



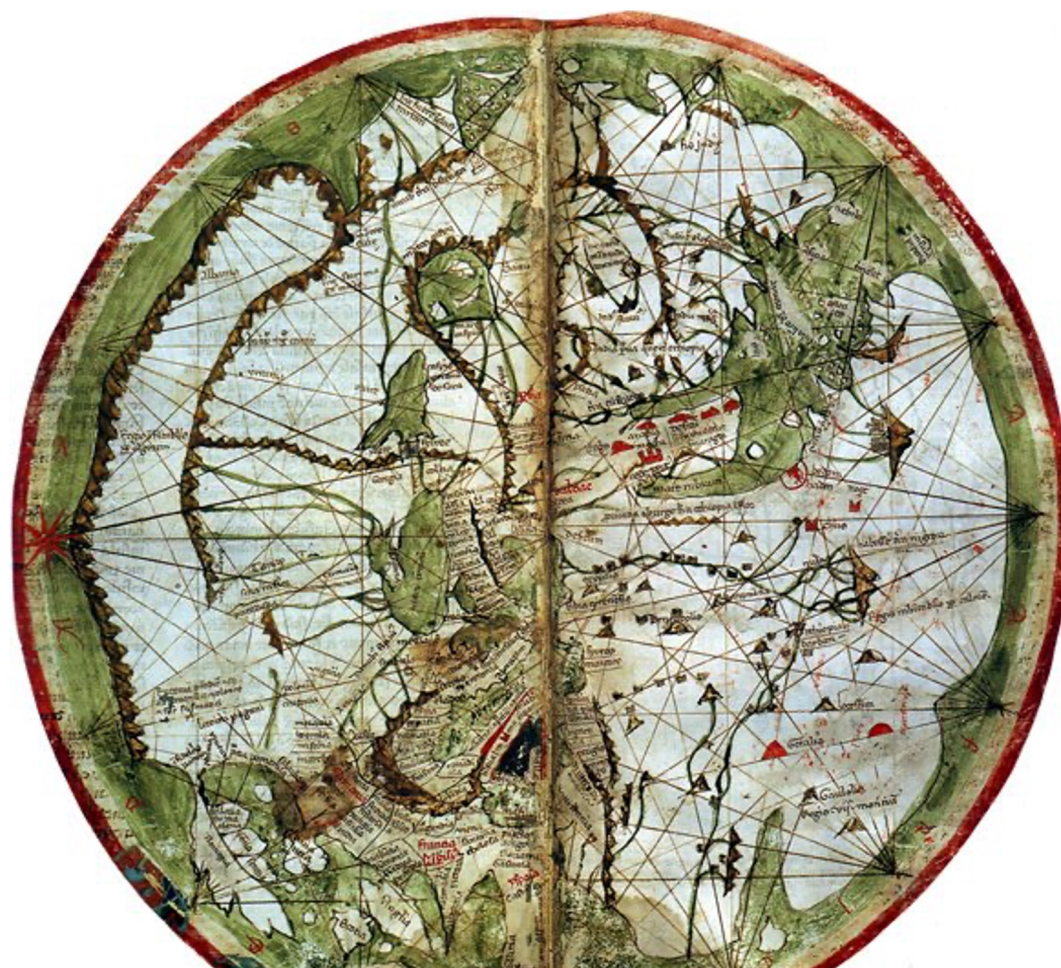
# Infrastructure and Transatlantic Spectrum SIG-NGN

**Bram Peeters**  
CNOO GÉANT

Catania, Sicily - April 8<sup>th</sup> 2024

Public

# Global Networking – Map Day!



# GÉANT: European Membership Association

**38 European National  
Research and Education  
Networks (NRENs)  
+ NORDUnet (5 Nordic NRENs)**

**Reach:**

**over 10,000 institutions and  
50 million academic users**



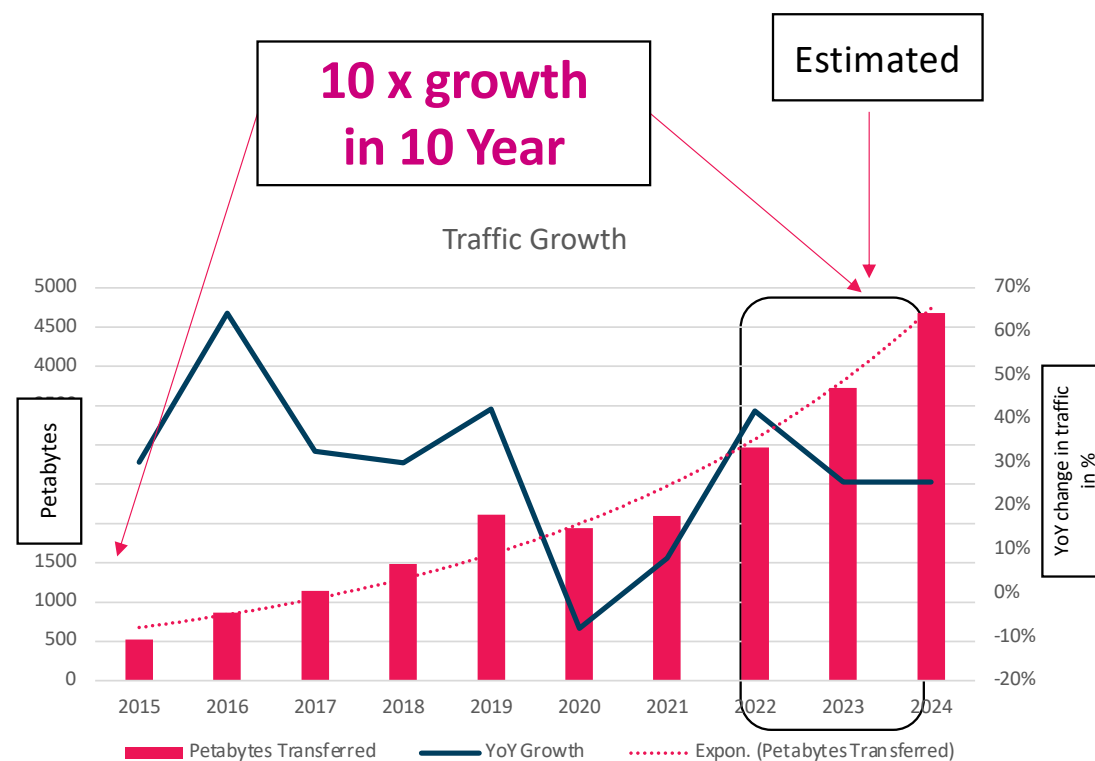
# The Standard Network Challenge: Traffic Growth

## Total Backbone Trunk Capacity

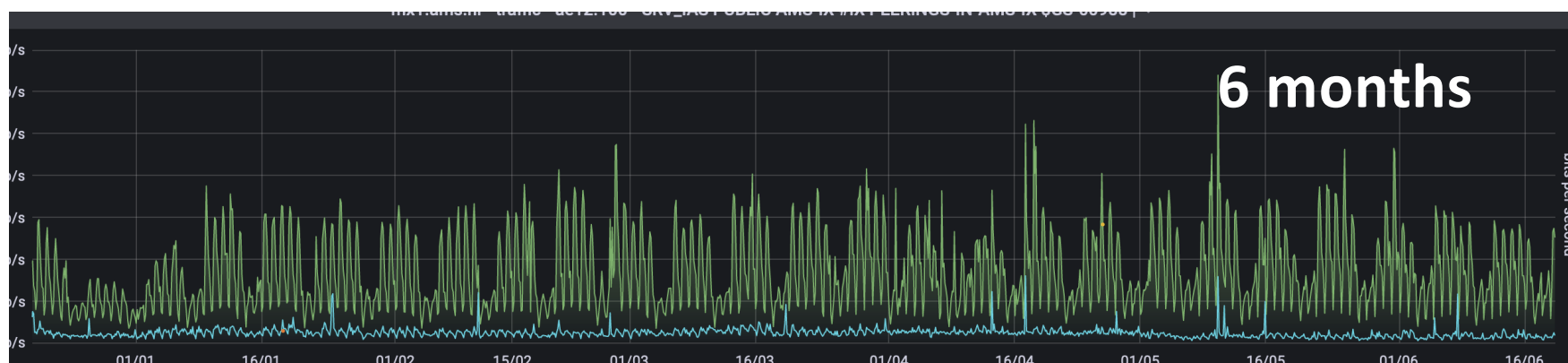
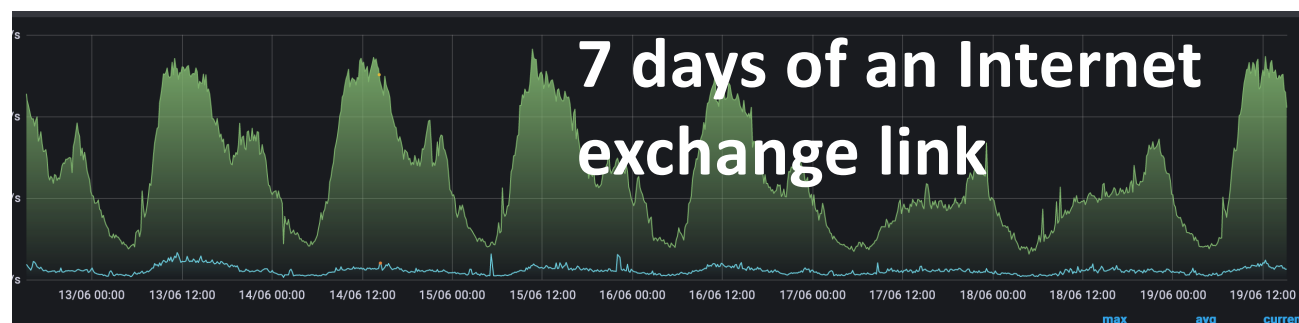
2019 : 2.7 Tbps

2022 : 9.4 Tbps

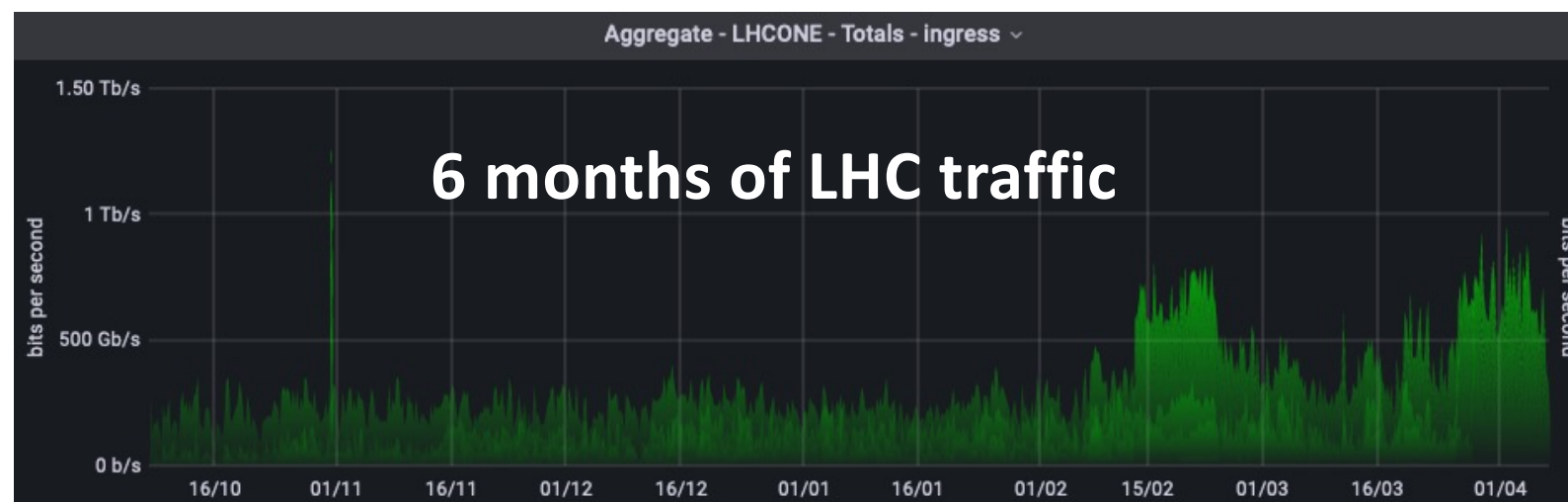
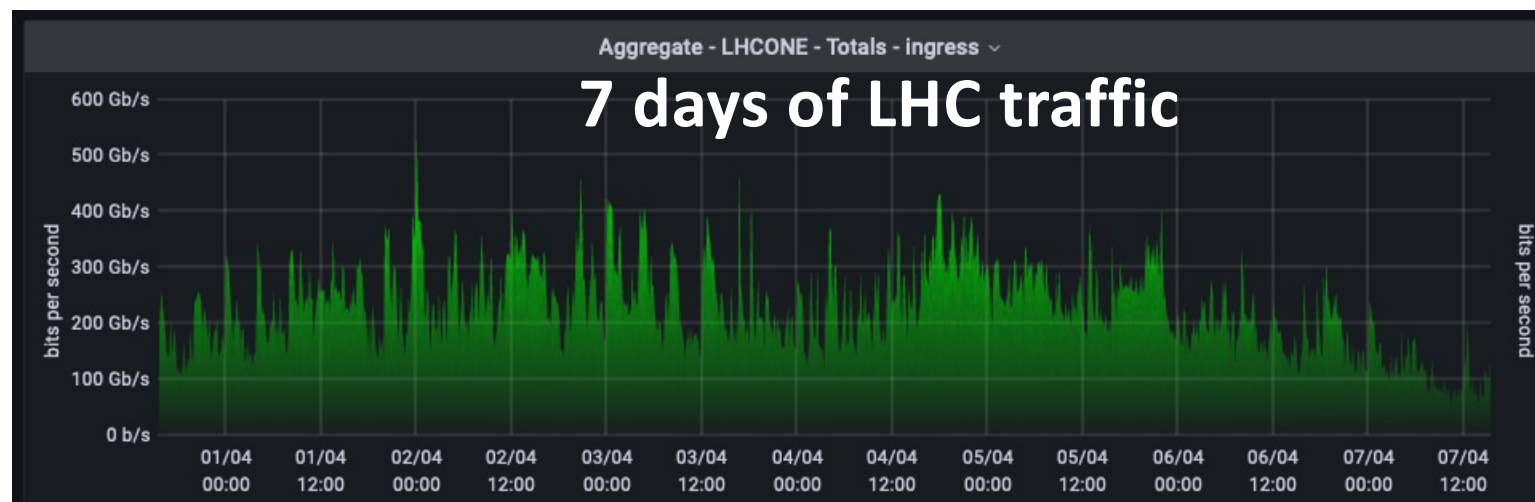
Long-term Growth: 30%



# The Challenge: Traffic



A Harder  
Challenge:  
Science Traffic



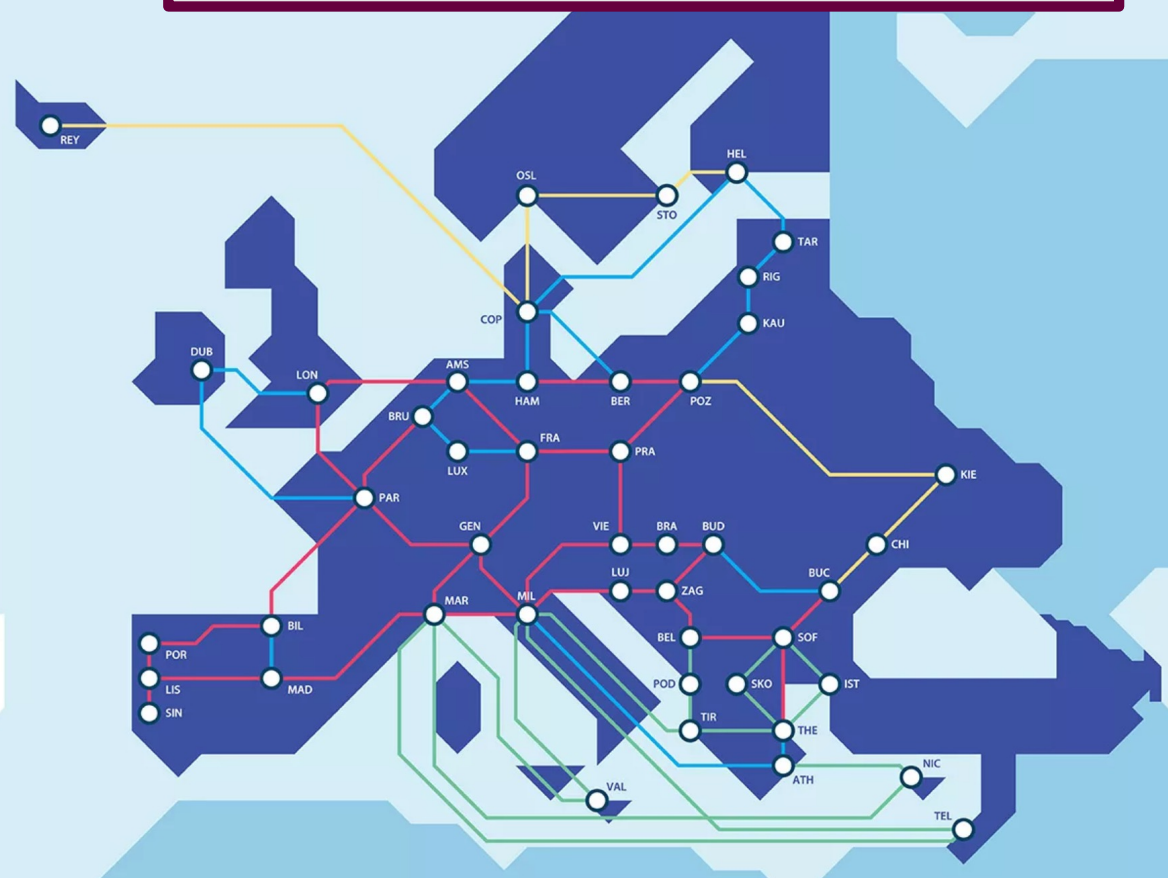
## 2019 – 2023 projects:

- European footprint
- EC-funded investment
- 50 million project

## Result: the new GÉANT network

- Fiber and spectrum
- 32 + 5 countries
- Long term control

## Long Term Approach: Invest in Infrastructure



**Before:**  
**Fibre And Spectrum**  
**Infrastructure**  
*Short Term Contracts*





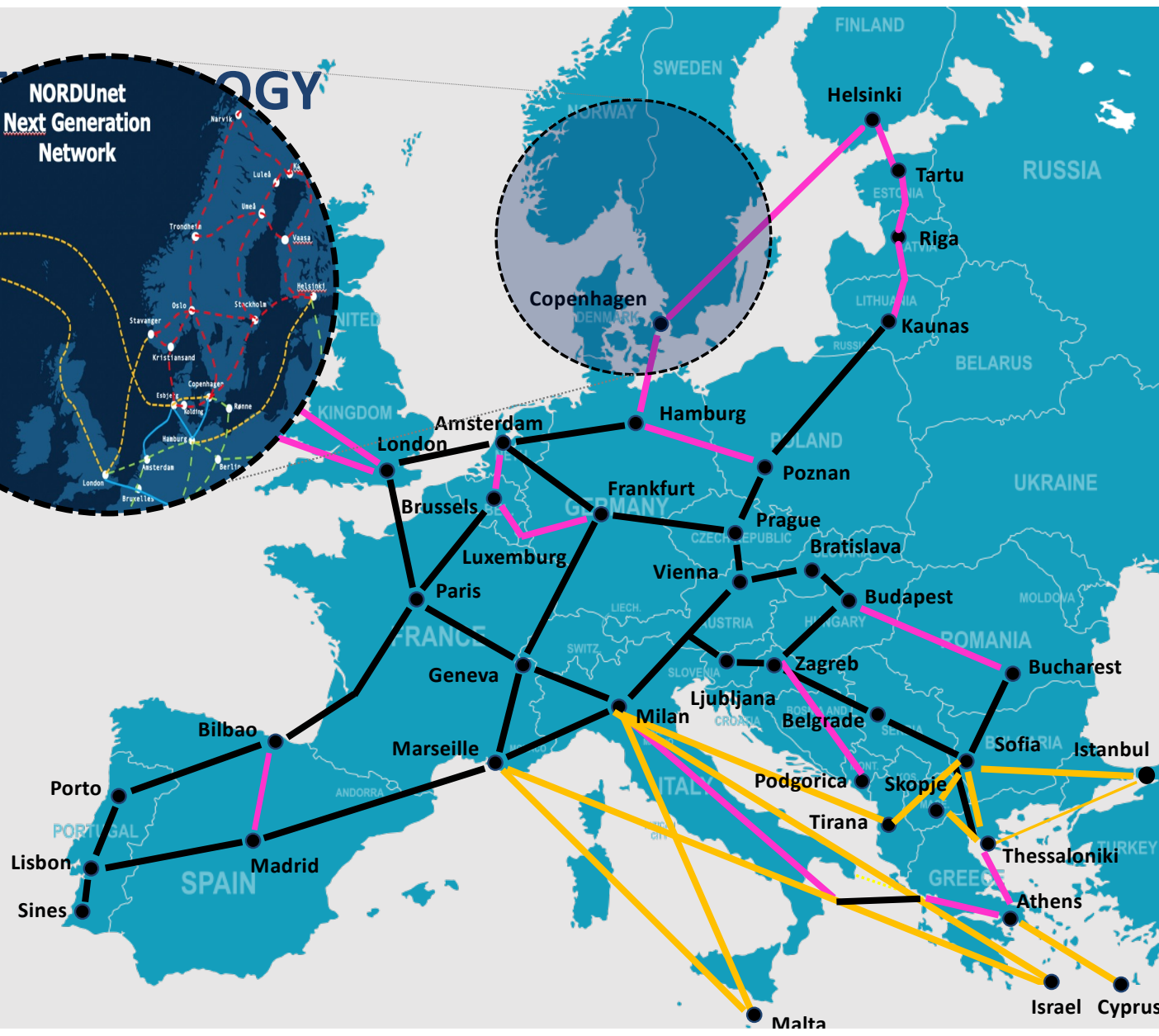
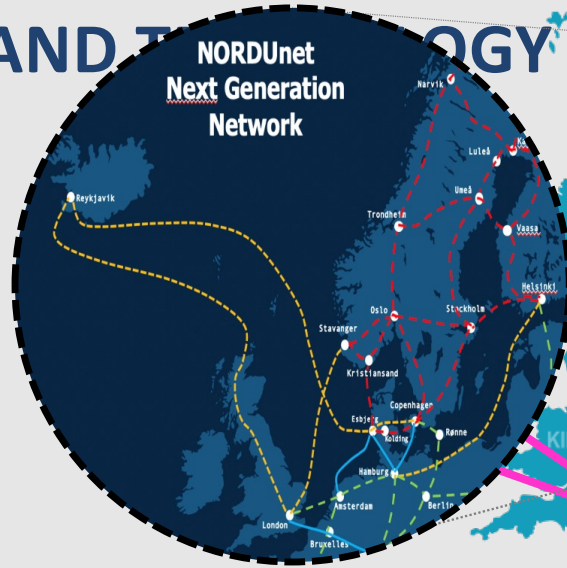
**NOW:**

**Fibre and Spectrum Infrastructure –  
*Long Term Contracts: 21 year***

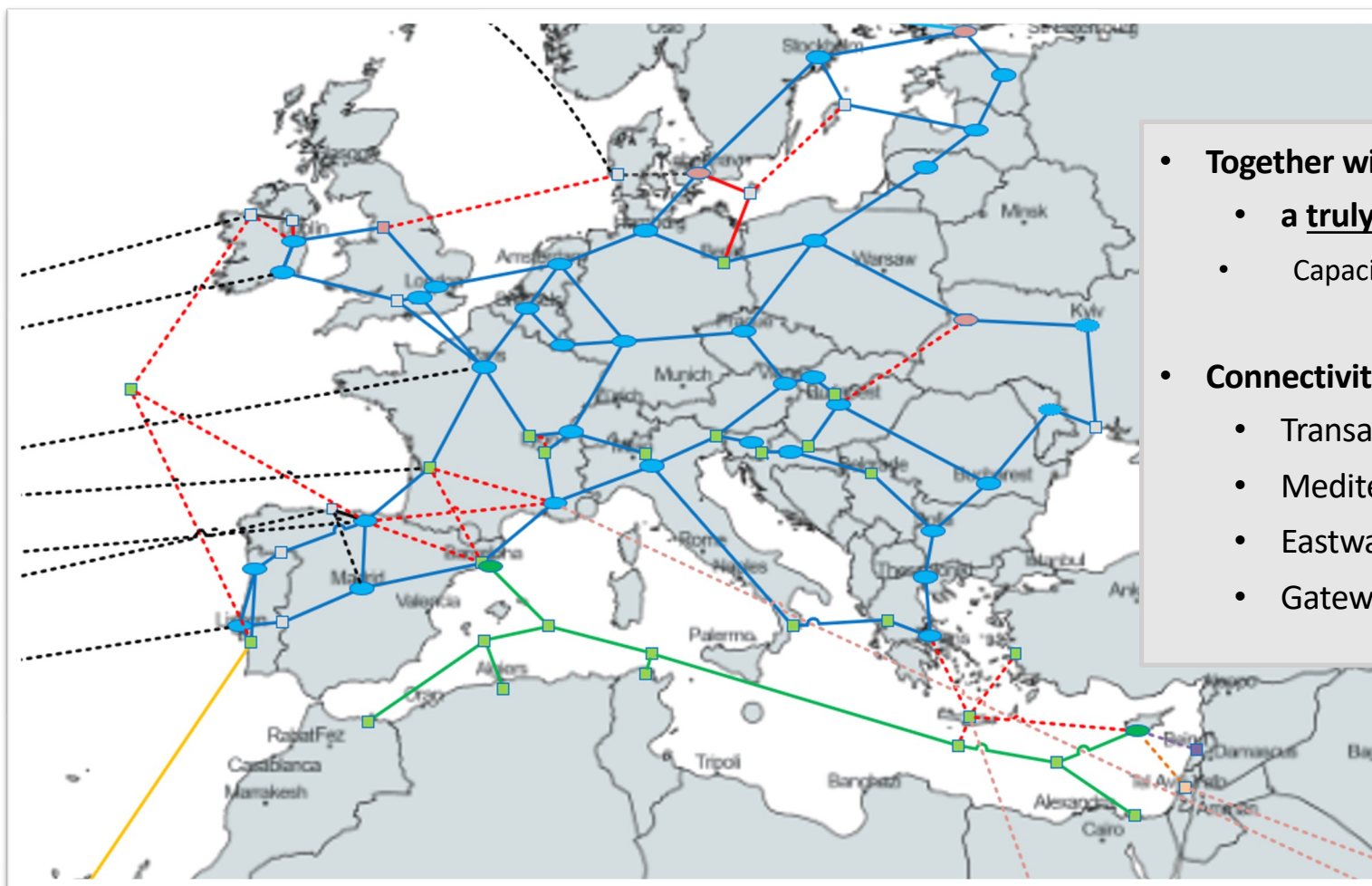


# FINAL TOPOLOGY AND TECHNOLOGY

- Dark Fibre IRU
- Leased Spectrum (10% or 25%)
- N x 100G Leased Services



## Network Infrastructure as a Platform – after GN4-3N: Improvements and Opportunities



- **Together with NRENs:**
  - a truly European-wide reach for services
  - Capacity in Europe is no longer a real challenge
- **Connectivity Optimisations and Opportunities:**
  - Transatlantic links
  - Mediterranean connections
  - Eastward connections
  - Gateways

## International and Transatlantic

About 120 years  
ago...

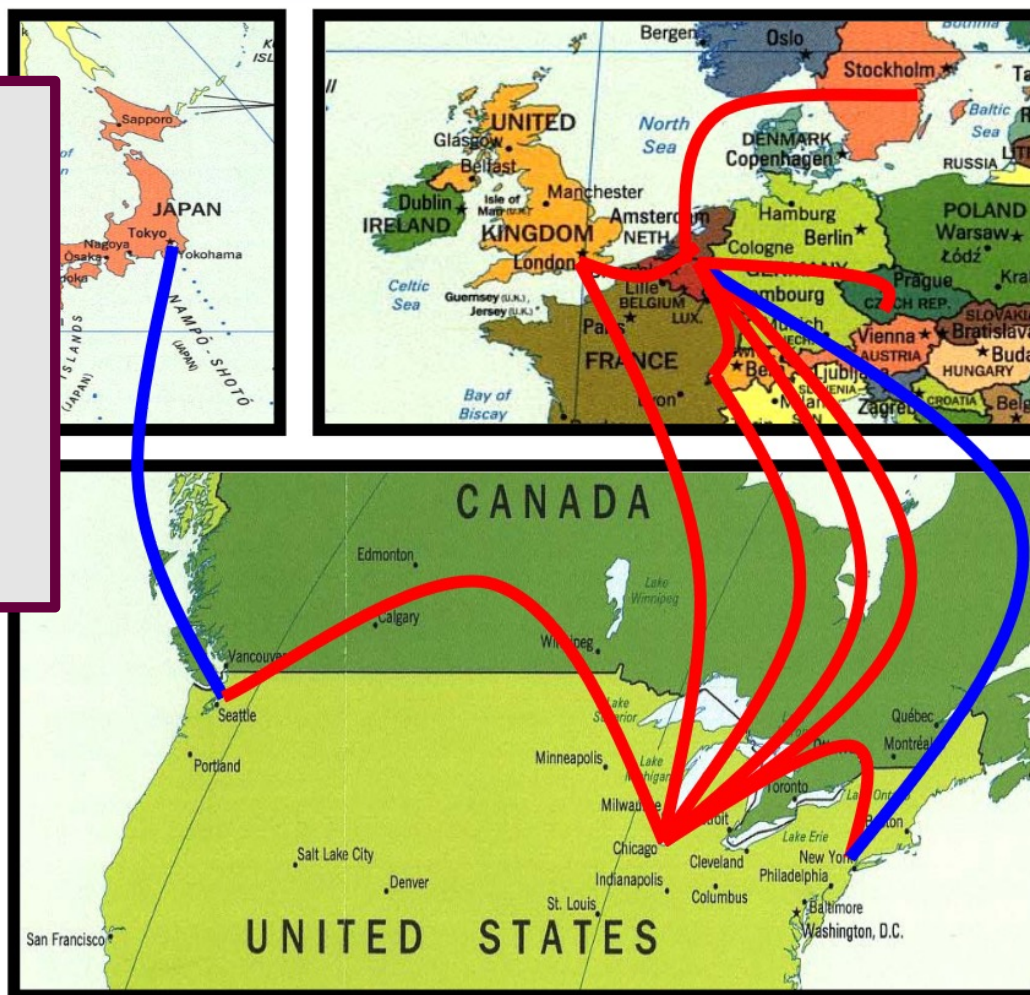
1901 network of  
Eastern Telegraph  
Company

bits per second



**NRENs -  
About 20 years  
ago...**

**10 Gbps**



## TransLight Lambdas

### European lambdas to US

- 6 GigEs Amsterdam—Chicago
- 2 GigEs CERN—Chicago
- 8 GigEs London—Chicago

### Canadian lambdas to US

- 8 GigEs Chicago—Canada—NYC
- 8 GigEs Chicago—Canada—Seattle

### US lambdas to Europe

- 4 GigEs Chicago—Amsterdam
- 2 GigEs Chicago—CERN

### European lambdas

- 8 GigEs Amsterdam—CERN
- 2 GigEs Prague—Amsterdam
- 2 GigEs Stockholm—Amsterdam
- 8 GigEs London—Amsterdam

### IEEAF lambdas (blue)

- 8 GigEs Seattle—Tokyo
- 8 GigEs NYC—Amsterdam

**NRENs –  
about 10 years ago...**

**100 Gbps**

**ANA 100G**  
**ADVANCED NORTH ATLANTIC 100G PILOT**

**TNC2013 DEMOS JUNE, 2013**

**AMSTERDAM NetherLight**

**MAASTRICHT TNC2013**

**NEW YORK MAN LAN**

**CHICAGO StarLight**

**ATLANTA Esnet Hub**

**RALEIGH RENC1**

**INTERNET2**

**NORDUnet**

**ESnet**

**SURF NET**

**canarie 1993-2013**

**ciena**

**JUNIPER NETWORKS**

**GÉANT**

**TATA COMMUNICATIONS**

**UNIVERSITY OF AMSTERDAM**

Add proper attribution



**NOW...**



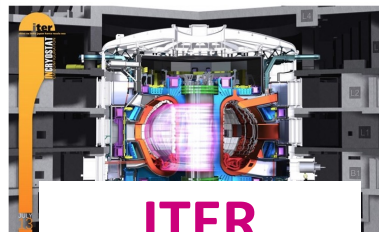
# Global Research – Global Traffic

## LHC

- 200 sites across the globe
- 50% of GÉANT global traffic
- High Luminosity HLC from 2029



Map courtesy of Google.com



## ITER

### Fusion Research

- Several PBs of data per year
- To be copied from France to multiple locations globally



## Astronomy

- Square Kilometre Array
  - Detectors in 100 Gbps capacities required
- Chile:
  - Cherenkov Telescope Array
  - ESO – Very Large Telescope

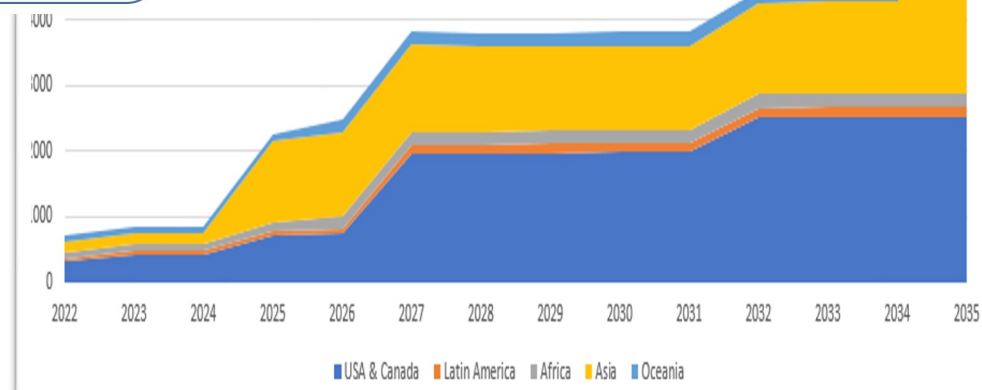


## Earth

- **Observation**
  - Copernicus

**Estimated annual  
growth  
35%**

Global Traffic Forecast 2022-35 (Gbps)



## An Opportunity: GN5-IC1 (International Connectivity) Project

3 years GÉANT project - €15M funding



### Two Main Objectives:

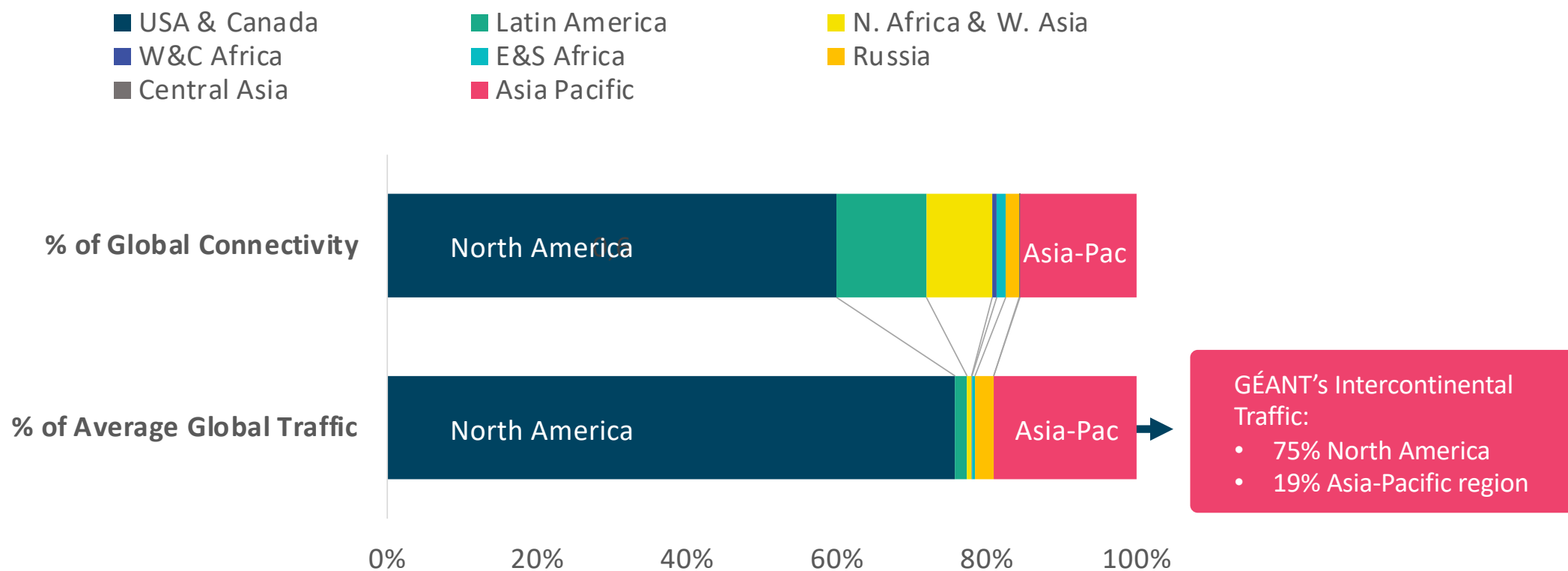
**Objective 1: Procure connectivity to at least 2 world regions**

**Objective 2: Create intercontinental connectivity investment plan**

## Understanding the Challenge: Statistics-Gathering

- **Kentik analysis from 00:00 on 01/01/2023 to 23:39 on 30/06/2023**
  - Sample every 60 mins
  - Average, 95<sup>th</sup> percentile and max.
- **Statistics gathered:**
  - GÉANT and GÉANT Members to/from each International REN Peer (next hop)
    - **Canada & USA:** CANARIE, ESnet, Internet2, NISN (NASA)
    - **Latin America:** RedCLARA
    - **Central Asia:** CAREN
    - **West & Central Africa:** WACREN
    - **East & Southern Africa:** UbuntuNet, TENET/SANReN
    - **North Africa & Western Asia:** ASREN, ANKABUT, ARN, ENSTINET, HBKU, IRAnet, Maeen, KAUST, OMREN,
    - **Asia-Pacific:** TEIN, AARNet, ASGC, CERNET, CSTNET, KREONET, NII/SINET, NKN, SingAREN, TWAREN
    - **Russia\*:** NIKS, KIAE (Kurchatov Institute)

## Global Challenge – European perspective: Connectivity and Traffic



## Objective 1: “Deliver Connectivity to at least two world regions”

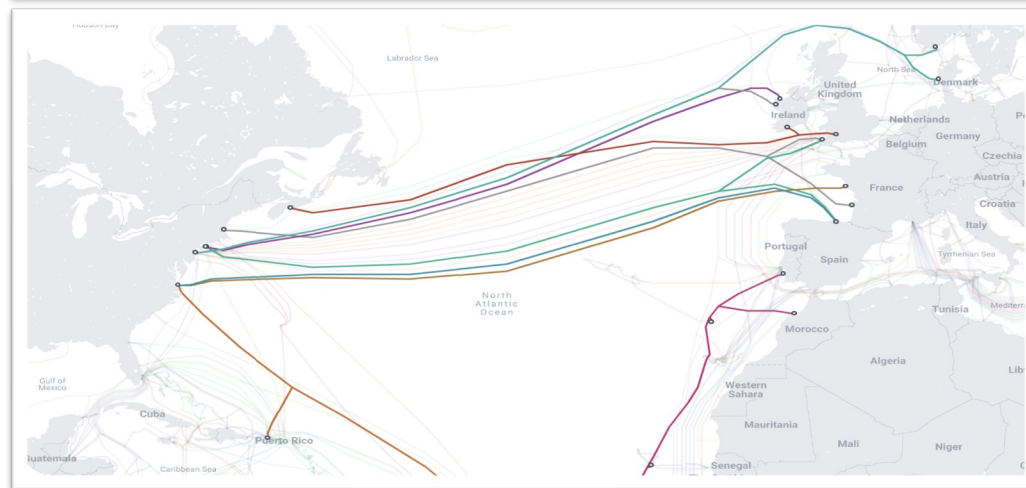
### • First region: Asia

- Marseille – Singapore: 100G
- Connection to a hub
- Collaborate with regional partners
- **DONE (7 year+ contract)**



### • Next region: North America

- **Spectrum!**
- Collaborate with partners
- **Ambition: access to up to 4 systems**



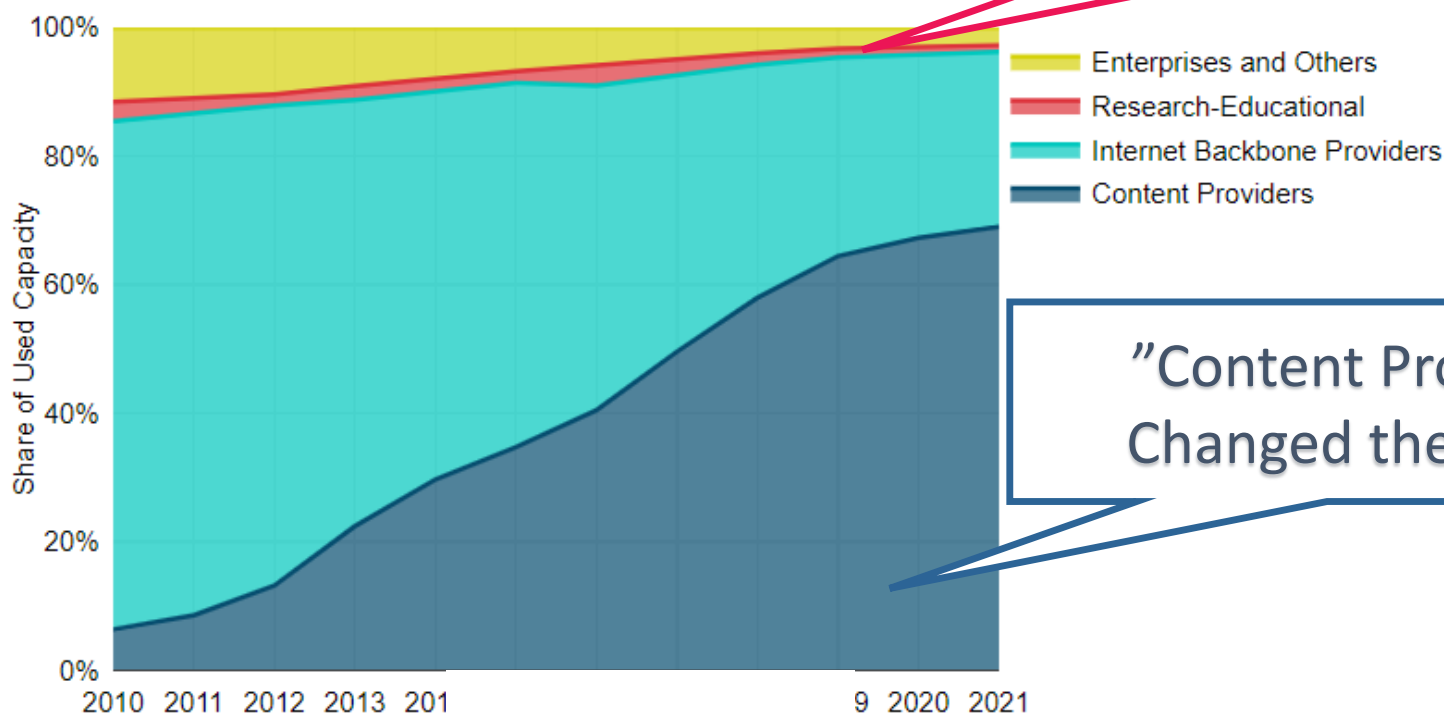
## Specific Analysis: Canada & USA

	Average Ingress	Average Egress	Forecast Max Ingress	Forecast Max Egress	Required Capacity 2 Systems	Required Capacity 3 Systems	Required Capacity 4 Systems
<b>2028</b>	278.4 Gbps	264.1 Gbps	835.3 Gbps	792.2 Gbps	1.6 Tbps	2.1 Tbps	2.8 Tbps
<b>2033</b>	1.0 Tbps	1.0 Tbps	3.1 Tbps	3.0 Tbps	6.0 Tbps	7.8 Tbps	10.3 Tbps
<b>2038</b>	3.8 Tbps	3.6 Tbps	11.5 Tbps	11.0 Tbps	22.0 Tbps	28.8 Tbps	38.4 Tbps

- Figures are based on today's GÉANT General Purpose traffic.
  - Excludes:
    - Step increase traffic for HL-LHC (LHCONE and LHCOPN).
    - Traffic that GÉANT does not see (e.g. SURF/NORDUnet direct peerings, traffic on ESnet's own TA infrastructure)
- Current estimates on HL-LHC traffic (excluding LHCOPN traffic) of 1.5 Tbps, increasing to 2.0 Tbps

## How: Submarine cables – but, who is driving?

Used International Bandwidth by Source



R&E makes it on the charts

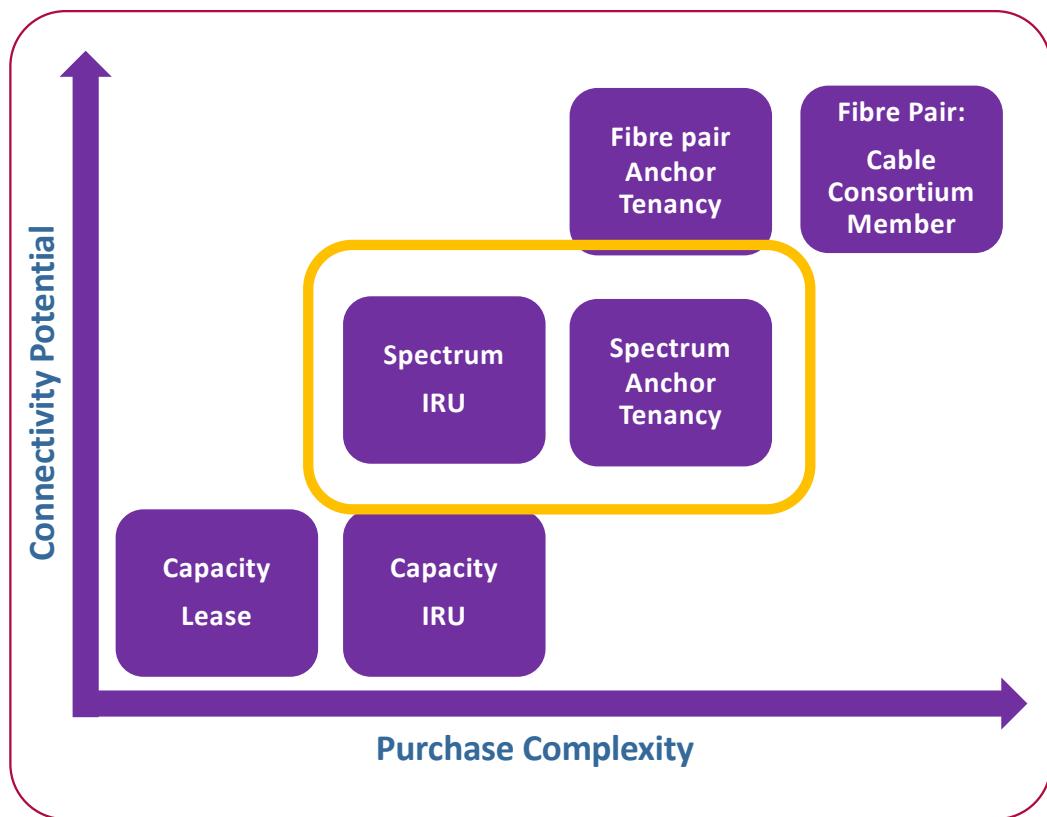
"Content Providers"  
Changed the market

Source: TeleGeography

[Download spreadsheet](#)

© 2022 TeleGeography

# Accessing the Network: Different Shapes and Sizes





## North America – systems

11 Systems less than  
10 years old available  
3x Announced  
7x Operational

### Selection

AEC-1

Amitie

Anjana (2024)

Dunant

EXA Express

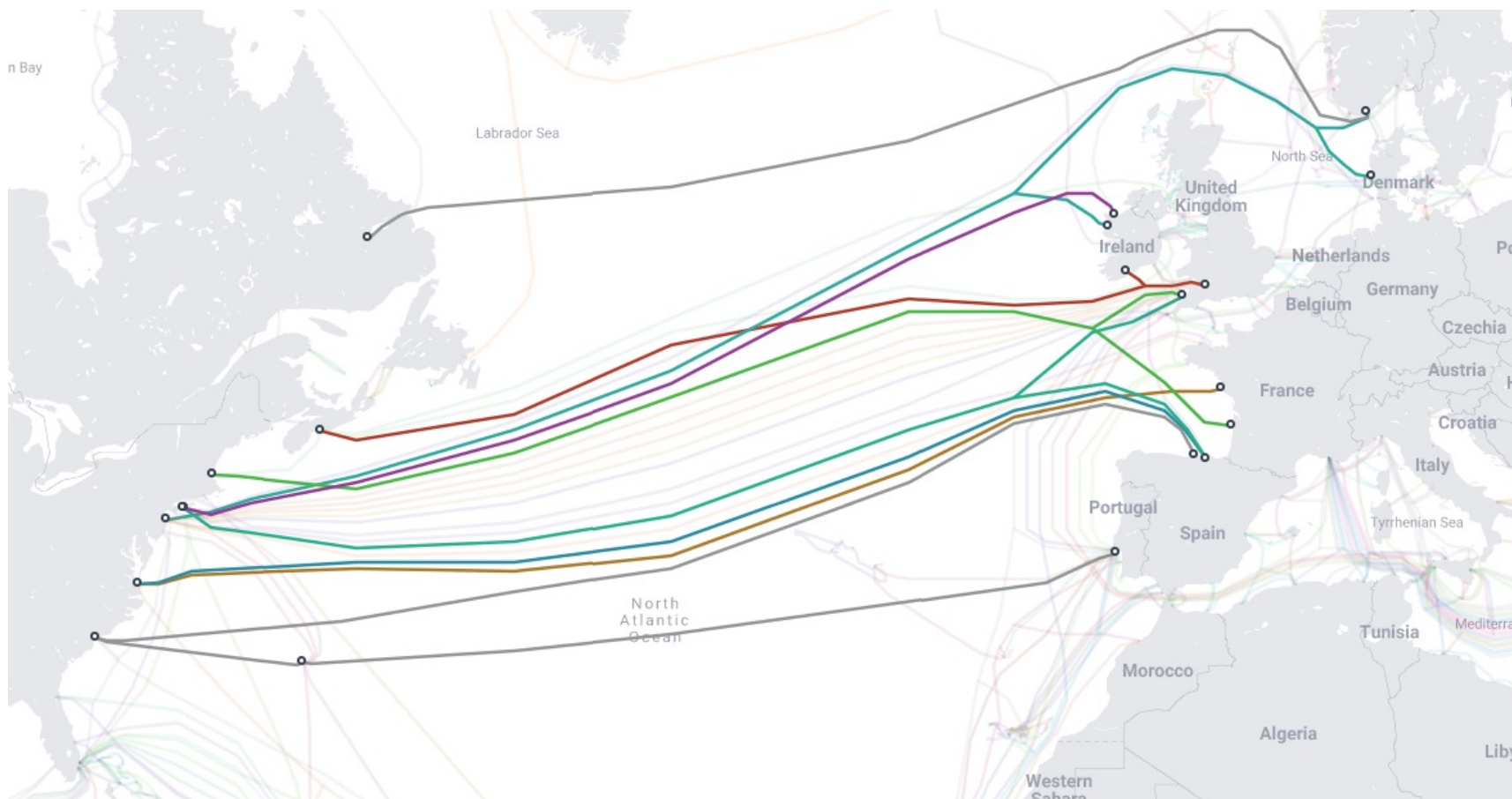
Grace Hopper

Havfrue/AEC-2

Leif Erikson (2026)

MAREA

Nuvm (2026)



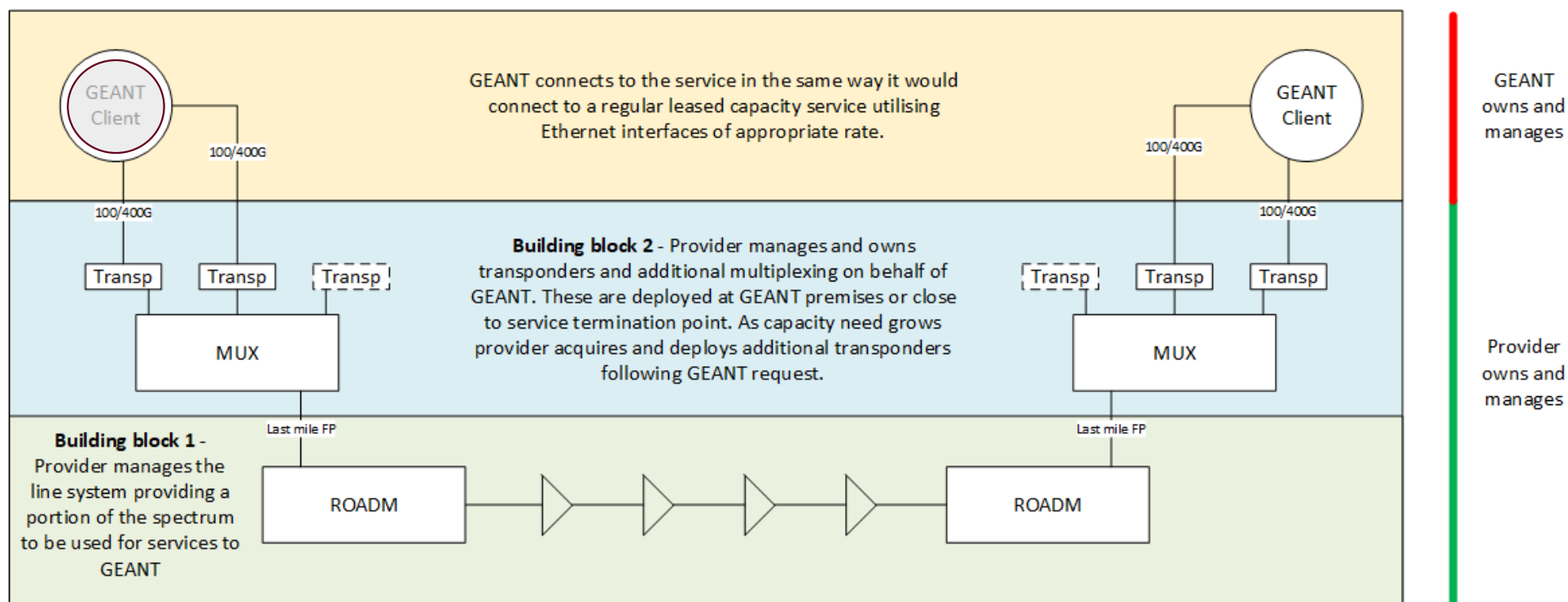
**Already announced!**  
**Amitié, AEC-1**



## North America – Europe: Managed Spectrum for now, for GÉANT?

Avoiding compliance and tax challenges: minimise presence in US?

Procurement in 2 lots?



## Considerations: 1. Spectrum changes the game

- **Capacity** - it feels like we skipped a step
  - **2003**: 10 G
  - **2013**: 100G
  - **2023**: 1 Tbps?
  - **2024**: 10 Tbps ;-)
- **The spectrum setup is different**
  - Longer term contracts
    - Investment up front
    - Maintenance cost “manageable”
  - Promise of technological longevity
  - There is now “Available capacity”
    - At marginal cost, largely
    - *Opportunities to share/allocate in the community*

## Considerations: 2. Resiliency

# RED SEA WAR: HOUTHIS DIVE DEEP KNOCK OUT UNDERWATER CABLES

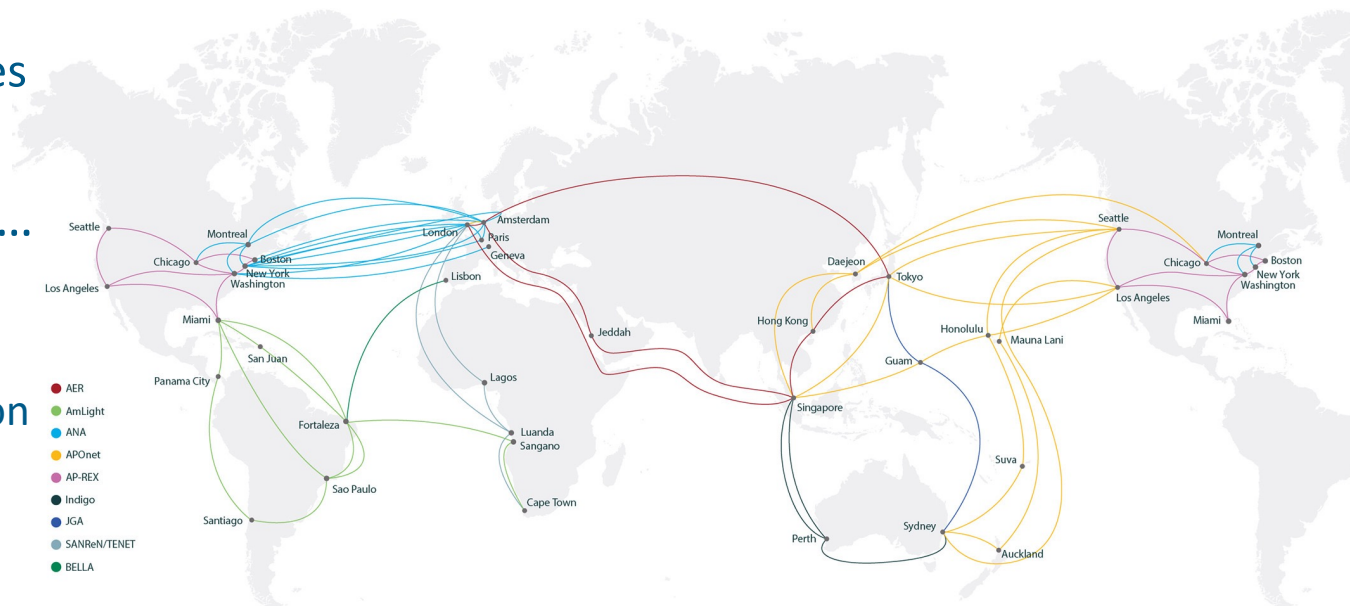
## Four More Subsea Cables Disrupted Off Africa



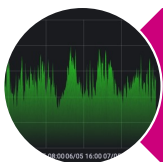
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PUBLISHED MAR 14, 2024 9:38 PM BY THE MARITIME EXECUTIVE

## Considerations: 3. Partnerships

- Operating at intercontinental scale needs partnerships
  - Investment pooling/coordination
  - Resiliency coordination
  - Technical – services on the links
  - Technical – driving global services
- Operating at a global scale needs...
  - Coordination
    - Resilience
    - Technology/service coordination
    - Topology?



## To summarize



Science traffic at global scale remains a good challenge



Infrastructure control helps: fibre and spectrum



Project funding can be an opportunity



Global R&E collaboration ever more important



# Thank You

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[www.geant.org](http://www.geant.org)



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