

GÉANT - Networking for Europe

Bram Peeters – CNOO GÉANT



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).



GEANT – the Company



GEANT: A Membership Association



Mission: To provide an open, innovative and trusted information infrastructure for the European knowledge economy and to the benefit of society worldwide

In Europe: 40 NRENs, 10.000 institutions and 50 million academic users



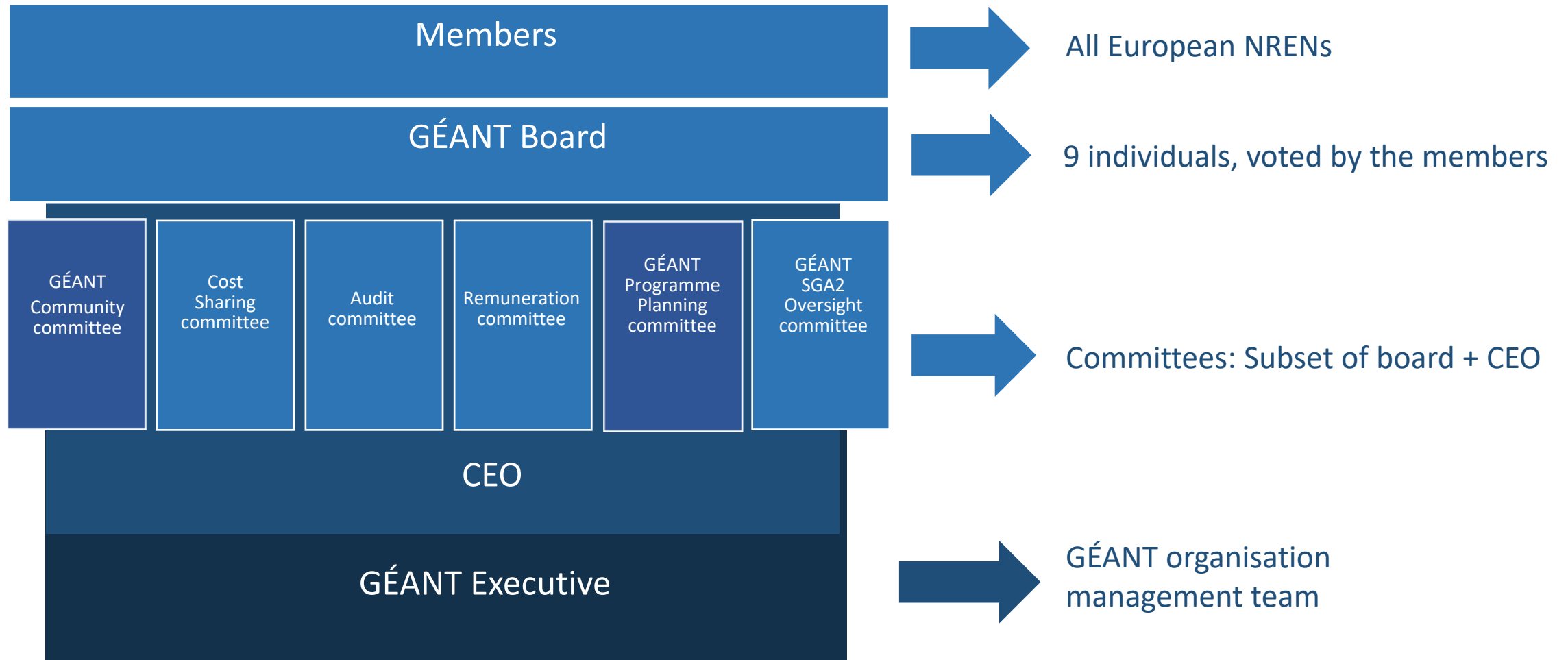


Members





Governance



The company

- Not for profit
- Offices in Amsterdam and Cambridge
- 140 people, 30 different nationalities, seven coffee machines, redundant cookie jars





Runs a membership association for Europe's National Research & Education Networks (NRENs)
GÉANT Association



Coordinates and participate in EC-funded projects

Under Horizon 2020 the financial instrument for implementing the Innovation Union, a Europe 2020 flagship initiative aimed at securing Europe's global competitiveness



Operate a pan-European e-infrastructure

GÉANT network



Manage a portfolio of services for research & education

EduX



Organises and runs community events & working groups

TNC, task forces & special interest groups



Some Projects



European
e-infrastructure
projects



Trust & identity
projects



Network
projects



Collaborative
projects



GEANT – Non-Network Services



Services NRENs can use to support researchers, educators and innovators – at national, European and international levels.



**Network centric
services**



**Trust identity
and security**



**Clouds and
Real-time
Communications**



**Professional
services**



Trust, Identity & Security

Supporting users and enabling secure access to services



eduroam - secure global roaming access service **250+ million authentications per month** in 101 territories



eduGAIN - interconnects identity federations around the world, simplifying access to content, services and resources ~ 3500 identity providers accessing services



InAcademia - Lightweight student validation service



eduTEAMS - Making managing virtual teams easy

Trusted Certificate Service – delivering cost-effective digital certificates.



eduroam

Linking students to the global community

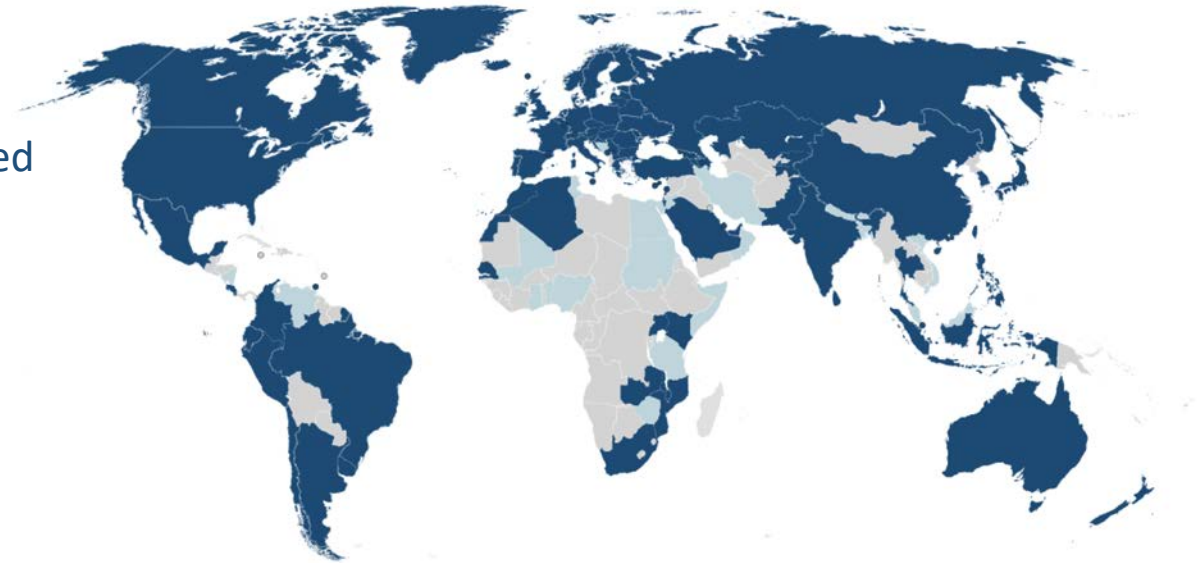


eduroam provides a secure global roaming infrastructure for the research and education; users authenticate locally and get online in eduroam-enabled locations

**A global network of users across 106 territories.
More than 4 billion national and international authentications a year.**

A worldwide success story

From its early beginnings as a joint venture between a few European universities to today – with millions of users in more than 100 territories worldwide, eduroam has been an amazing success story and an example of research and education collaboration.



NEW

eduroam Managed IdP
service to simplify
onboarding of smaller
institutions

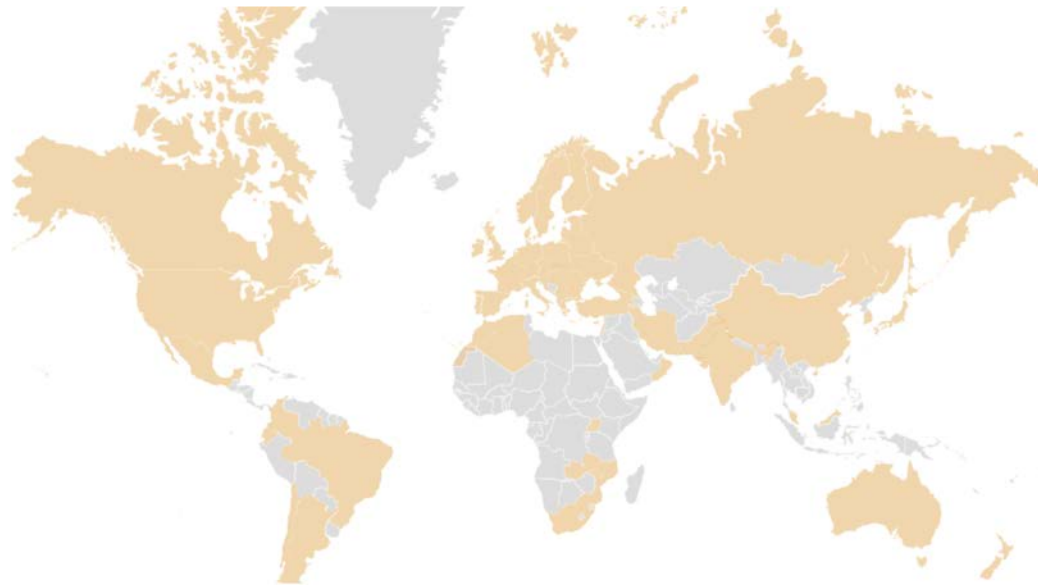
eduroam.org [@eduroam](https://twitter.com/eduroam)



Enabling secure Single Sign On services to global research and educational resources

Federated identities enable users to access a wide range of services using their account managed by their 'home' institution

- Improves access
- Improves security
- Reduces management overhead and costs.



December 2019:
70 Federations active
7204 entities
4078 Identity Providers
3131 Service Providers

eduGAIN.org



Making managing virtual teams easy

- eduTEAMS leverages eduGAIN federated identities to support Virtual Organisation (VO) collaboration.
- Enables teams to be created and managed flexibly and securely.
- Provides consistent access and sharing policies across VOs.
- Single Point of Management for community managers to add and remove users and services.

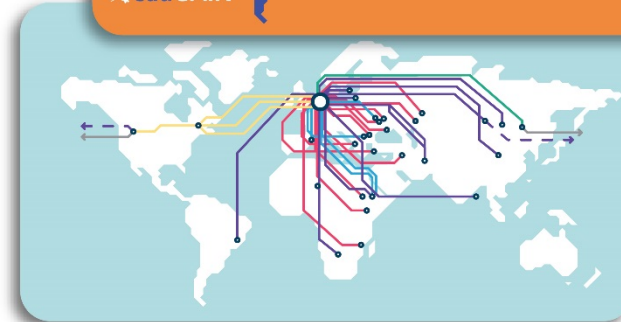
Collaborate



Identify



Connect





- Open-Source, Video Conferencing Software
- Institutions can build their own eduMEET service quickly and easily
- No client software – 100% web-based
- Ideal for remote learning

The screenshot shows the eduMEET website homepage. At the top, there is a header with the eduMEET logo and the text "web-based videoconferencing platform". Below the header is a navigation bar with links: "WHY EDUMEEET", "TECHNICAL OVERVIEW", "INSTALL EDUMEEET", "PRIVACY NOTICE", and "CONTACT US". The main content area features a large image of a young man smiling while using a laptop. To the right of the image is a sidebar with three menu items: "Build Your Own eduMEET Service", "Platform Overview", and "Clientless VC platform - No app downloads required". Below the image, there is a paragraph of text: "The eduMEET platform has been developed by the Research and Education community for the community. Enabling Institutions to build a low-cost, easy-to-use VC platform for small to medium sized groups." At the bottom of the page, there is a footer with the eduMEET logo, a European Union flag, and text about funding from the European Union's Horizon 2020 research and innovation programme. There are also links for "Cookies", "Disclaimer", and "GÉANT Anti-Slavery Policy".



Community events & clusters



Community
Conference



Special Interest
Groups and
Task Forces



Research
Programmes



Service
Development



Special Interest Groups & Task Forces



Special Interest Groups (SIGs) & Task Forces (TFs)

Enable collaboration across the community for the development of the next generation of networking technologies and services.

Explore emerging issues in research and education networking, develop strategies and solutions to address them.

Produce and test fresh and innovative ideas applied through specific research activities and initiatives.

Welcome grass roots and world experts.

GEANT – The Network Services

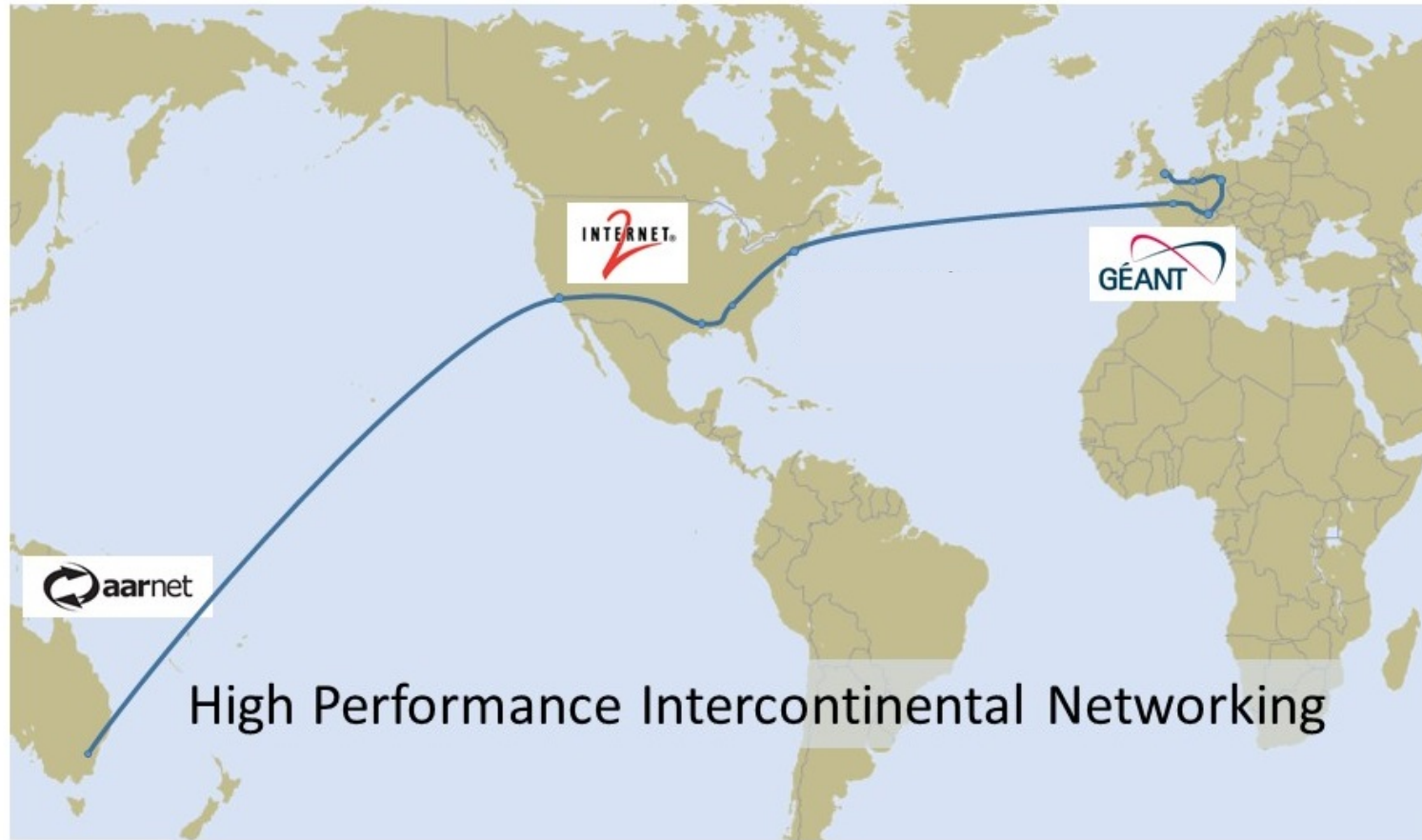


Who do we build the network for?

- National Research and Education Networks (NRENs)
- Large research collaborations



Why at all? Do R&E Networks Really Make a Difference for Data Transfer?



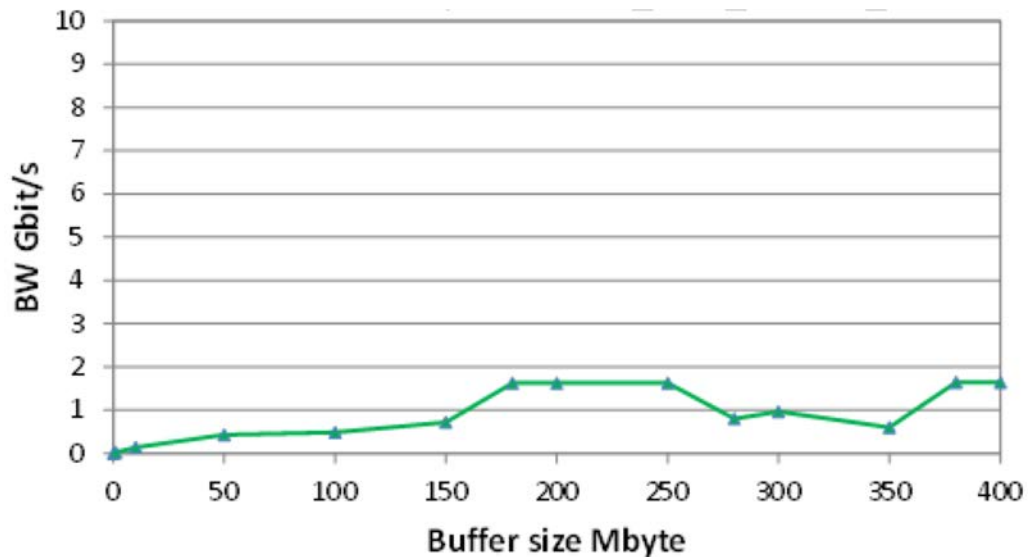


London to Canberra (2018 or so)

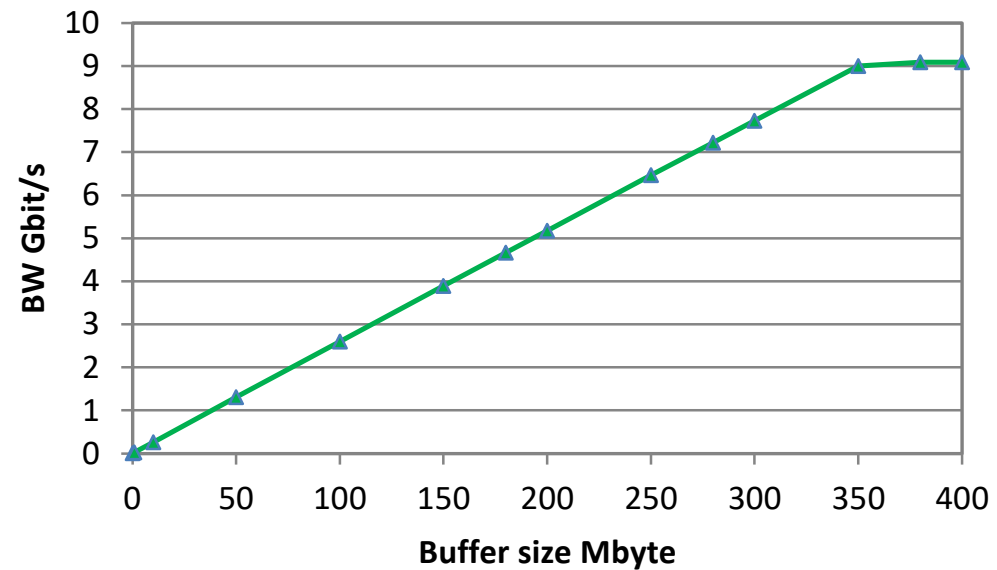
10 Gigabit TCP performance - Public vs R&E



Public Internet



GÉANT, R&E partners



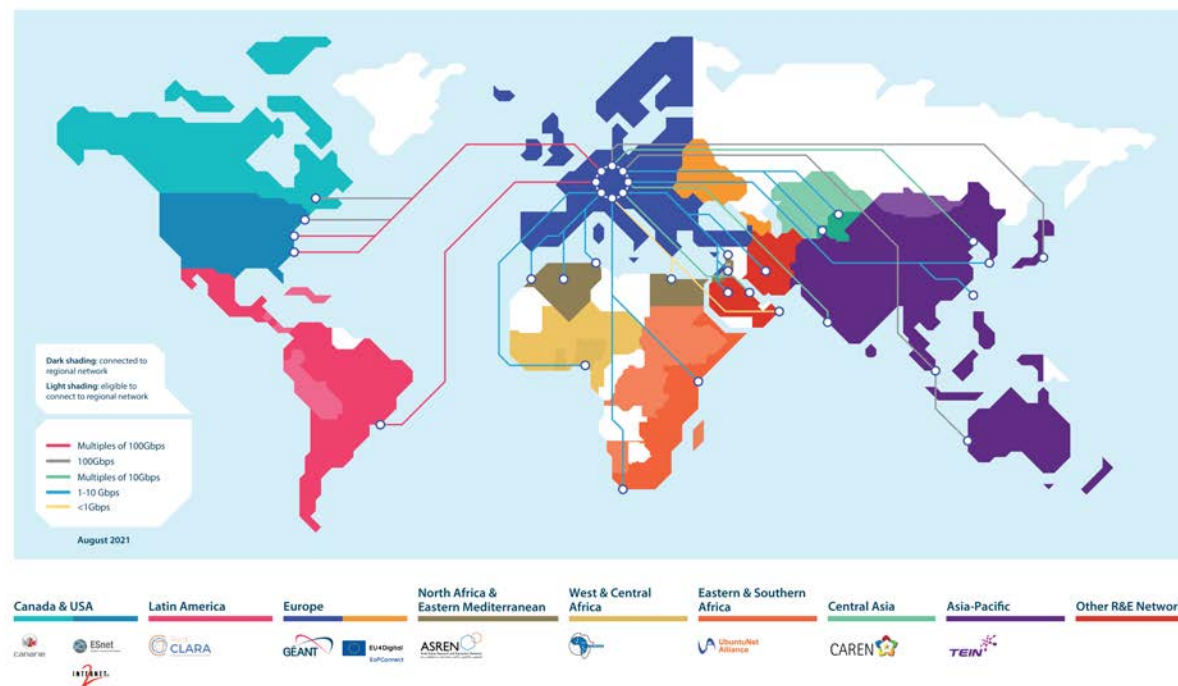
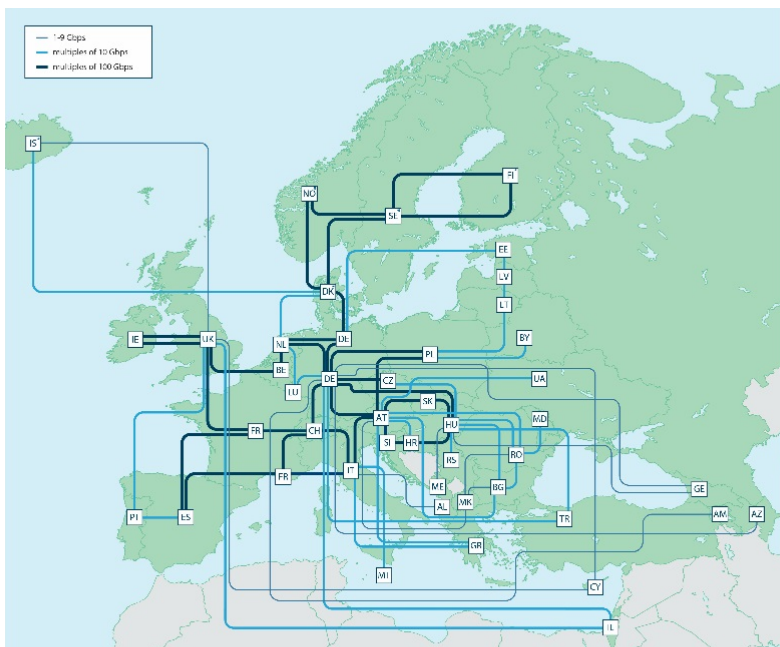


The network - basics



The GÉANT network interconnects research, education and innovation communities worldwide, with secure, high-capacity networks.

connects European NRENs to each other and the rest of the world for sharing, accessing and processing the high data volumes generated by research and education communities, and for testing innovative technologies and concepts.





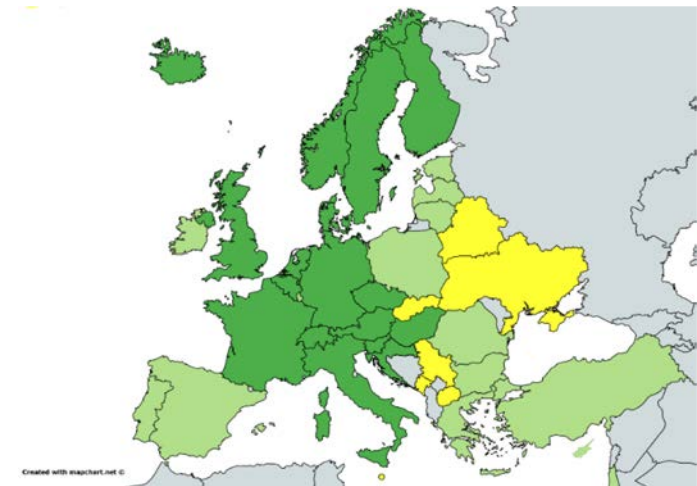
GÉANT network services

GÉANT IP – Ultra-high performance uncontended IP connectivity at up to 100Gbit/s or multiple 100Gbit/s connections

GÉANT VPN – Layer 3 and Multi-domain VPN services for NRENs and institutions supporting private networking needs

GÉANT Point-to-Point – High performance dedicated connectivity up to 100Gbit/s for the most demanding applications

GÉANT Open – Allows NRENs and approved commercial organisations to exchange connectivity in a highly efficient and flexible manner



Availability Targets

99.999% - 27 seconds downtime/month

99.99% - 4.5 minutes/month

99.4%* - 4 hours/month



Ultra-high performance uncontended IP connectivity at up to 100Gbit/s

GÉANT IP provides IP transit for NRENs and other approved research and education partners and providers. Its core function is to provide a private service for IP (Internet Protocol) traffic that is separated from general-purpose access to the internet. Working at speeds of up to 100Gbps, GÉANT IP provides core connectivity that supports inter-NREN connectivity.

Features

Peering

Provides NRENs with a high-performance, highly resilient peering facility, allowing access to a wide range of commercial network and cloud service providers.

GÉANT World Service (GWS)

Access to the wider, commercial internet. Ideal for NRENs that wish to take advantage of competitive costing, or those that are keen to diversify their existing commodity IP access.



Increased privacy and control - helping to build effective virtual teams across borders.

VPNs are ideal for many-to-many (peer-to-peer) or one-to-many (central-site-to-satellite) environments, where each site can be allocated bandwidth according to its own requirements. Each site can support bandwidths from 1Gbps to 100Gbps (subject to availability). GÉANT and the national research and education networking (NREN) organisations have worked together to provide a range of uniquely flexible and powerful services.

Services:

MD-VPN

L3 VPN

MD-VPN

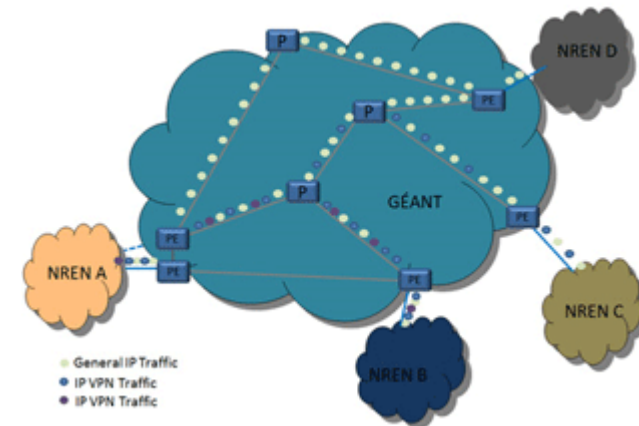
The GÉANT Multi-Domain Virtual Private Network (MD-VPN) provides an end-to-end international network service that enables scientists all over Europe to collaborate via a common private network infrastructure.

MD-VPN can be used for connectivity between clusters, grids, clouds and HPC (high-performance computing) centres, allowing them to form virtual distributed resources for third-party research projects.

MD-VPN offers fast delivery of VPNs to end users and so can be used in a variety of ways, from a long-term infrastructure with a high demand for intensive network usage to quick point-to-point connections for a conference demonstration.

L3 VPN

The GÉANT L3-VPN service provides NRENs with the backbone infrastructure to enable custom VPN services for their users across the GÉANT backbone.





GÉANT Point-to-Point Services



Interconnectivity for the most demanding networking requirements.

For when shared IP services can't provide the capacity or performance needed, GÉANT's point-to-point services provide the perfect solution.

Service Options

GÉANT Plus

point-to-point Ethernet circuits between end-points at GÉANT PoPs (points of presence). Circuits can be established to any European NREN. Microsoft ExpressRoutes interconnectivity can be provided via NRENs using GÉANT Plus

GÉANT Lambda

GÉANT Lambda provides high capacity dedicated circuits to support NREN users. The service provides transparent 10Gbps, or 100Gbps circuits between GÉANT PoPs.

GÉANT Guaranteed Bandwidth Service

GÉANT Guaranteed Bandwidth Service appears to its private users as a private Layer 2 circuit using dedicated physical interfaces at the edges of the GÉANT . This combines the privacy and availability advantages of a private circuit with the cost efficiency of a shared network.



Network Performance and Management



Supporting High Performance Networking

perfSONAR

- Network performance monitoring
- Joint venture with Internet2, ESnet and Indiana University
- Over 1650 measurement points deployed globally
- Helping measure and diagnose performance issues for the R&E community



- A world-wide Open Community for Performance Enhancement Response Teams,
- A virtual community covering performance issues for R&E networks

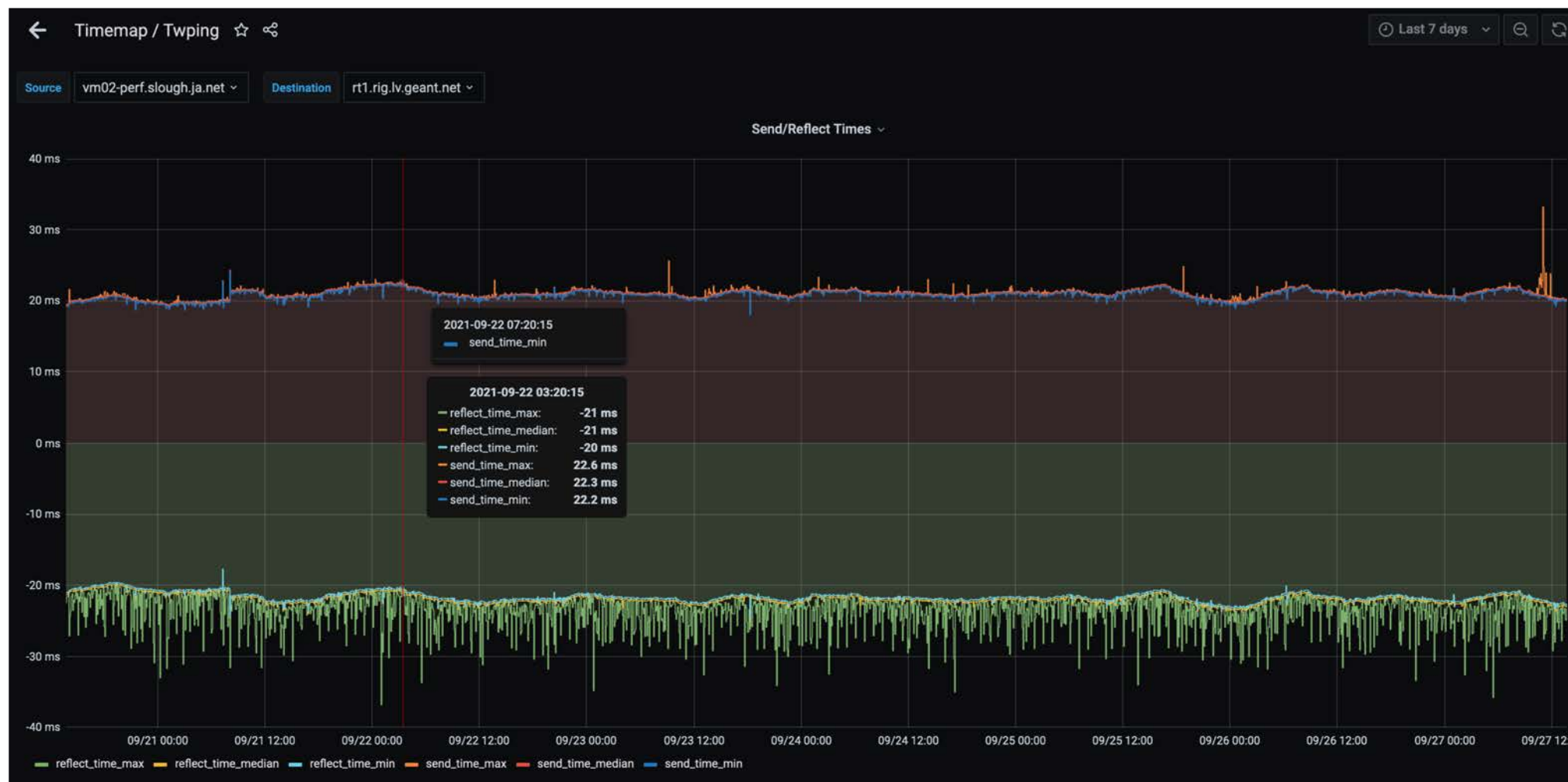
GÉANT CERT

Pan-European Computer Security Incidence Response Team coordination and a suite of network security tools (Distributed Denial of Service (DDOS) attack mitigation tools etc.)



<https://pmp-central.geant.org/>

Timemap

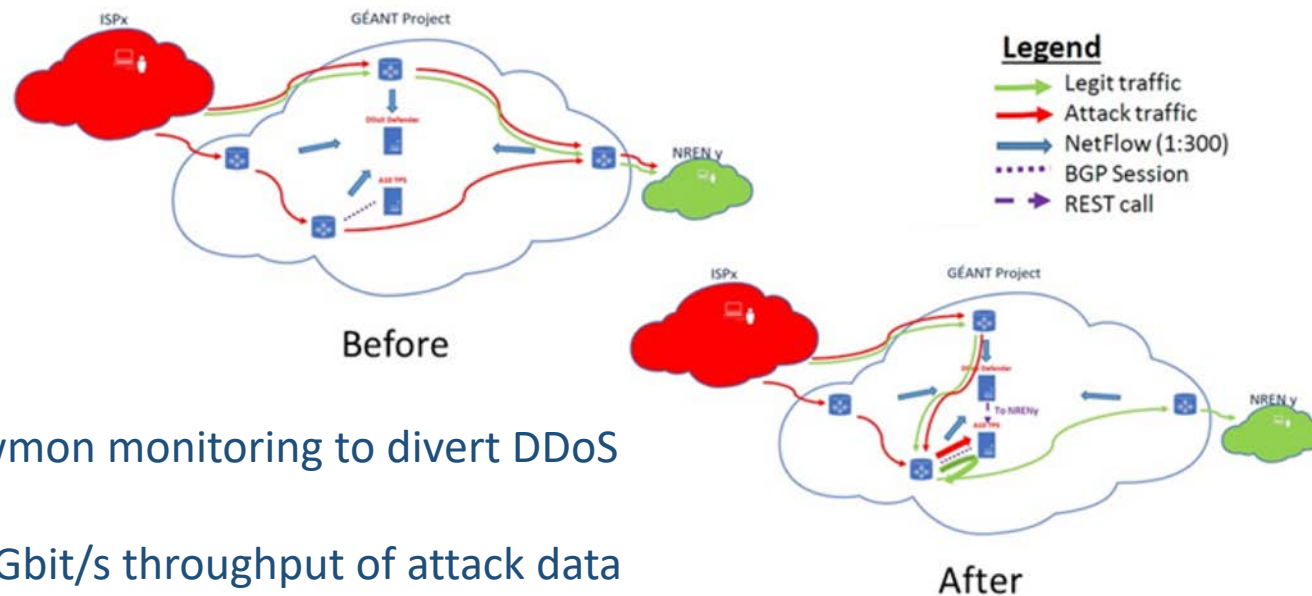




GÉANT DDoS Cleansing and Alerting



- Distributed Denial of Service (DDoS) is a large and growing problem
- GÉANT DDoS Cleansing provides a dynamic, automated detection and mitigation service



- DDoS Cleansing using Flowmon monitoring to divert DDoS traffic to A10 TPS service.
 - Can support up to 38Gbit/s throughput of attack data
 - No NREN staff resource required
 - No-cost option to add service to peering users
- Firewall on Demand remains to support inter-NREN DDoS

GEANT – Networks services

Some Use Cases





Scientific user groups we liaise with



Physical Sciences

Exploring the universe, e.g.
SKA, JIVE, NEXPreS, LIGO-VIRGO and CERN,
Neutrino observation (KM3NET)



e-Infrastructures

e.g. PRACE, EGI, EUDAT, EOSC-hub,
HelixNebula)



Health and Food

Pharmaceutical research, e.g.
EMBL-EBI, Human Brain Project



Earth and Environmental Sciences

Earth observation, climate monitoring,
sustainable development, e.g. EUMETSAT,
Copernicus, ESA, Group on Earth
Observation, WMO



Social Sciences

Music, art, language, e.g.
CLARIN, ASTRA, LoLa



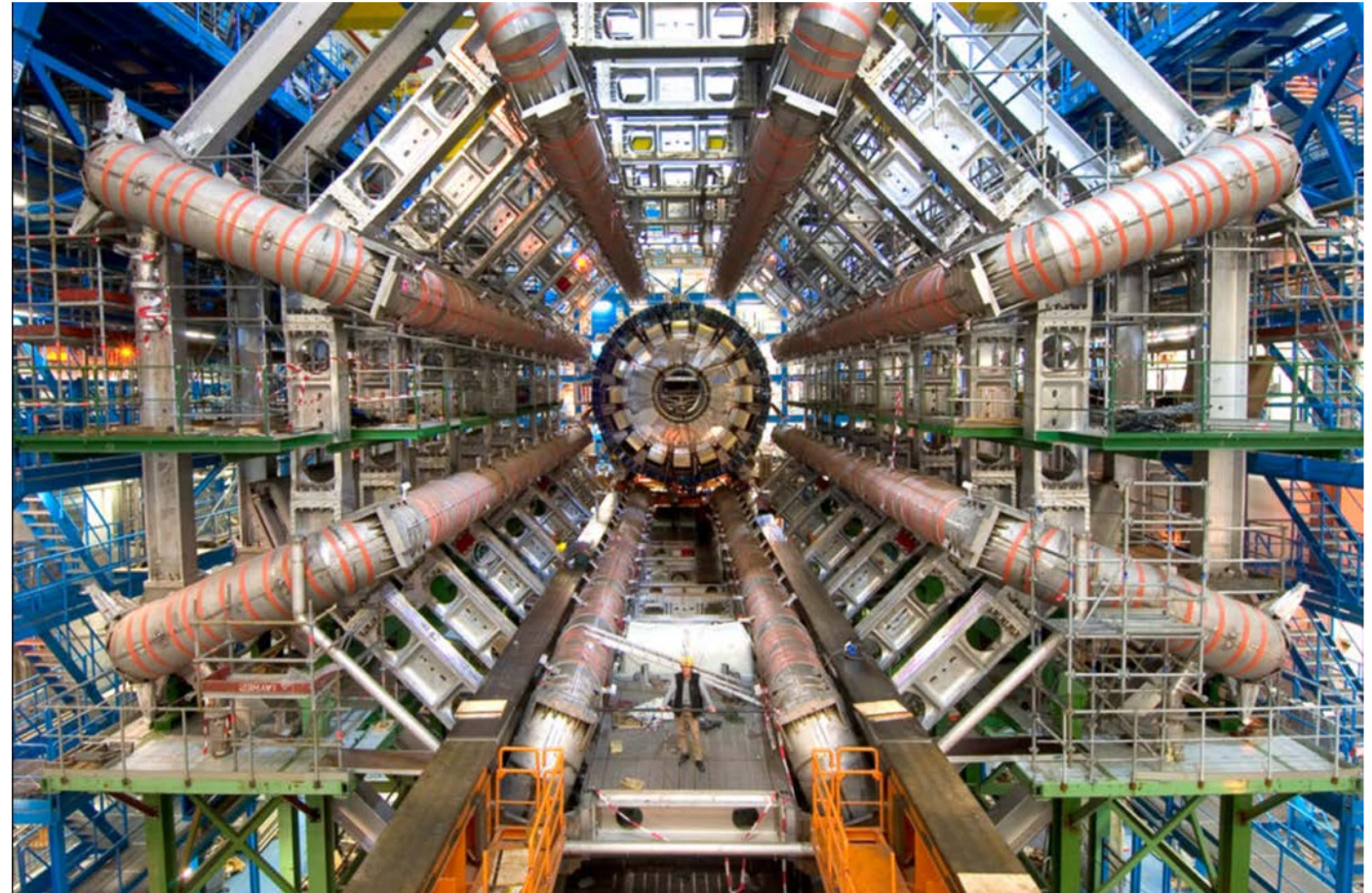
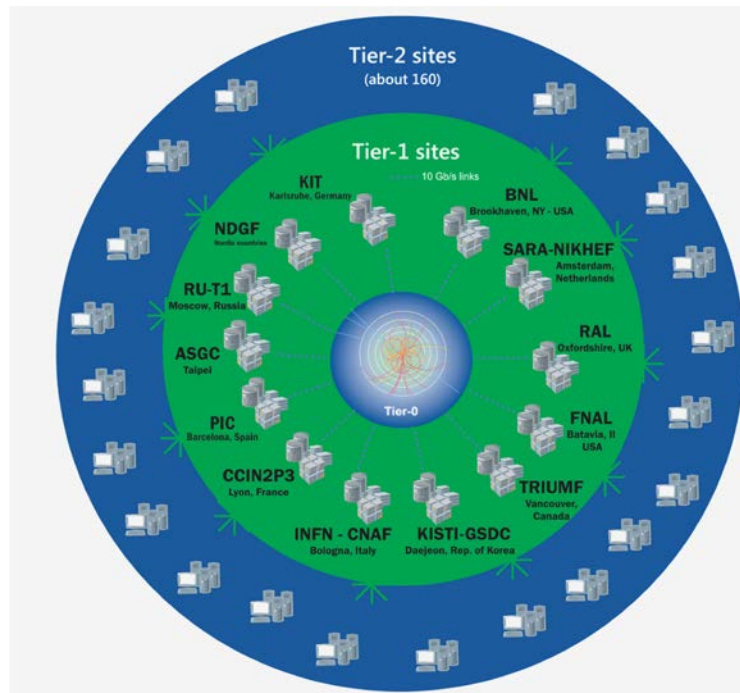
Energy

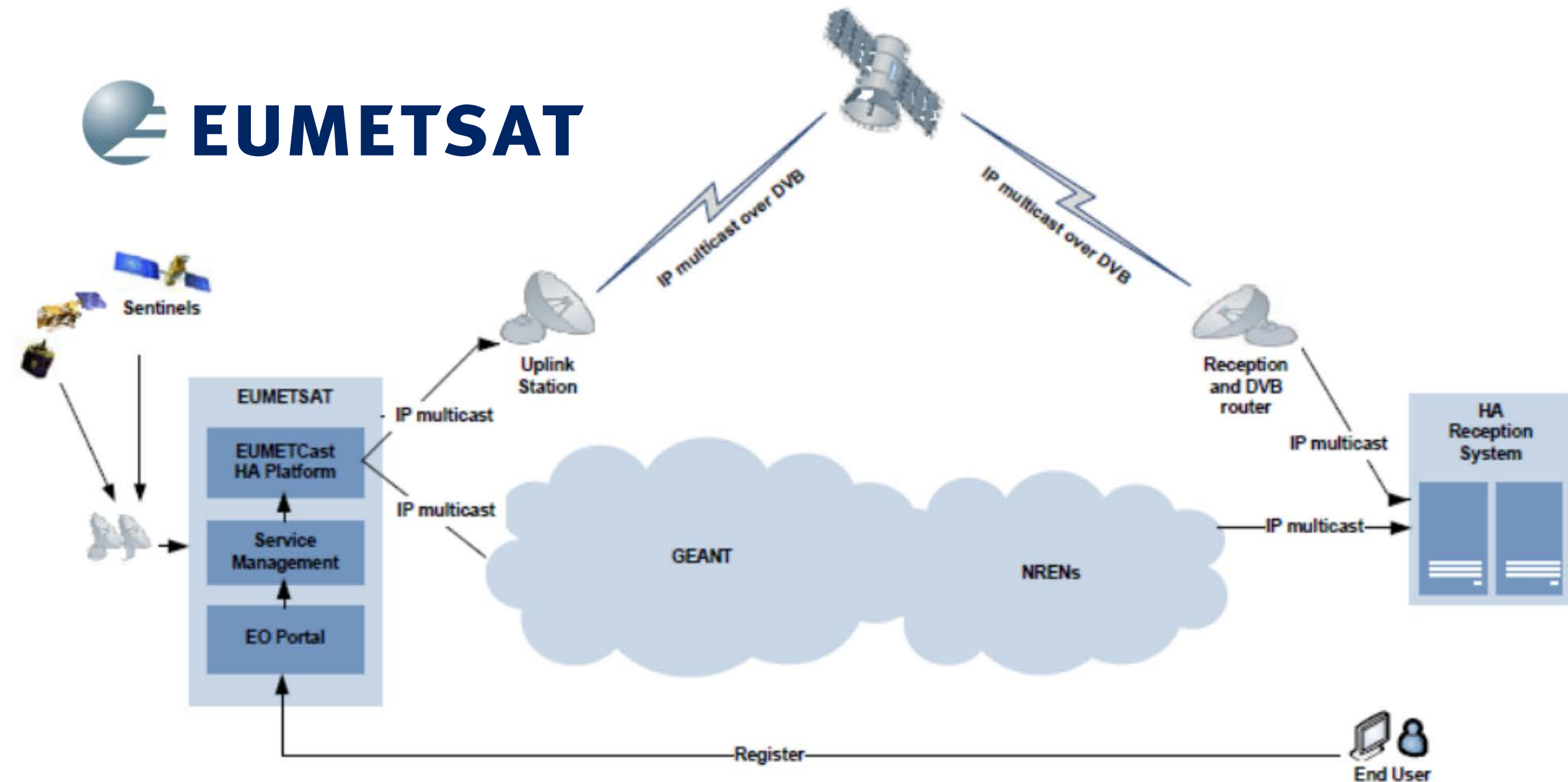
Nuclear power, fusion energy
research, e.g. ITER

Large Hadron Collider

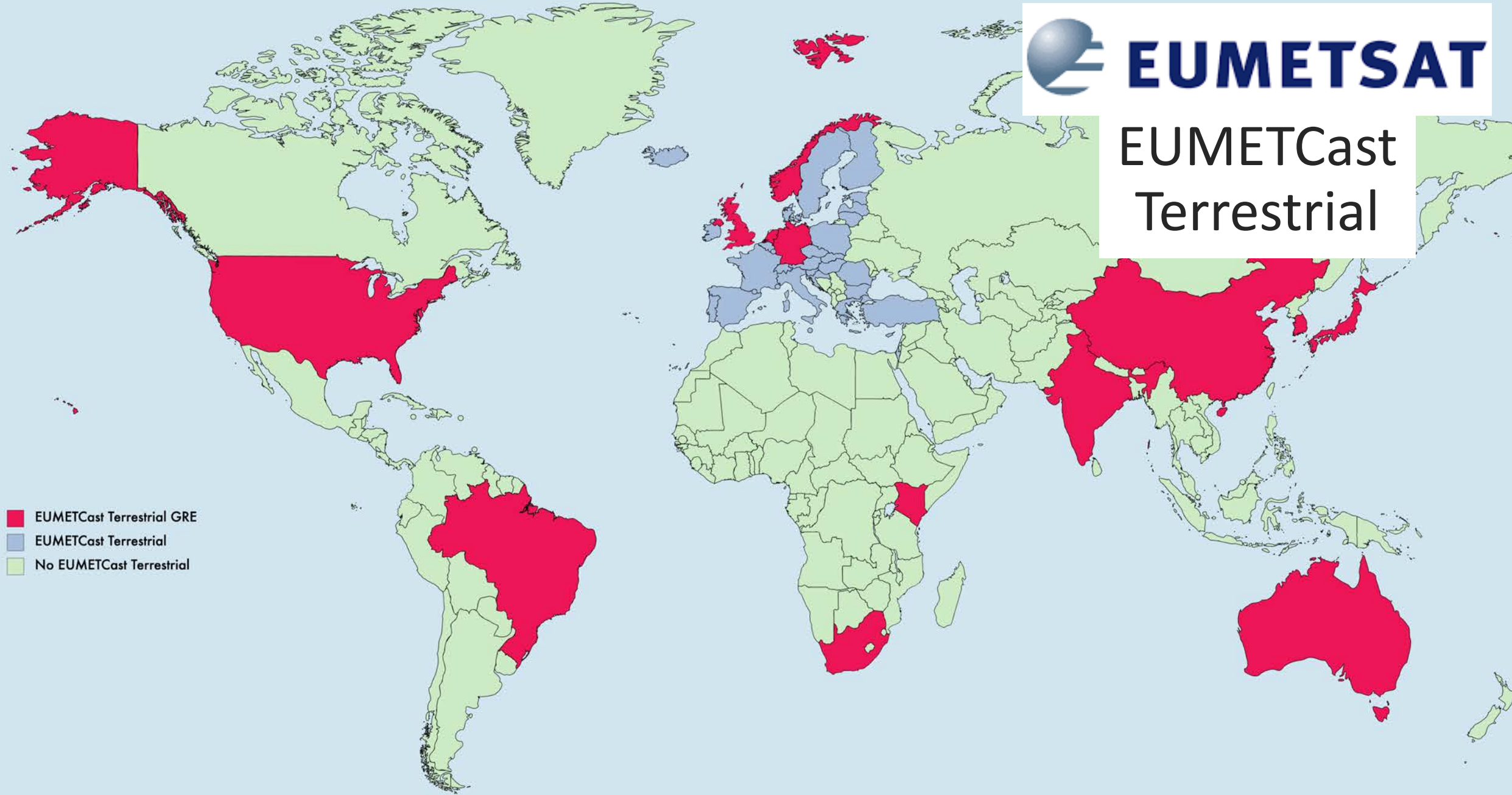
(<https://wlcg-public.web.cern.ch/>)

- Accessible full dataset (100s of PB)
 - 1 exabyte of storage
- Backup data centre for full dataset
- Evolving science instruments => needs keep growing





EUMETCast
Terrestrial



-  EUMETCast Terrestrial GRE
-  EUMETCast Terrestrial
-  No EUMETCast Terrestrial

EUMETSAT – linking sites

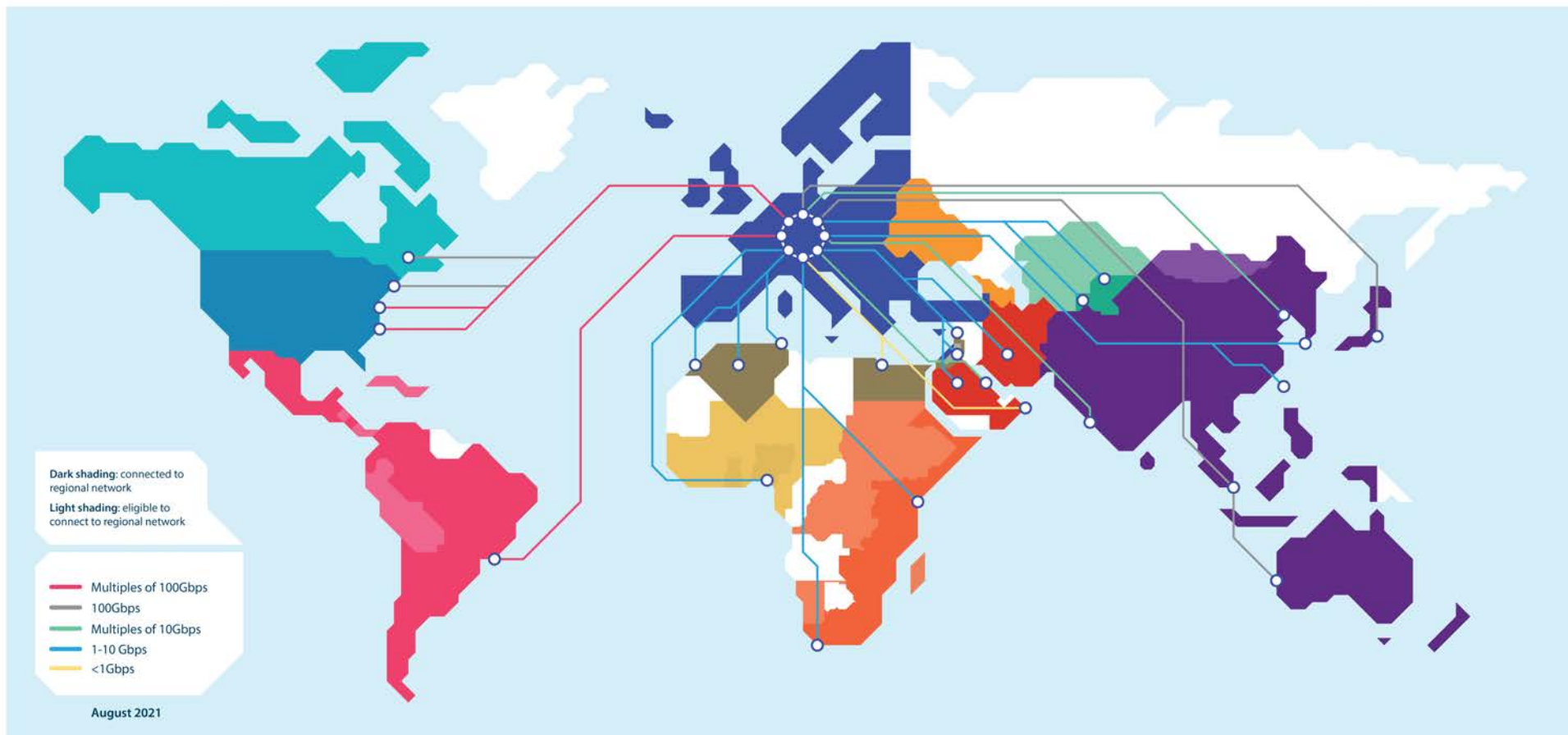


GEANT – the network, global reach through partners





Global Connectivity – with partners



Canada & USA



Latin America



Europe



North Africa &
Eastern Mediterranean



West & Central
Africa



Eastern & Southern
Africa



Central Asia



Asia-Pacific



Other R&E Networks





Example international networking: South America at the heart of astronomy



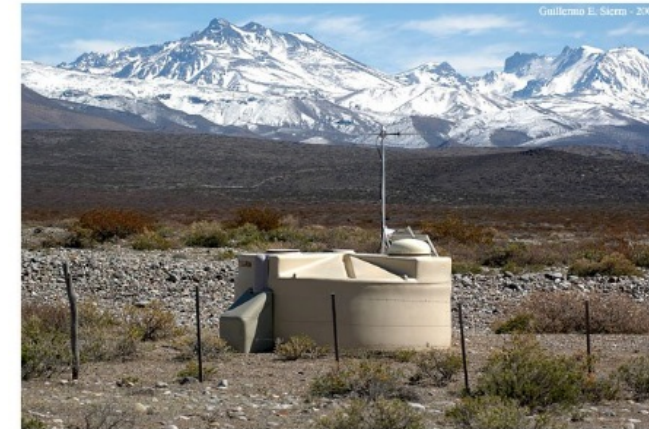
[ALMA](#). Credit: ESO/C. Malin



ESO Very Large Telescope (VLT). Credit: ESO/B. Tafreshi ([twanight.org](#))



[ESO](#). Credit: ESO/S. Brunier



[Pierre Auger Observatory](#). Credit: ©
Guillermo Sierra 2007



All research (it's not just astronomy...)



Images from www.inthefieldstories.net



Latin Americ Connectivity



www.redclara.net

Services Latin American NRENs

10Gbps interconnection with GÉANT

Funded via NREN membership

- Previously co-funded by DG-DEVCO ALICE and ALICE2 projects (2003-2013)



EU-funded BELLA Programme is strengthening Latin America and Latin America-Europe connectivity:

- BELLA-S: 25-year spectrum IRU on new EllaLink cable for direct interconnection (co-funded by DG CONNECT & DG DEFIS)
 - EllaLink cable deployment underway; operational in early 2021
- BELLA-T: Deployment a 100Gbps-capable RedCLARA backbone (co-funded by DG DEVCO).



Enter Bella (2020)



Consortium setup:

GÉANT, RedCLARA + number of European and Latin American NRENs are part of the cable consortium

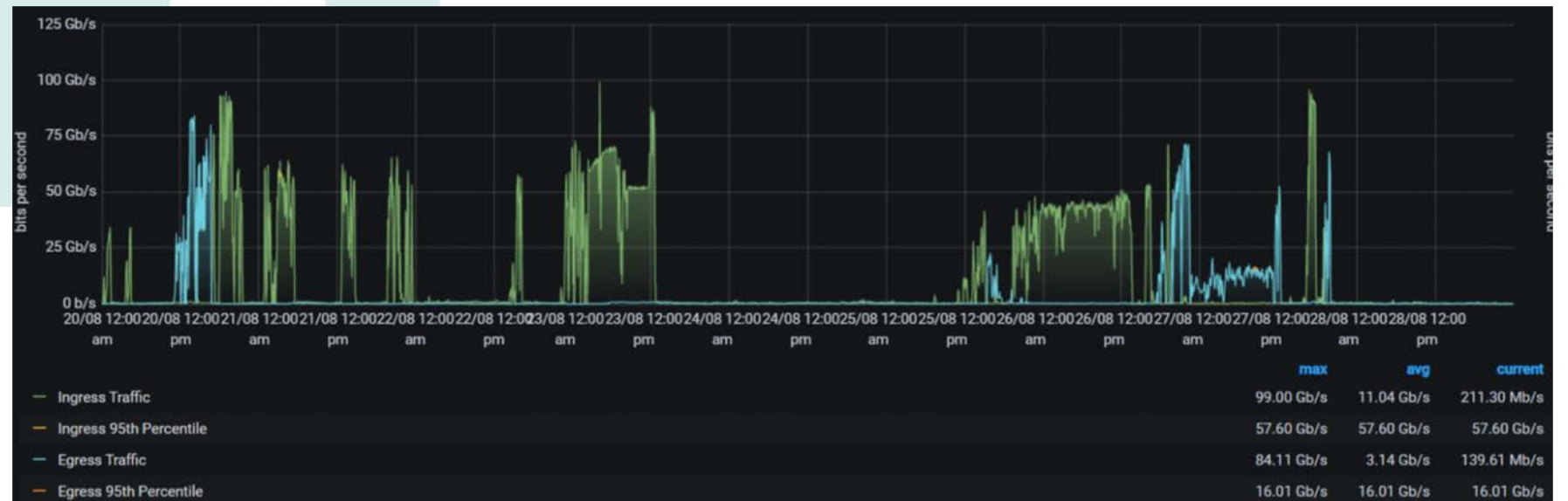
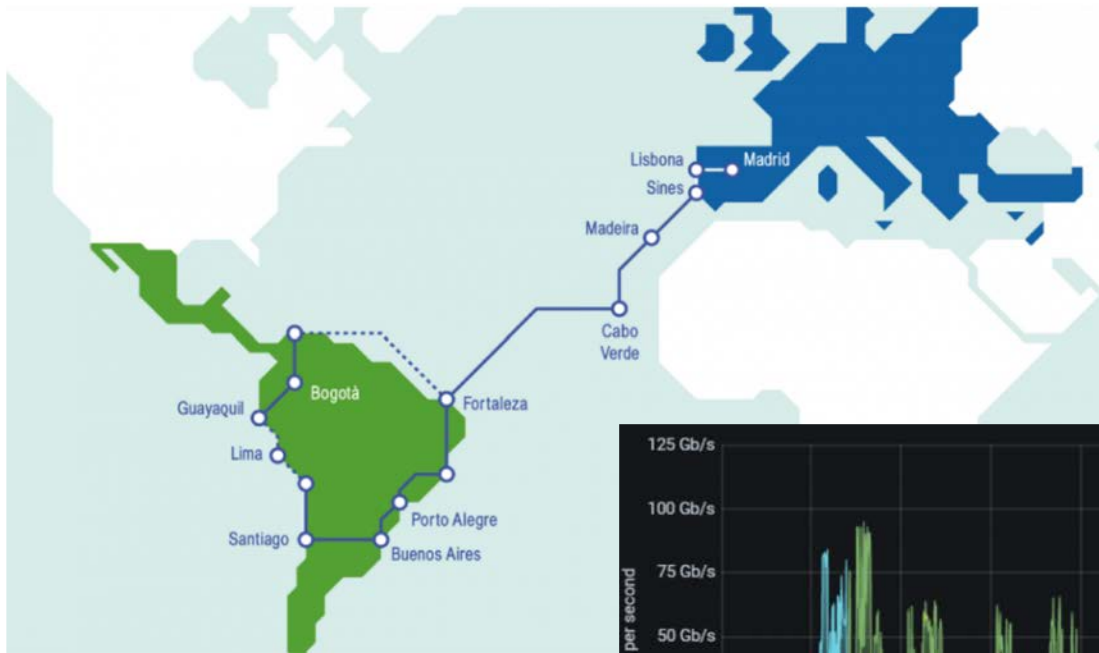
IRU on Spectrum

on Europe-Latin America submarine cable

- Now: 2x100Gbps links for GÉANT-RedCLARA & Copernicus to start
- Easily upgradeable in the future



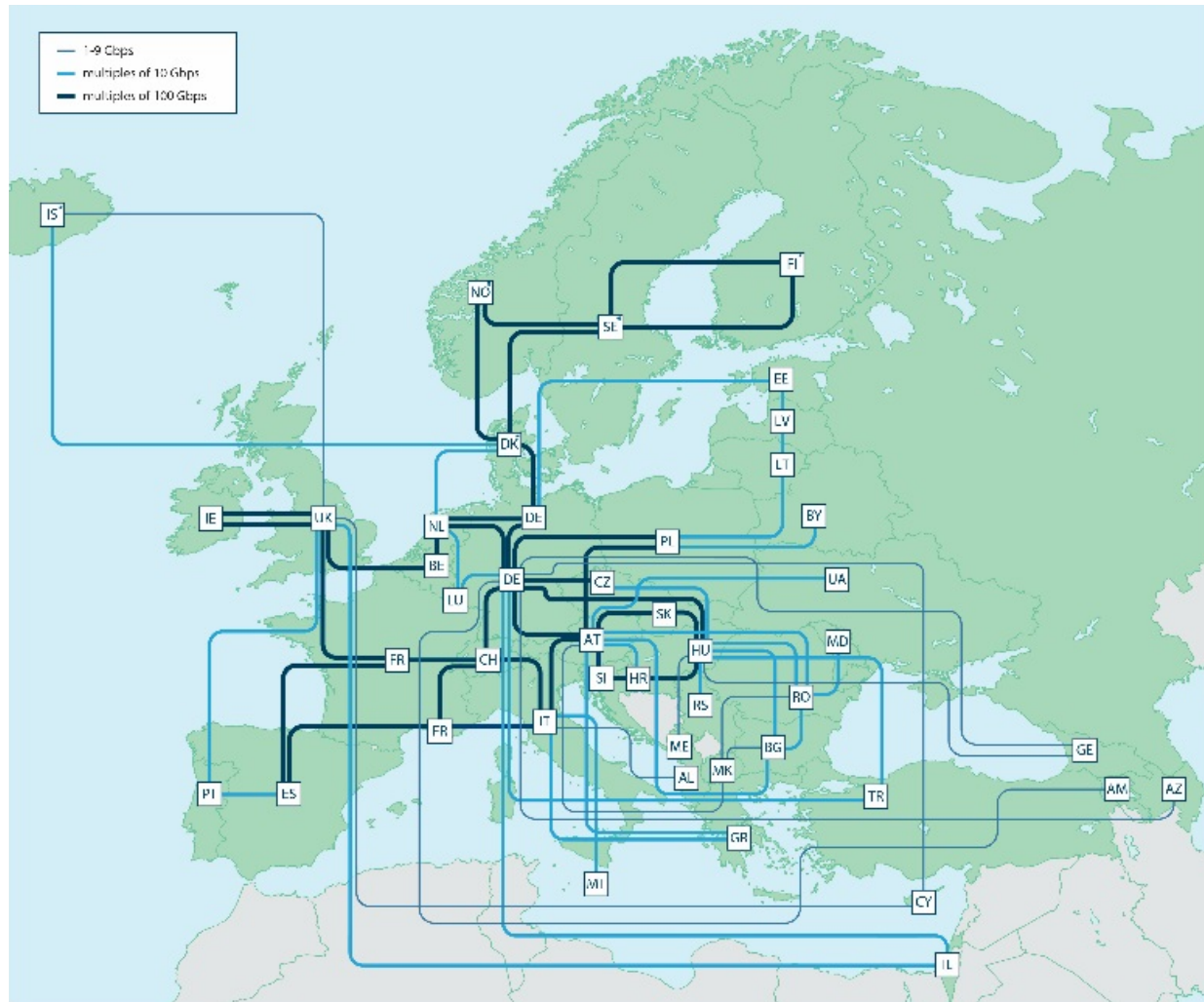
Actually... 2021: Bella now live



GEANT – European network

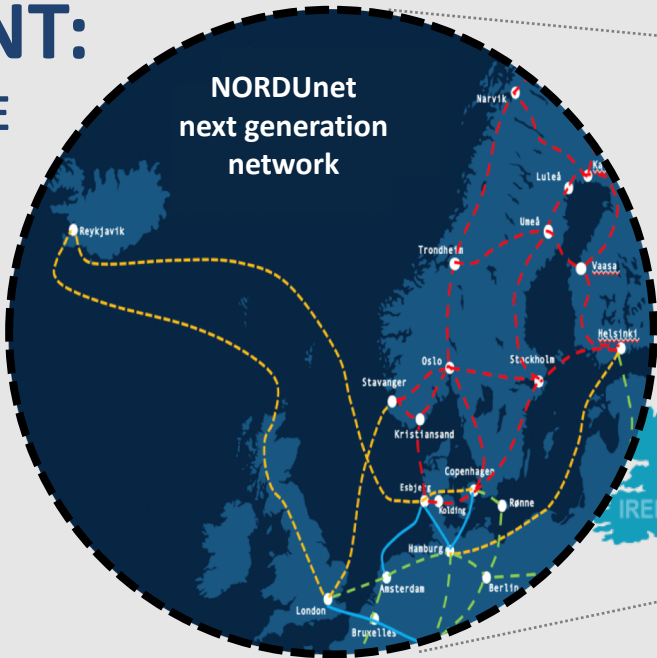


GN4-3N – upgrading this network

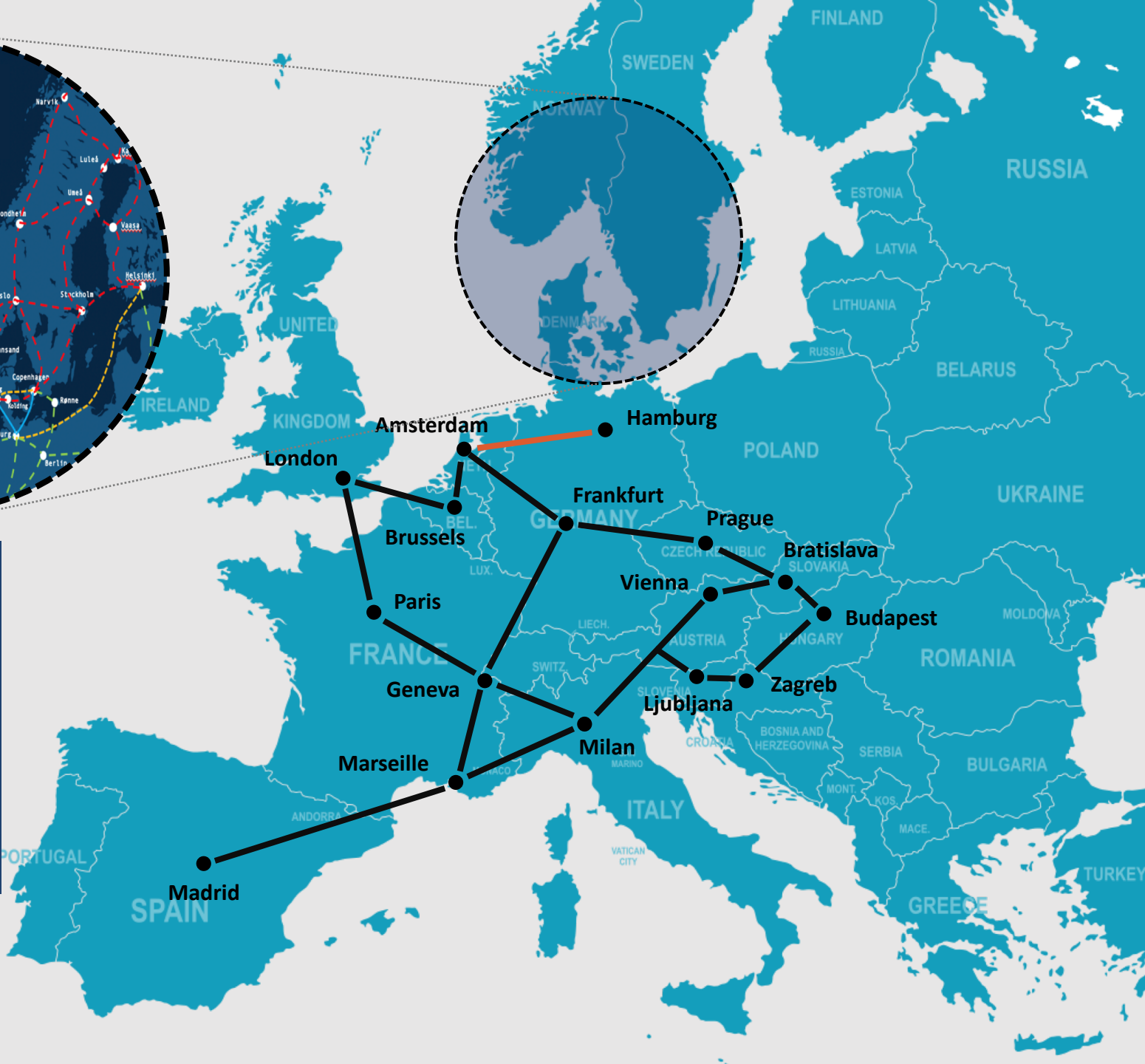


STARTING POINT:

FIBRE INFRASTRUCTURE AT START OF GN4-3N



Fibre Network at start of project
14 countries (+NORDUnet) on fibre
Shorter term contracts => higher maintenance costs, to be replaced
Other countries on (sometimes expensive) leased lines



| | |
|---|---|
|  |  |
| Commercial Dark Fibre | NREN Spectrum |

INITIAL AMBITION 2018:

REFERENCE NETWORK IN GN4-3N PROPOSAL

Reference Topology –
based on extensive community consultation and market information

Estimated investment cost for this network: 48 M€

24 countries integrated in this infra

Other partners – depending on budget:
Additional dark fibre (DF) /spectrum projects
or
Standard leased capacity (minimally 10GE,
might be 100GE by end of project)



STATUS EARLY 2020

ROUTES ACQUIRED

5 routes under procurement

Acquired

Under procurement

To be done



INCREASED AMBITION FOR END OF PROJECT

- Bridging digital divide
- Long term infrastructure
- Sustainable

- 6 additional countries integrated in the infrastructure
- Network improvement projects

Estimated (maximum) Non Recurring Cost for this network: 51 M€

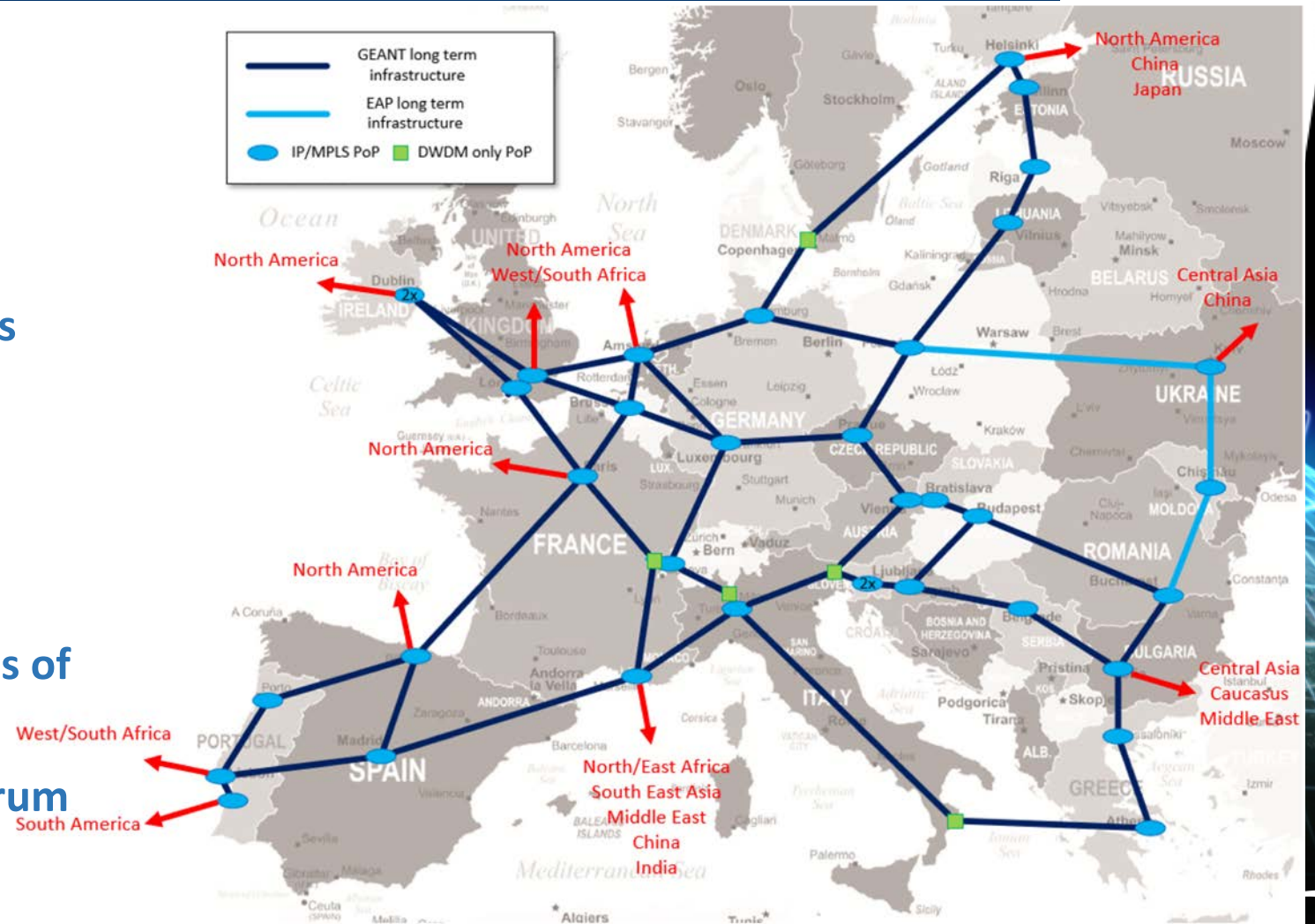
Original reference Improvement



WHAT WILL THE GÉANT NETWORK LOOK LIKE?

The GN4-3N network in numbers:

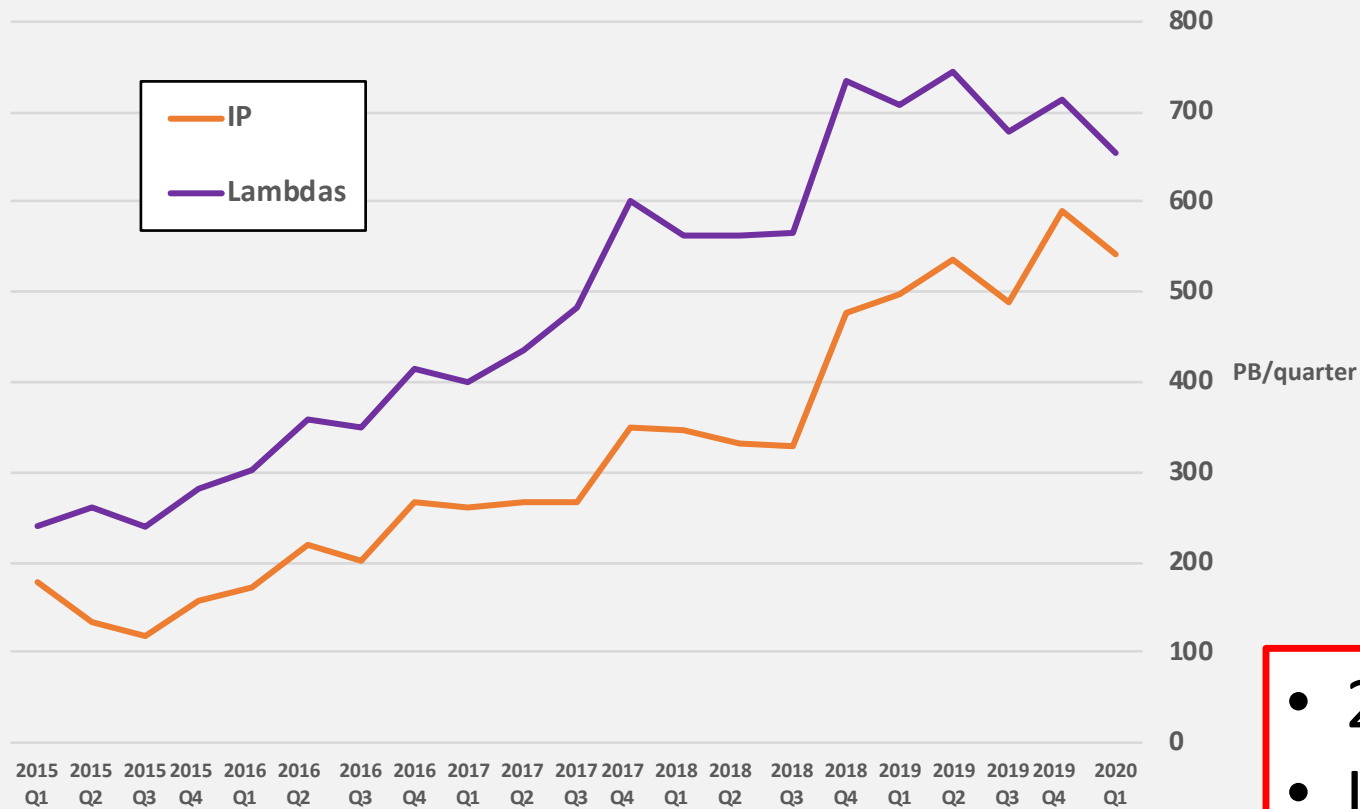
- 24+ countries connected by Fibre/Spectrum (about 70%)
- 2 Fibre connected PoPs in the Nordics area Helsinki and Copenhagen
- ~30.000 Km of Fibre/Spectrum infrastructure
- 15 + (3x2) years IRU contracts
- Maximum capacity on Fibre, in excess of 24 Tbps
- Minimum link capacity at 25% Spectrum 6Tbps+



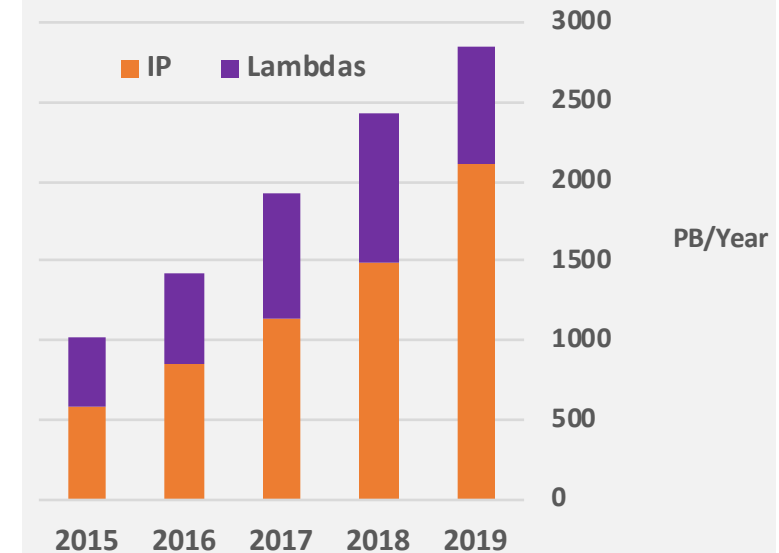
BUT... why?

Network challenge number 1: Network Traffic Growth

GÉANT traffic



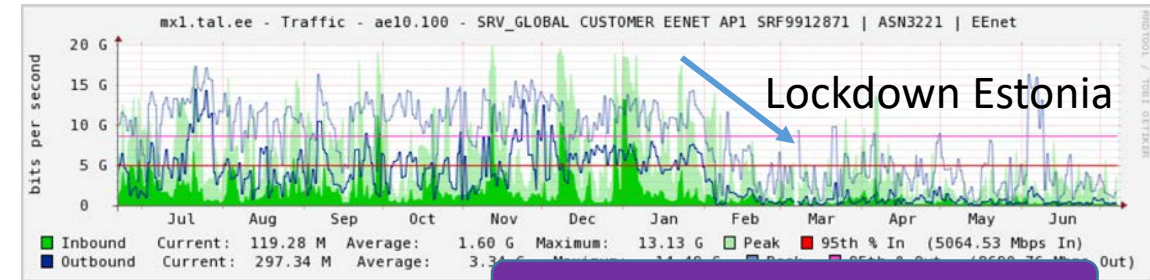
Annual Growth



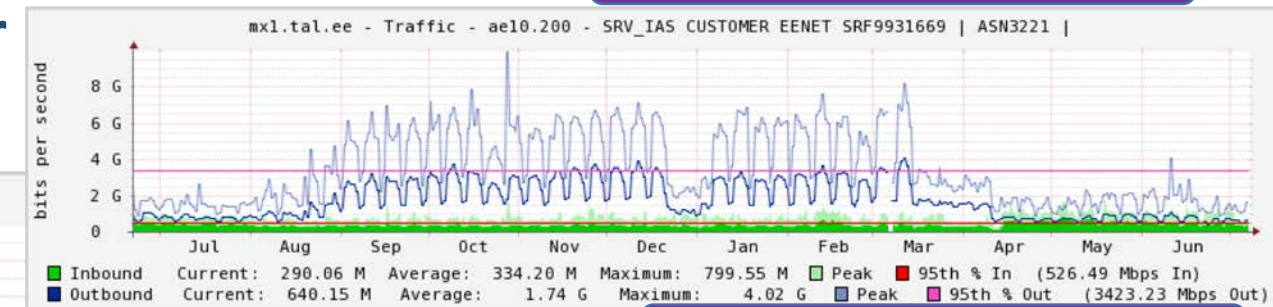
- 2.8 Exabyte of traffic in 2019
- Long term growth 30%
 - 10 times the traffic over 10 year

COVID-19 - and the Network Traffic:

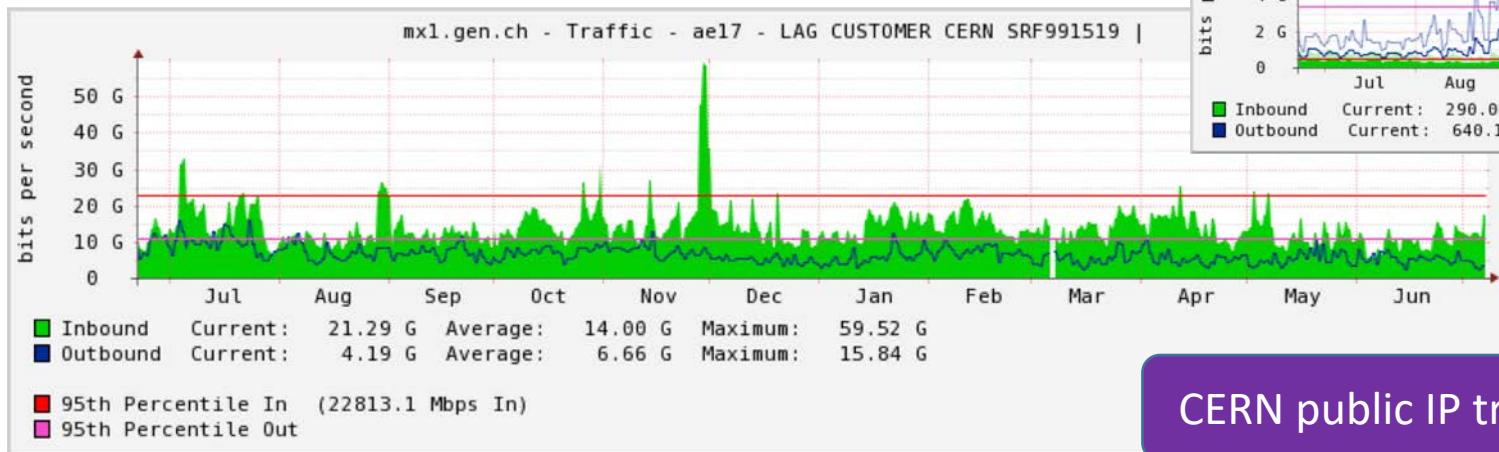
- Clearly people moved off campus
- Commercial traffic (general internet) declined considerably
 - Note: increase in access *from* commercial
- BUT science-drive traffic remains similar**



EENet all traffic

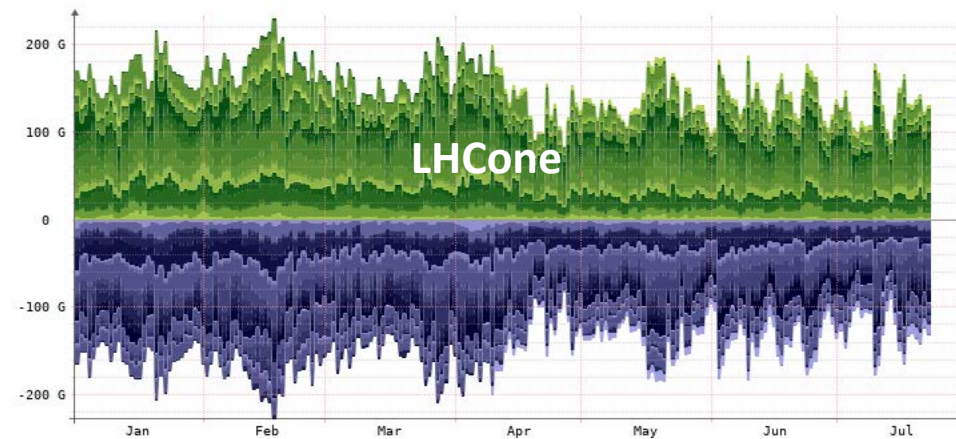
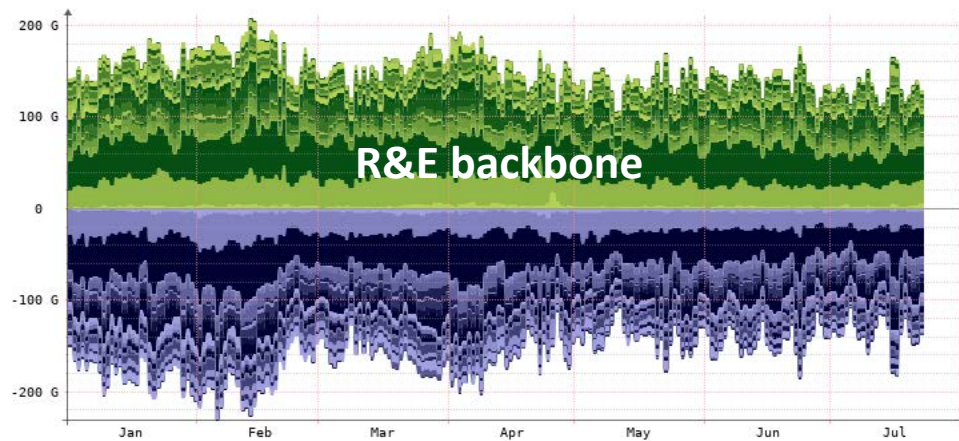
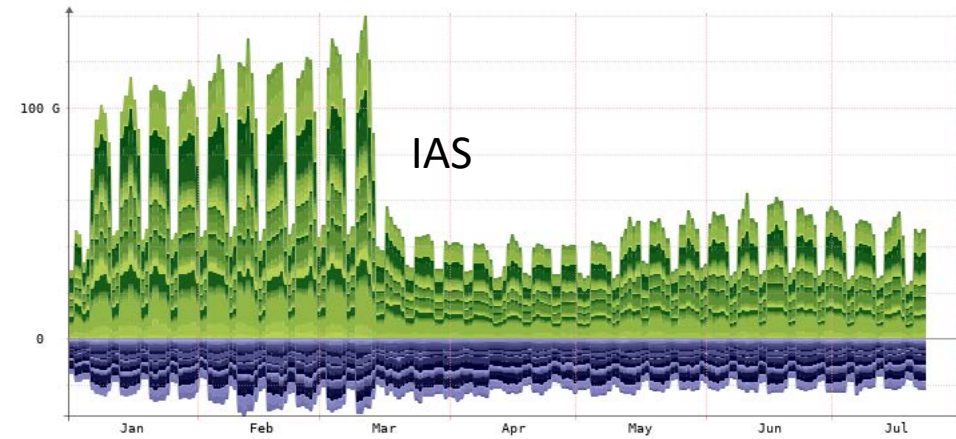
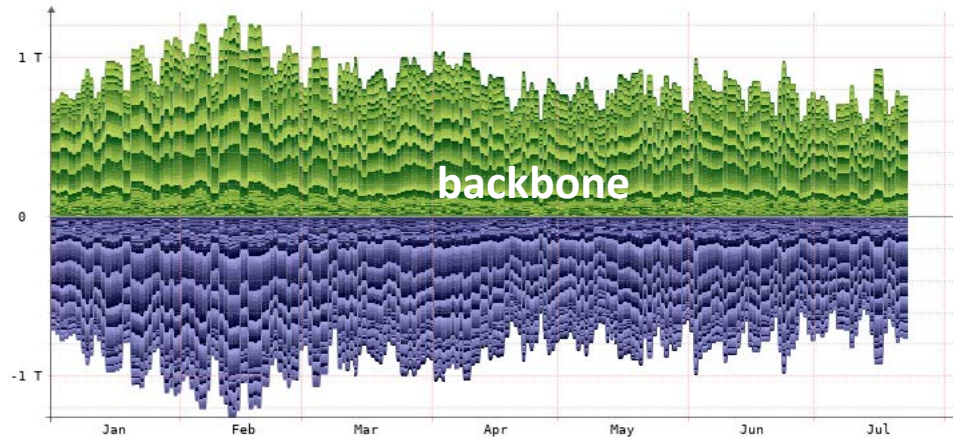


EENet "commercial" IP traffic



CERN public IP traffic

Some more from 2020

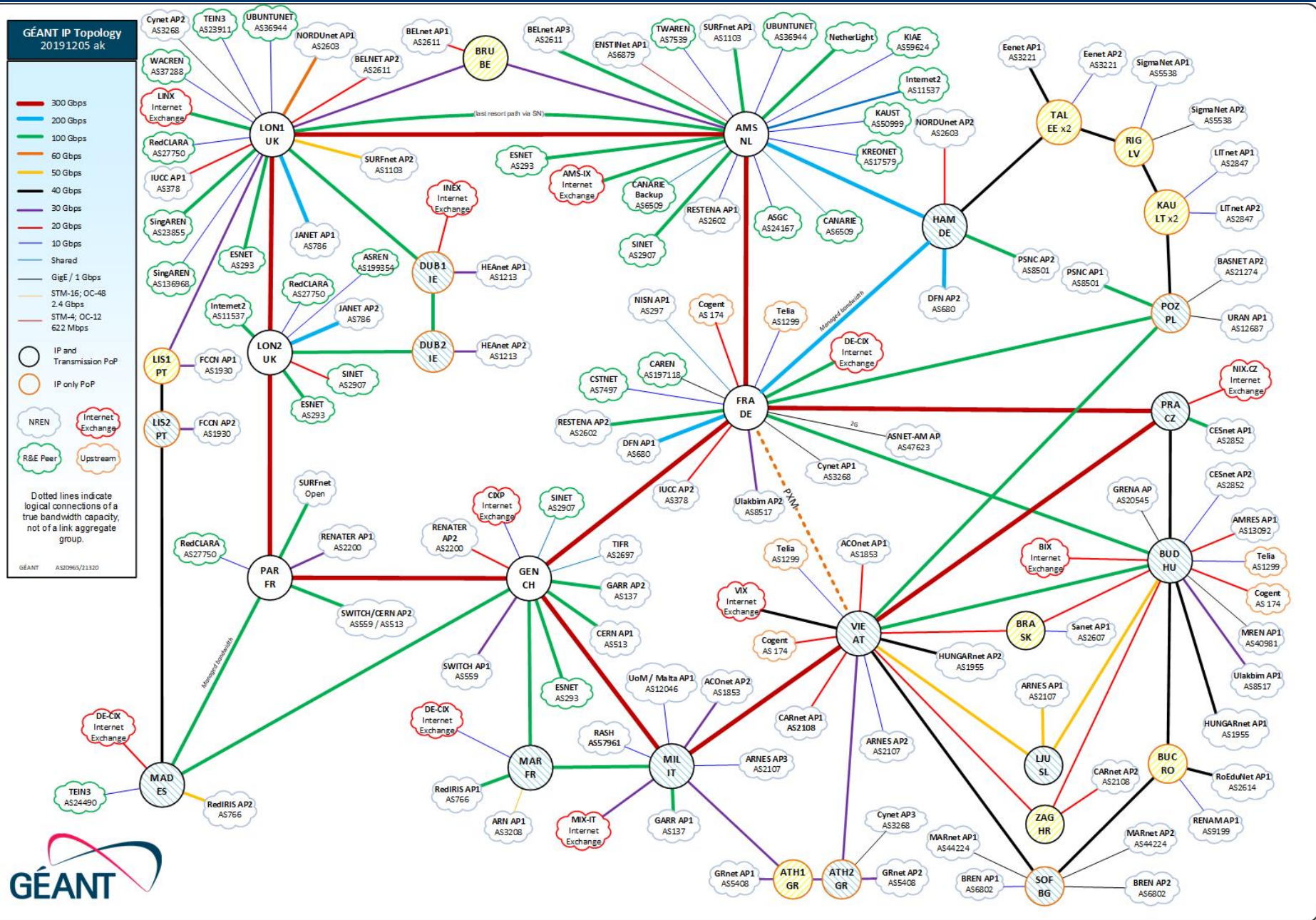


GEANT – IP network



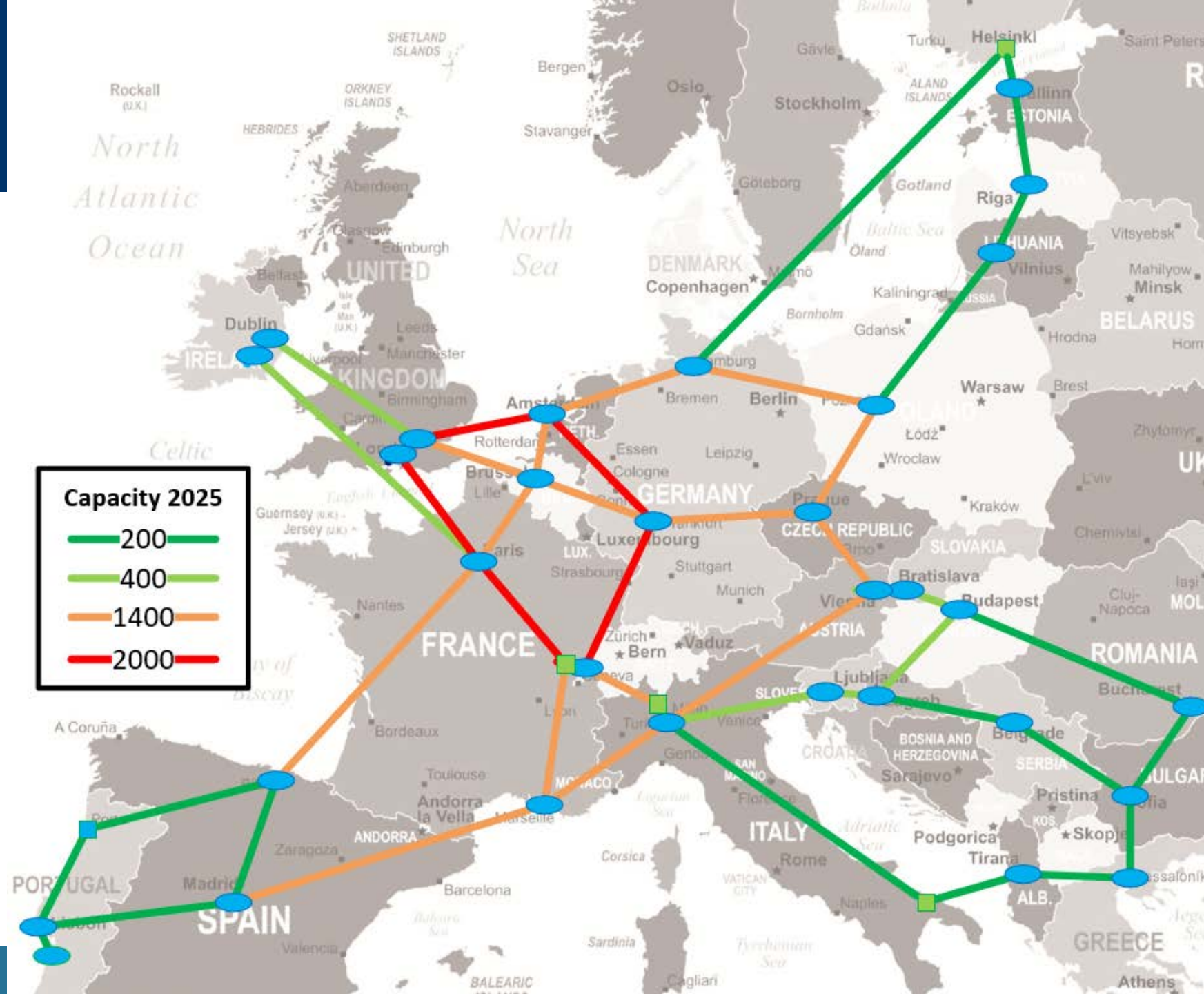
IP/MPLS layer 2020

- N x 100G in the Western and Eastern rings
- 200 & 100G surrounding
- N x 10G further afield



Expected IP/MPLS layer 2025

- Forecast in 2025 according to current growth rate and planned expansion – up to 2 Terabit/s
- 400G+ interfaces become a necessity in core locations



- To gain experience operating, GÉANT installed two instances in the lab
 - Routinator (NLnetlabs)
 - Octo-RPKI (cloudflare) + GoRTR (cloudflare)
- Now dropping INVALID routes – no material impact on any of GÉANT's customers

Implementation of MANRS Actions

- ✓ Action 1: Prevent propagation of incorrect routing information
- ✓ Action 2: Prevent traffic with spoofed source IP addresses
- ✓ Action 3: Facilitate global operational communication and coordination between network operators
- ✓ Action 4: Facilitate validation of routing information on a global scale

Why GEANT Supports MANRS



GEANT strives to implement best practice in everything we do and have been de facto proponents of MANRS norms in the decades before its inception. We are cognisant of the shared responsibilities incumbent upon us all: to be good netizens and practice good BGP hygiene. It is a matter of professional pride that GEANT tries to lead by example in hopes that this will encourage others to adhere to MANRS principles and other best current practices.

Screenshot from
MANRS website

Richard Havern
Head of Network Engineering, GEANT

Current 'next big thing': Segment Routing



- **we need a way to explicitly define a path** for specific circumstances, such as low latency applications
- RSVP-TE in a large number of nodes is hard work to set up and maintain in a dynamic environment
- Segment routing give us this functionality without the pain of RSVP-TE
- Recent versions of Junos give the option of running Topology Independent Loop-free Alternate Fast Re-route (TI-LFA)
- GÉANT running SR in parallel with LDP since Jan 2019, but not yet preferred; script compares the two and alerts if not same

Current 'next big thing': Streaming Telemetry



- **SNMP based polling inefficient:** everything polled at the same frequency
 - Without considering (likelihood of) data change
 - Currently polling at 5 min therefore **microbursts are invisible**.
- **Netflow** data has one-minute averages, better view of elephants, but still no view of microbursts
- **Streaming Telemetry:** Subscription based, **adjustable for the expected useful granularity**
 - Infrequent changes (line card/hostname changes) set with a longer interval, couple of times per day.
 - Network interfaces every couple of seconds - finally giving level of granularity to capture microbursts!
 - **Highly granular data** from the network, for as long as we can store it
 - No smoothing of data as it ages, brilliant for when new traffic analysis tool is introduced
- Streaming Telemetry: Base for *future* path computation/routing adjustments
 - Near real-time network data allow **PCE controller to make near real-time adjustments**
 - Avoid congestion, dynamically make space for long duration elephant flows

Streaming Telemetry: a to do list

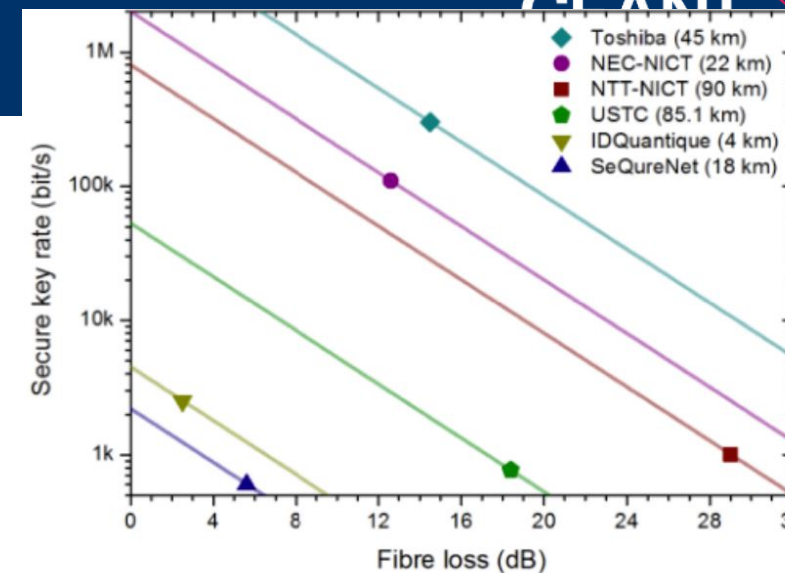
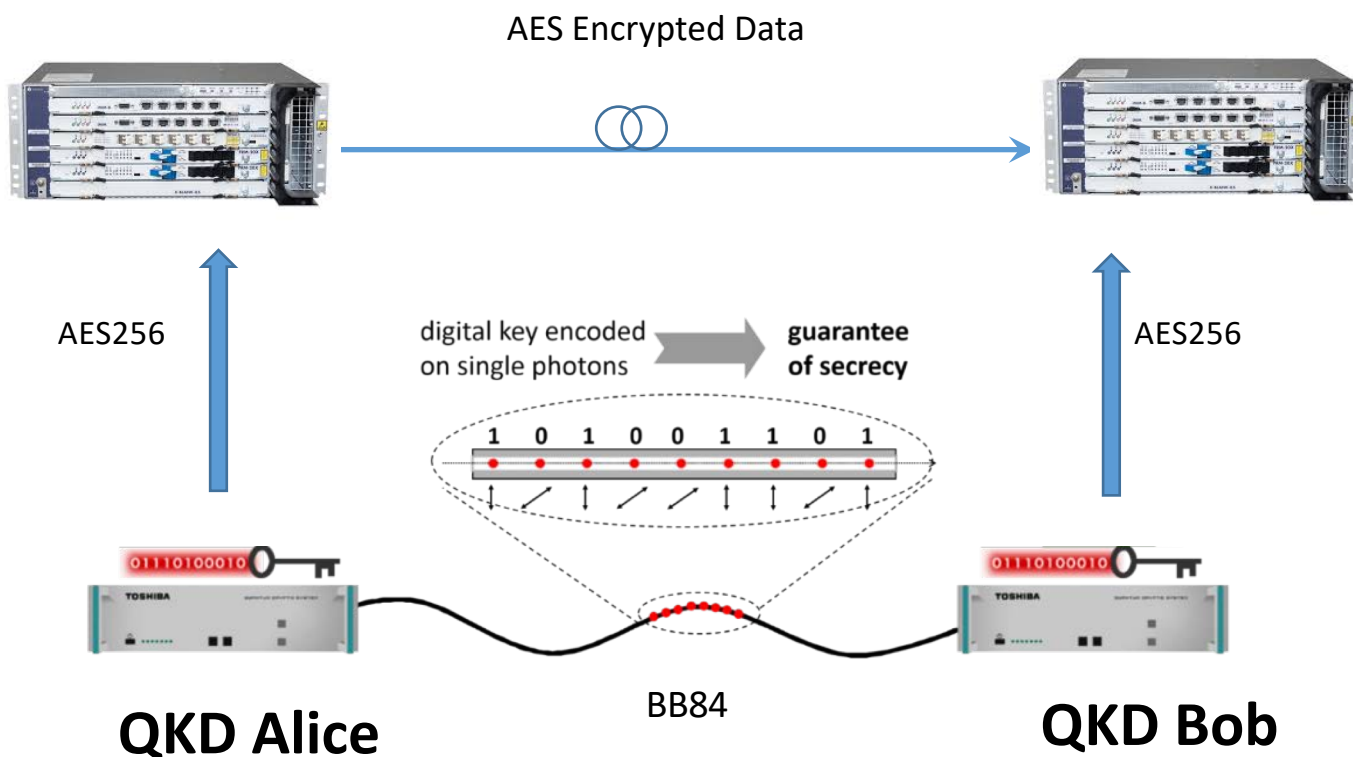
- Determine what to measure and how frequently
- Software packages for collection, storage and analysis
- Proof of concept in lab
- Does it work as expected or break any existing service
- Gather business requirements for data retention
- Dimensioning hardware required to meet requirements for production
- Production POC

Non-IP: Quantum and T&F





Single photon Quantum Key Distribution



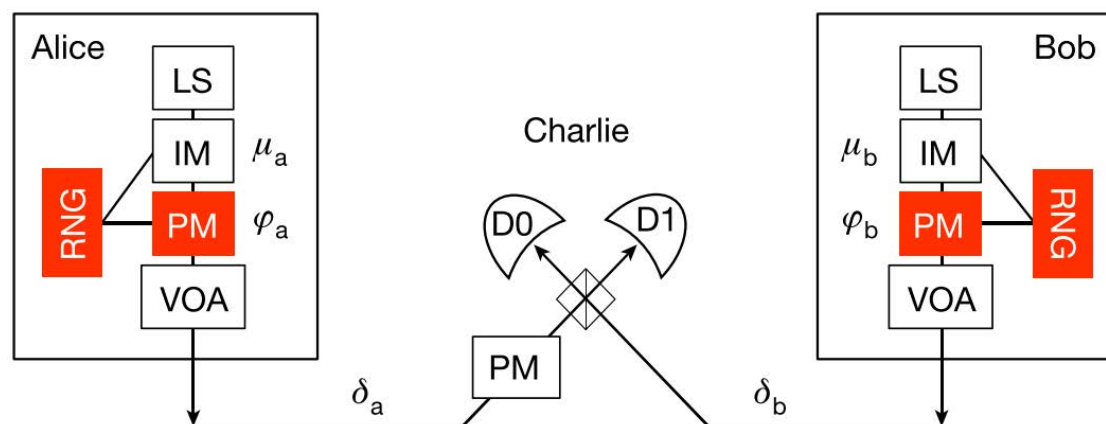
- Keys are distributed using a 'single photon' quantum channel.
- A quantum key protocol such as BB84 is used for key transmission.
- Data for transmission is encrypted using AES.
- Reach limited to single hop of 100km

A decent explanation:
https://mpl.mpg.de/fileadmin/user_upload/Chekhova_Research_Group/Lecture_4_12.pdf



Twin-field based QKD

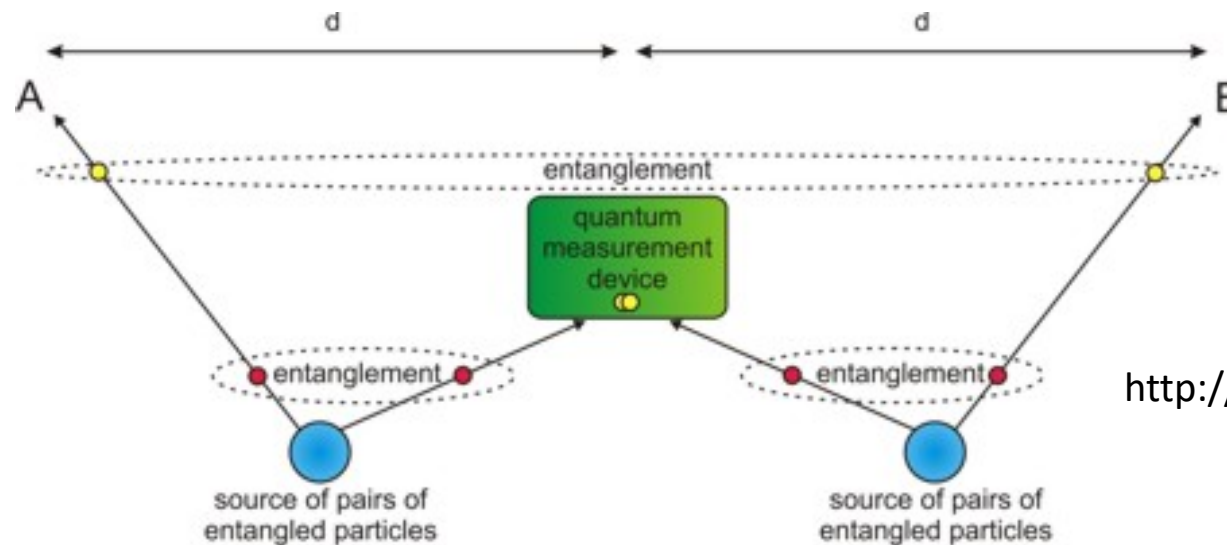
- A twin field (two-hop) system can be built by sending coordinated photons from both Alice and Bob such that they interfere at Charlie.
- By sharing information out of band about the interference detected at Charlie, keys can be securely exchanged
- The theoretical reach is doubled from 250km up to 500km





Quantum Repeaters

- A method of building quantum repeaters has been proposed based on entanglement swapping *
- This extends entanglement to greater distances.
- The quantum measurement selects photons with a certain correlation (in a certain Bell state)
- This has the effect of projecting entanglement onto photon A and B.
- The technology required to build such repeaters is not yet ready.



<http://www.quantumrepeaters.eu>

* https://www.unige.ch/gap/quantum/_media/publications:bib:revmodphys.83.33.pdf

