line System



ROADM: Reconfigurable Add/Drop Multiplexer

Pilot Steps (1/2)

Activity started in late 2021

- **Prerequisites**
- Configuration and tuning of the GARR Open Line system between Bologna and Milan GARR/GEANT POP. [07/2022]
- GARR is procuring DCI for CERN node [already ordered, delivering] and CNAF node [to be ordered by 07/2022]
  - 2x Transponders per site *(To be ready for preproduction)*
    - Infinera Groove G30 (CHM2T DCI Metro)
    - 2 Transceivers QSFP28 (100G-Ethernet)
    - 1 QSFP-DD 400G Ethernet
- NNI interconnection in Milan [defined and agreed between GEANT and GARR, to be deployed]

Pilot First Steps

- Access to the GEANT spectrum sharing service and tuning activity:
  Different interconnection schema are under evaluation
- Transponders will be connected to the Datacenters LANs of the sites (CNAF and CERN) at the beginning at 2x100G to perform first tests. - Hope to have the first link up before the end of 2022-

Pilot Steps (2/2)

- **Pilot Next Steps**
- Grow in terms of capacity adding 100G Ethernet ports and activating 400G Ethernet
- Integrations with monitoring and control tools
- **Up to → Pre Production**
- Check the reliability of the interconnection
- Validate monitoring and operational management

Opportunities and Challenges [DC]

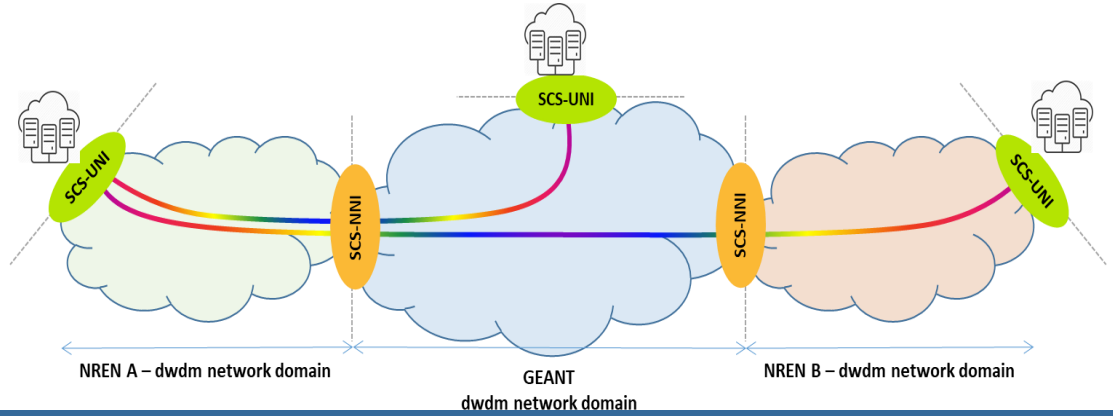
- L2 Stretching of specific networks between the DCs
- IP Fabric stretching
- Direct L1 Interconnection as part of the full capacity capability of a DC

Opportunities and Challenges [NRENs]

- Definition of best practices and limits related to Spectrum Connection Service
- PKT layer offload and overall network scalability enhancement
- Develop monitoring and control tools through open APIs

Goal achieved and pillars to preserve

- Generic and flexible Reference Model
  - ✓ Several use cases
- Model is independent from Network Domains Architecture
  - ✓ Neutral from Vendors and NREN's network platforms
- API based integration for management and control
  - ✓ Open source tool integration
  - ✓ Open and standardized interfaces
- Open and Flexible Line System



Further steps

- **Scaling up to a larger number of Spectrum and Waves**
- **Network Visibility**
  - Performance Monitoring and log/event management
- **Unified Management and Network Automation**
  - Provisioning and capacity allocation
- **AW and Spectrum Sharing privacy**
  - Share secure infrastructure
- **Network Design and Planning**
  - Planning tool for multi-domain and multi-vendor environmental

Thank you

Any Questions?

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As part of the GÉANT 2020 Framework Partnership Agreement (FPA), the project receives funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 856726 (GN4-3).