Innovative Research Initiatives in the Nordic Countries

NORDUnet

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KOREN Workshop

16 October 2008

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The Nordic Countries

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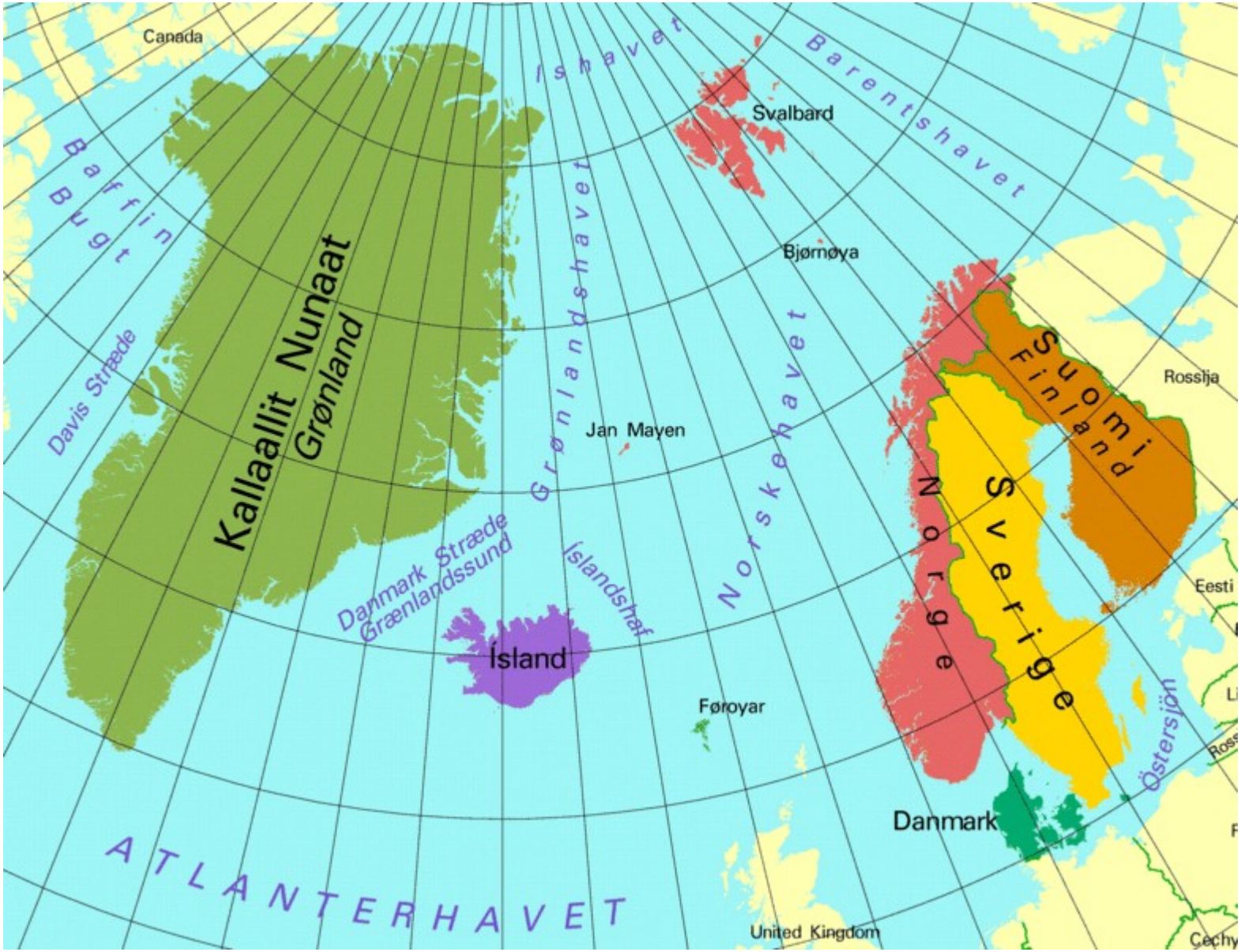
The Nordic Countries



The Nordic Countries

- Denmark, Norway, Sweden, Finland, Iceland.
  - 5 independent countries
  - 5 national R&E networks
  - Tradition of collaboration
- Large area, few people
  - 25 million citizens
  - 1,240,456 km^2 (3,406,542 km^2 w/Greenland)
  - Copenhagen – Svalbard: 2500 km
  - Copenhagen – Gibraltar: 2500 km

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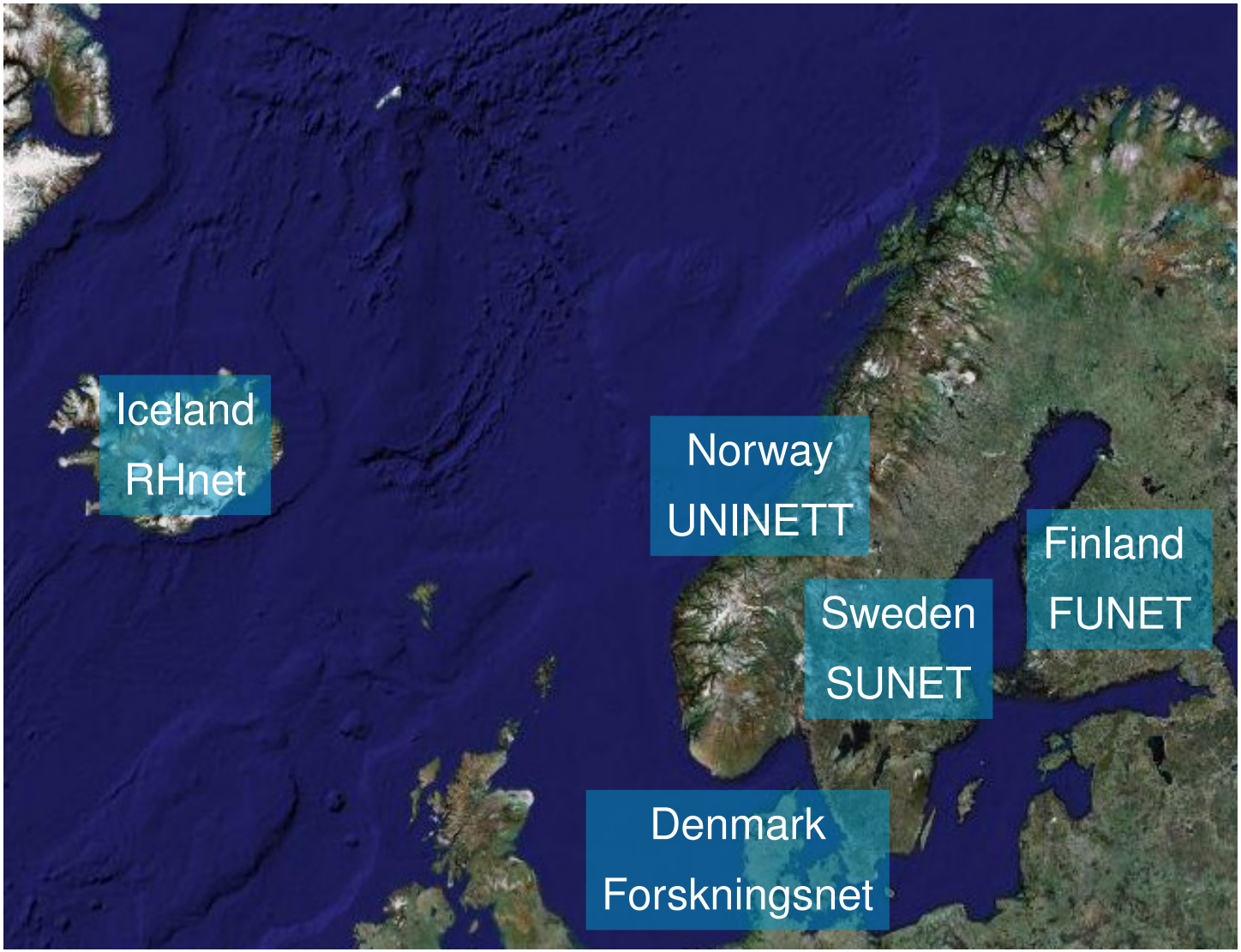
NORDUnet collaboration



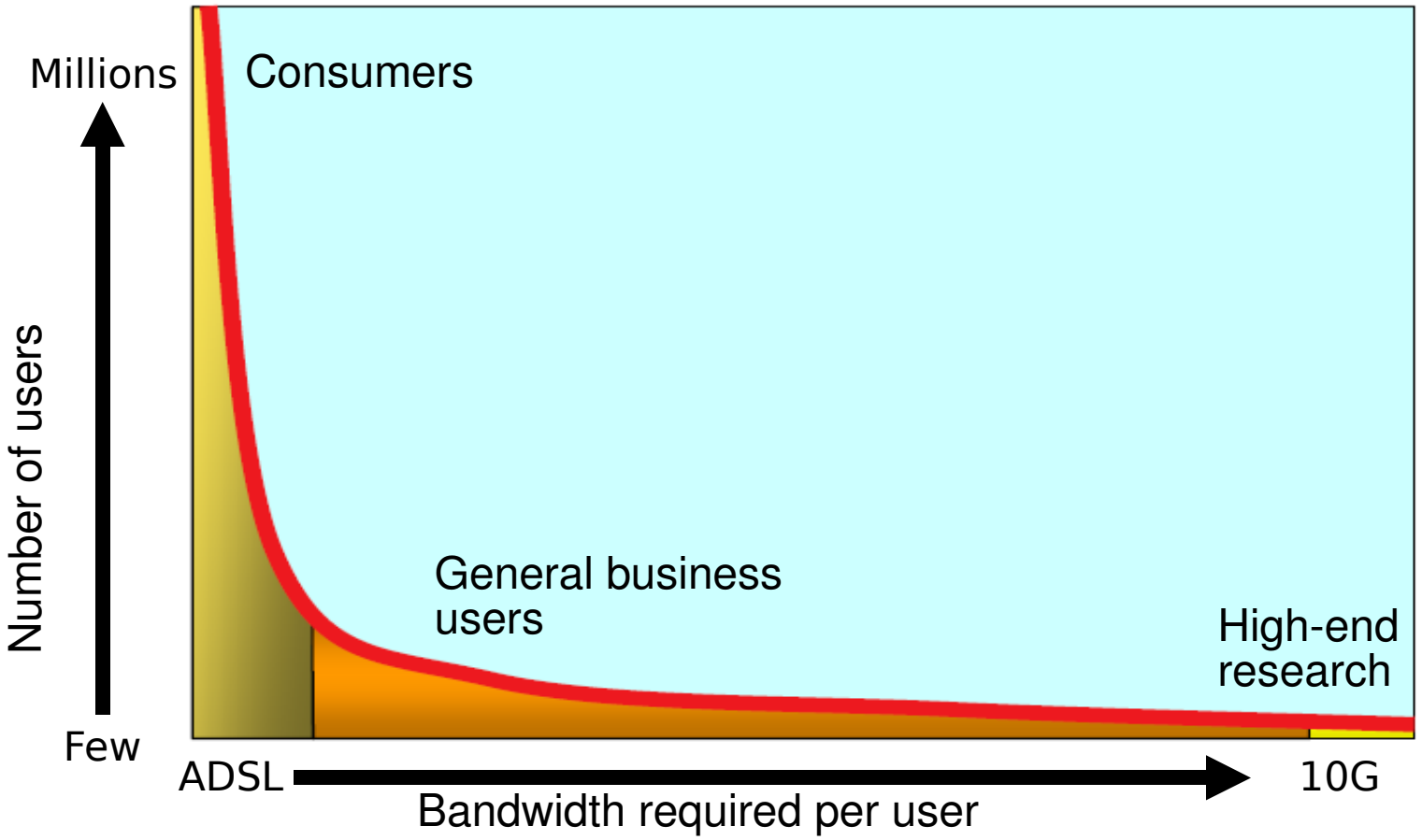
A Regional Network

- 25 years of collaboration
  - Doing together what we cannot do alone
  - Represent the Nordic countries internationally
  - 5 countries, one network, one voice
- Service the Nordic NRENs
  - Connectivity, cost efficiency
  - Project participation and coordination (GEANT, GLIF, GLORIAD, FEDERICA, ...)
  - International relations, international development efforts
  - eScience infrastructure services – networks for major projects and disciplines, grid computing, storage services

The Rise of e-Science

LHC: A large, shared scientific instrument with distributed (global) use and vast resource requirements.

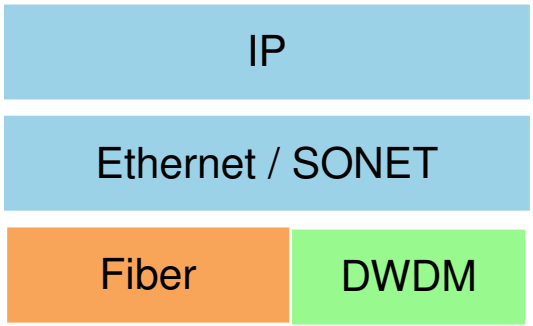
Not all users are equal



SERENATE Study Final Report, 2003, *Cees De Laat, David Williams* et. al.

Hybrid Networking

- Offer services at multiple network layers
  - L1 or L2 circuits for high capacity application
  - Shared IP networks for mass use
- Built on a single optical network fabric
  - Each layer uses the services provided by the layers below it
  - Don't go higher in the stack than needed – save cost and energy



- Hybrid networking is getting easier
  - Advanced in optical networking, L2 switching
  - Optimal use of such devices requires direct access to the fiber

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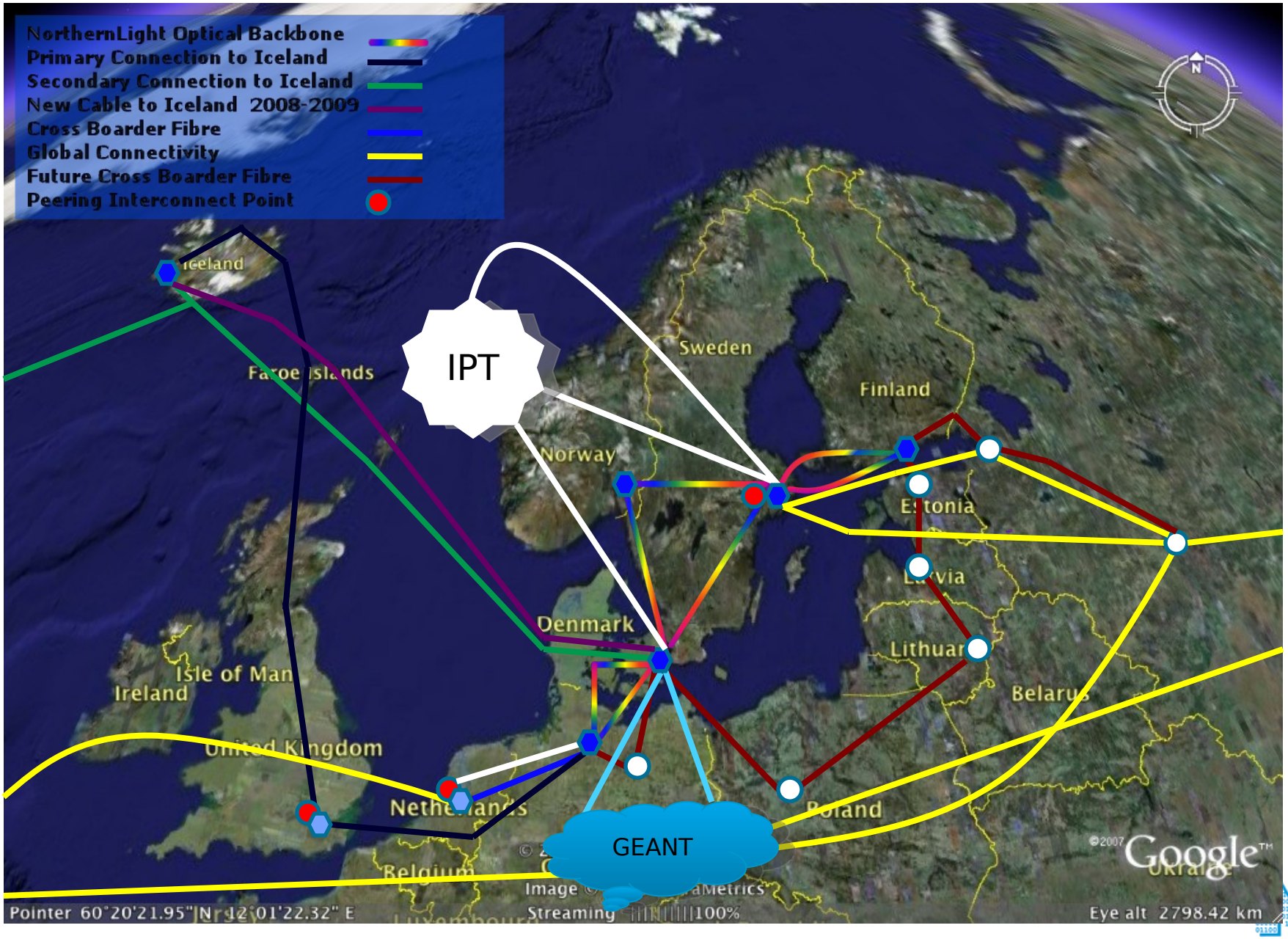
Connecting the Nordic Countries



1st Generation "hybrid" (2003)

- Services
  - 10G / 2.5 G shared IP
  - 1G (subrate) Ethernet lightpath service
- Design
  - Based entirely on leased lines
  - Cisco ONS 15454 SONET lambda service platform, OC48 carrier
  - Lambda service platform and IP service platform separate infrastructures (w/ shared PoP's)
  - OC48 to Netherlight

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2003 Lambda Grid Workshop

iGrid 2005 e-VLBI demo

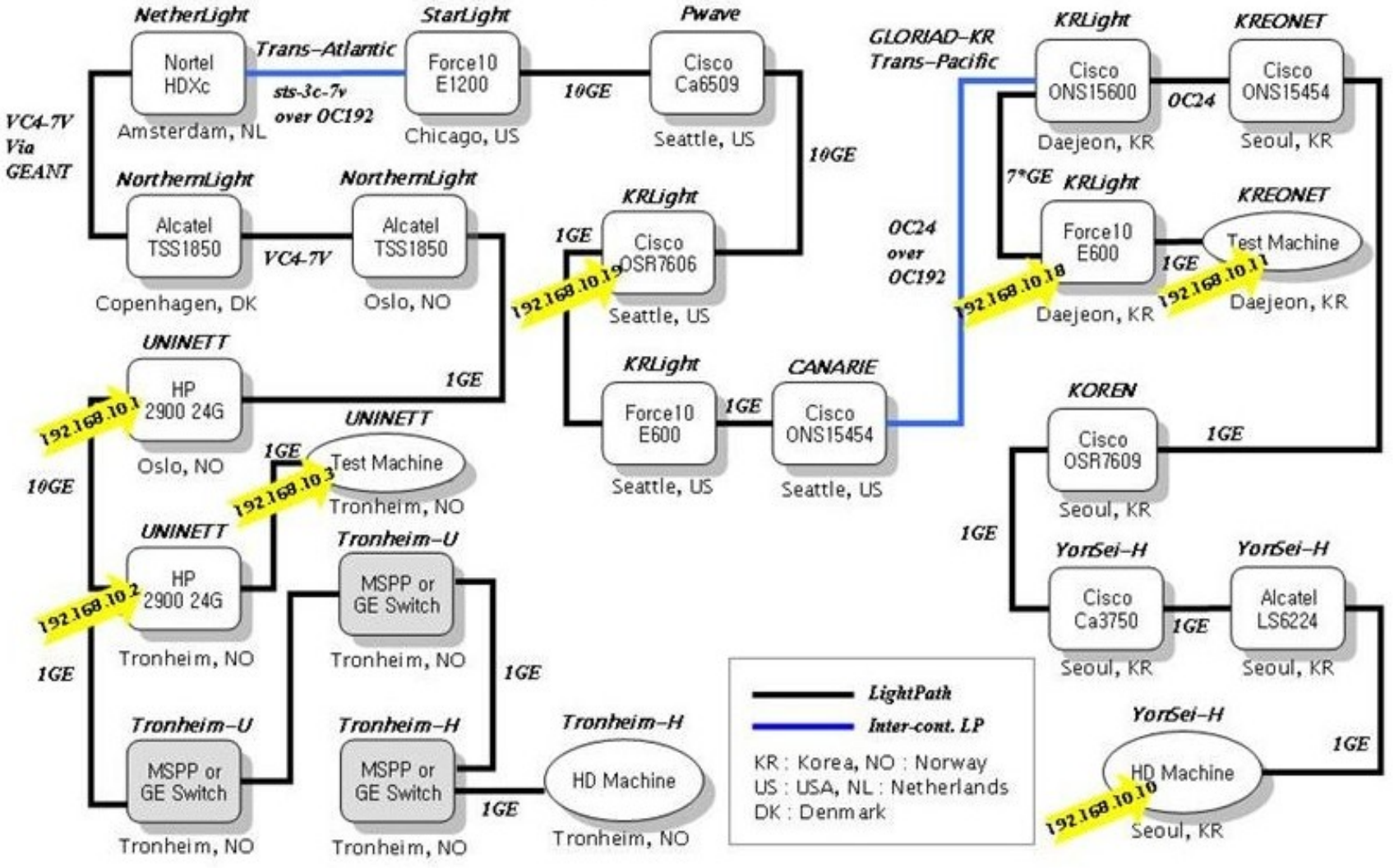
2nd Generation Hybrid (2007)

- Services
  - 10G shared IP
  - 10G full wave service
  - Subrate 10G SONET / SDH / Ethernet
- Design
  - Based on dark on dark fibre
  - OC192 to NetherLight, MoscowLight
  - DWDM – wave blocker, 10 G waves
  - Deploys SONET / SDH / Ethernet switching capability, GMPLS control plane interface
  - IP service on top of DWDM service

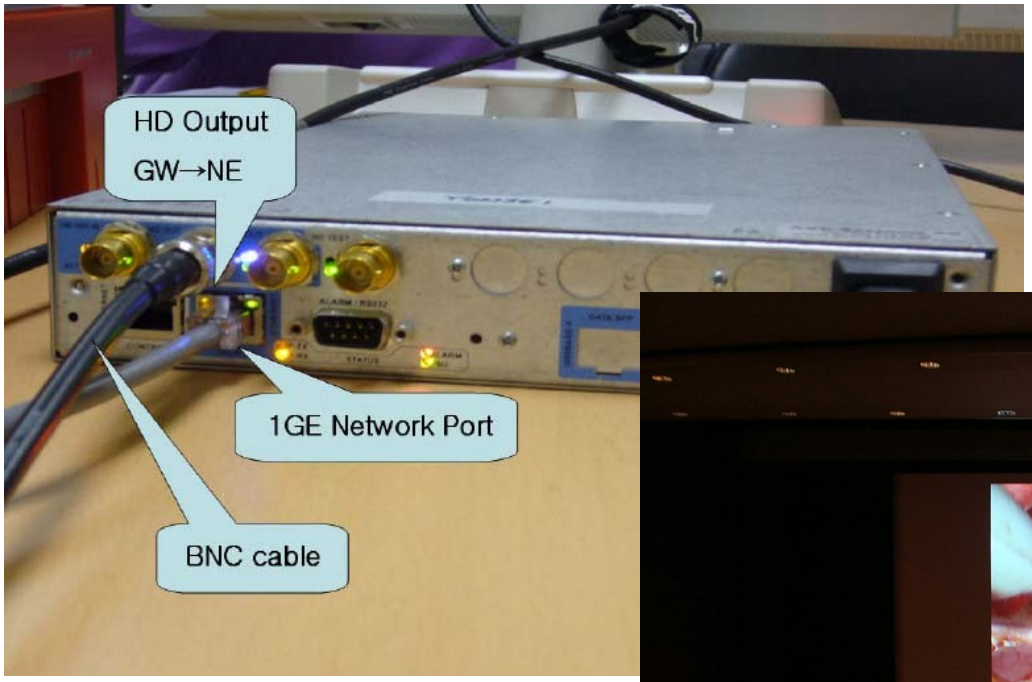
Korea – Norway Medical

- Medical Media HD Live Transmission
  - From Seoul, Korea to Trondheim, Norway
  - Test technologies for HD live medical surgery transmission
  - Viewing laparoscopy surgery in High Definition Video enable doctors to collaborate, learn, and see details normally not available
- Video Streaming
  - 800 Mbps, low jitter required
  - Dedicated 1 GE link Norway – Korea provide by collaboration in GLIF & GLORIAD

The Network


NetherLight
Nortel HDXc
Amsterdam, NL
Trans-Atlantic
sts-3c-7v over OC192
StarLight
Force10 E1200
Chicago, US
Pwave
Cisco Ca6509
Seattle, US
10GE
VC4-7V Via GEANT
NorthernLight
Alcatel TSS1850
Copenhagen, DK
VC4-7V
NorthernLight
Alcatel TSS1850
Oslo, NO
KRLight
Cisco OSR7606
Seattle, US
1GE
192.168.10.19
UNINETT
HP 2900 24G
Oslo, NO
192.168.10.1
1GE
10GE
UNINETT
Test Machine
Tronheim, NO
192.168.10.3
UNINETT
HP 2900 24G
Tronheim, NO
192.168.10.2
1GE
Tronheim-U
MSPP or GE Switch
Tronheim, NO
1GE
Tronheim-U
MSPP or GE Switch
Tronheim, NO
Tronheim-H
MSPP or GE Switch
Tronheim, NO
1GE
Tronheim-H
HD Machine
Tronheim, NO
KRLight
Force10 E600
Seattle, US
1GE
CANARIE
Cisco ONS15454
Seattle, US
GLORIAD-KR Trans-Pacific
OC24 over OC192
KRLight
Cisco ONS15600
Daejeon, KR
KREONET
Cisco ONS15454
Seoul, KR
OC24
7*GE
KRLight
Force10 E600
Daejeon, KR
192.168.10.18
KREONET
Test Machine
Daejeon, KR
1GE
192.168.10.11
KOREN
Cisco OSR7609
Seoul, KR
1GE
1GE
YonSei-H
Cisco Ca3750
Seoul, KR
1GE
YonSei-H
Alcatel LS6224
Seoul, KR
YonSei-H
HD Machine
Seoul, KR
192.168.10.10
1GE
LightPath
Inter-cont. LP
KR : Korea, NO : Norway
US : USA, NL : Netherlands
DK : Denmark

The Results



- http://wiki.krlight.net/medicalHD-pilot/doku.php

3rd Generation Hybrid (2008)

- Services
  - 10G / 40G shared IP
  - 10G, 40G full wave service (100G coming)
  - Subrate 10G SONET / SDH / Ethernet
- Design ...as 2nd generation, but:
  - DWDM Wavelength Selector Switches
  - 96 channels, 10/40/100G waves
  - Mix of OC192 and Cross Broder Fiber for international links
  - towards TMPLS based control plane interface
  - towards non-blocking distributed switching capability

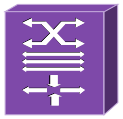
Suppliers

- Dark Fibre
  - **Telenor**
    - Scandinavian Ring
    - Finland Link
  - **Global Crossing**
    - Southern Cross

Dark Fiber G.652

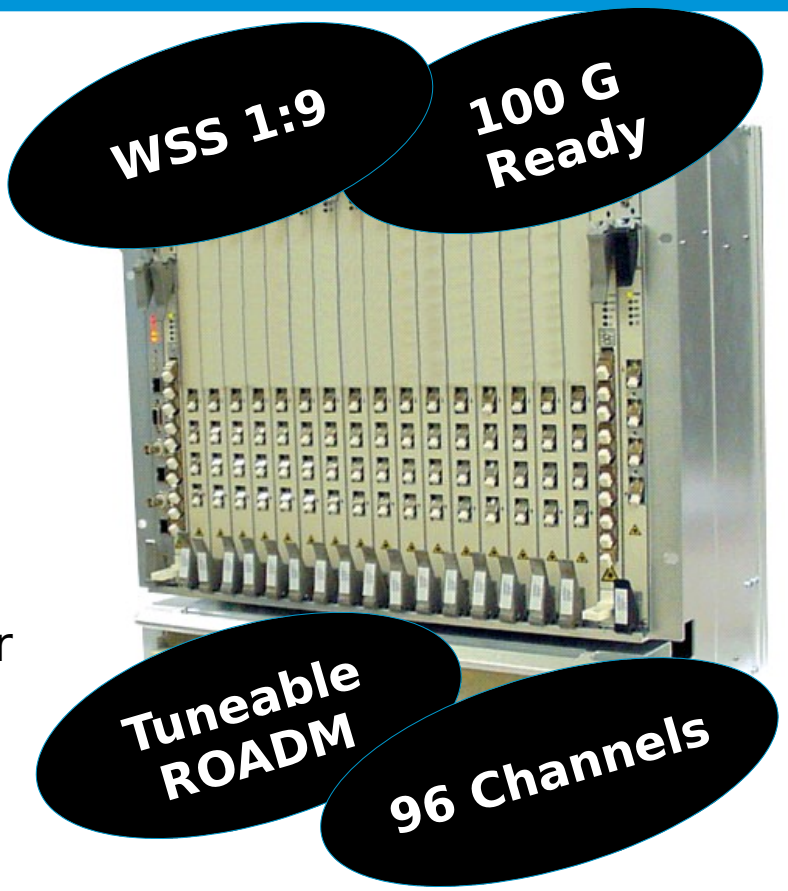
Dark Fiber G.655 TrueWave RS

- Equipment
  - **Alcatel-Lucent**
    - 1626 Light Manager
      - ULH DWDM
    - 1850 Transport Service Switch
      - SDH/Sonet/Ethernet
      - CWDM and SH DWDM
  - **Juniper**
    - T640



ALU 1626 Light Manager

- Wavelength Selector Switches
  - LH/ULH up to 96 channels
  - Add/Drop 72 channels
- Automatic system alignment
- Enhanced functionality
  - Tuneable filters
  - 50 GHz filters
- Long Haul:
  - Fully Tuneable ROADM
- Fully C band tuneable interfaces over any interface
  - 10 G Universal Transponder
    - STM-64
    - 10GE WAN & LAN
  - 40G transponder
    - PSBT (50 GHz - SH)
    - qDPSK (50 GHz – LH/ULH)
- Embedded Optical Protection
- Raman Amplification



- Same modules for OADM and ILA
  - Shelf
  - Amplifier

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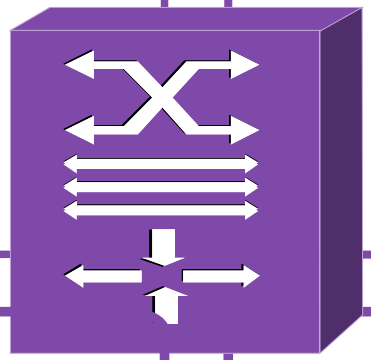
ALU 1850 TSS-320

SDH/SONET

- STM-1, 4, 16 & 64
- Cross-Connection
- Termination
- ETH Mapping over SDH
- Complete Scope of SDH/SONET Features

Ethernet

- 10GE LAN/WAN - Optical
- GE - Optical
- 10/100/1000 - Electrical
- ETH Traffic Classification
- Complete Scope of Ethernet Features



CWDM

- Terminal, Hub, OADM Ring
- Stacked C-WDM Rings

MSPP

- CLI, SNMP and TL1
- 2008 GMPLS feature set

1850 TSS-320

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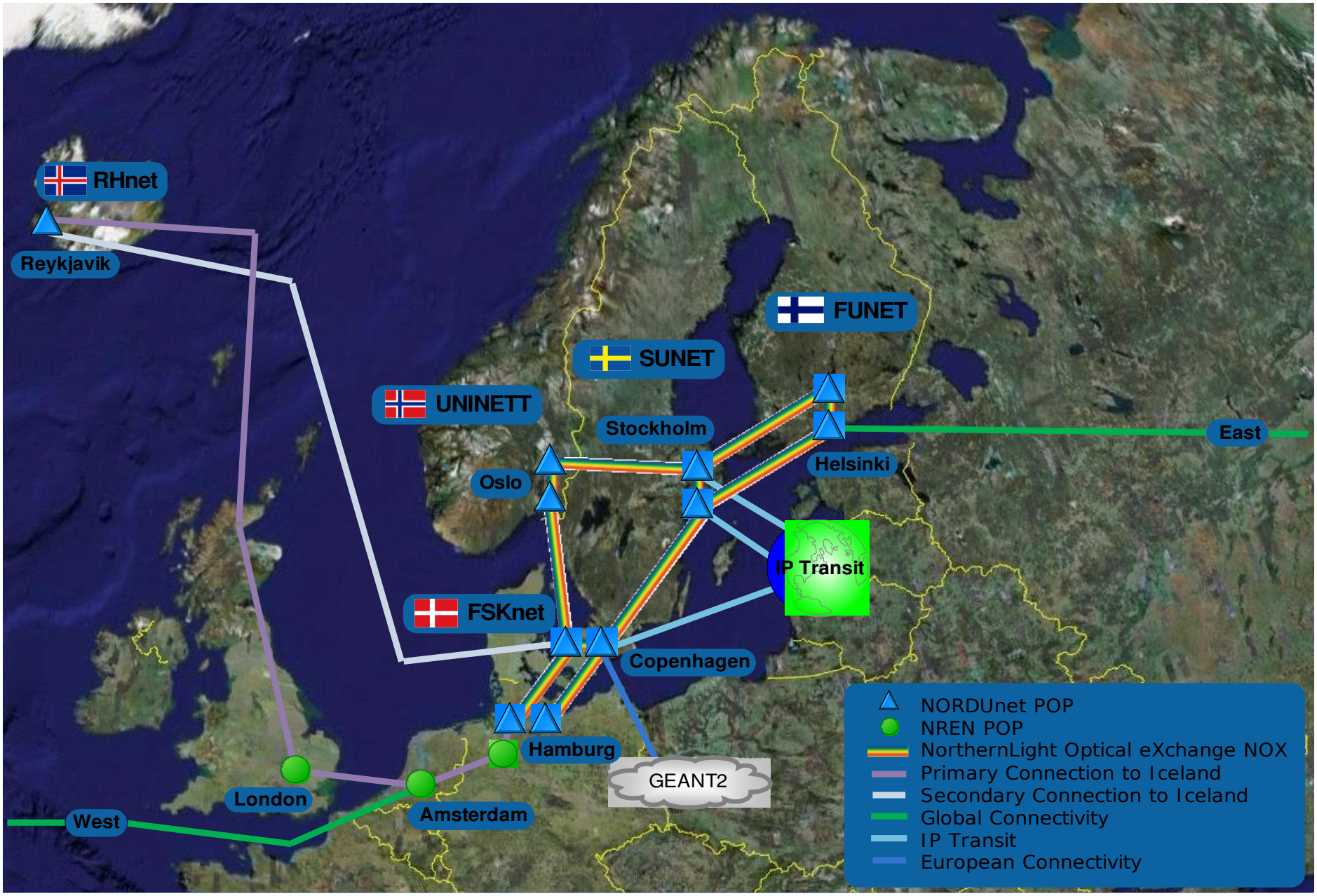
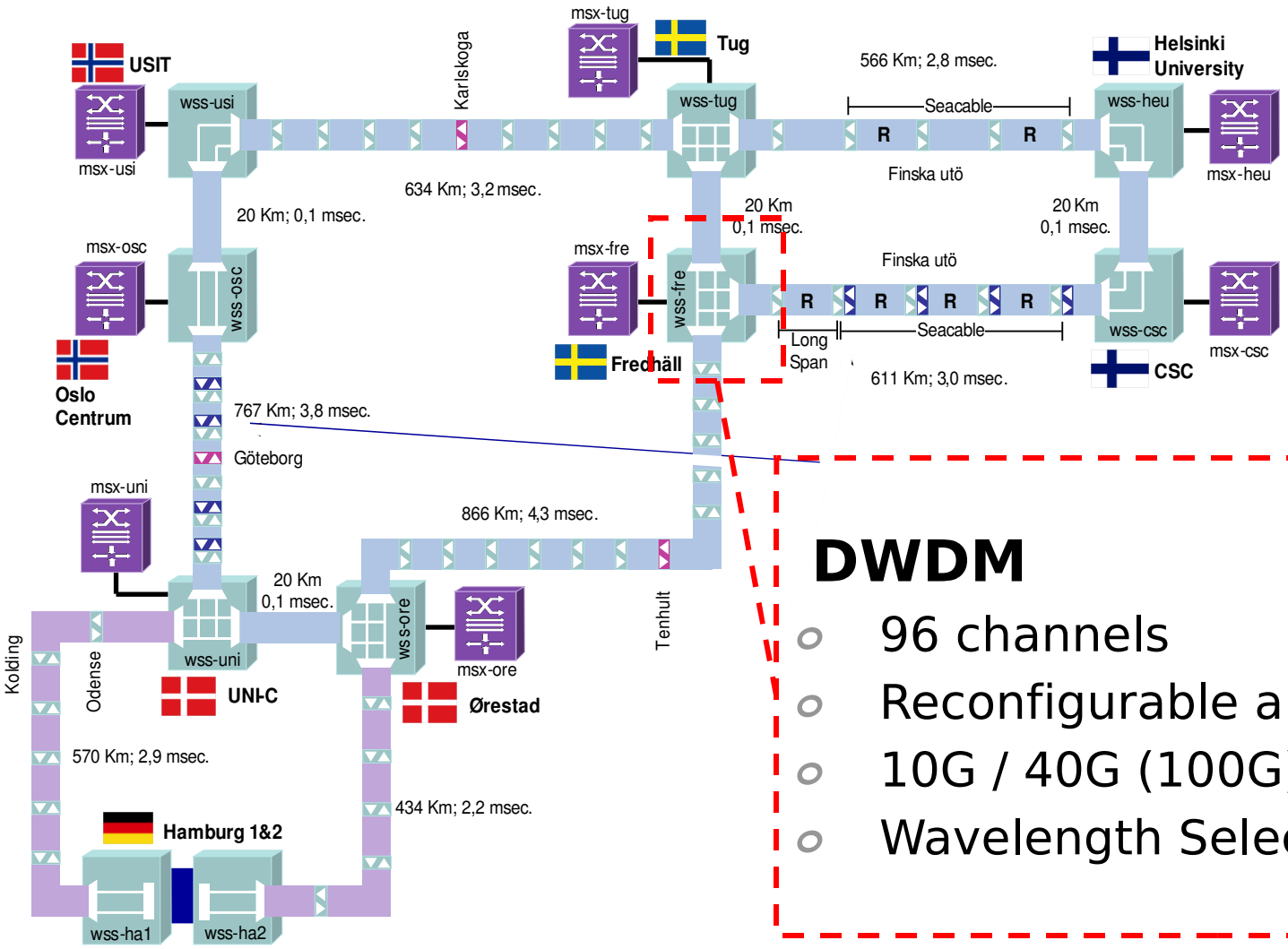
NorthernLight 2008



Optical Network



DWDM

- 96 channels
- Reconfigurable and tunable
- 10G / 40G (100G) waves
- Wavelength Selector Switch

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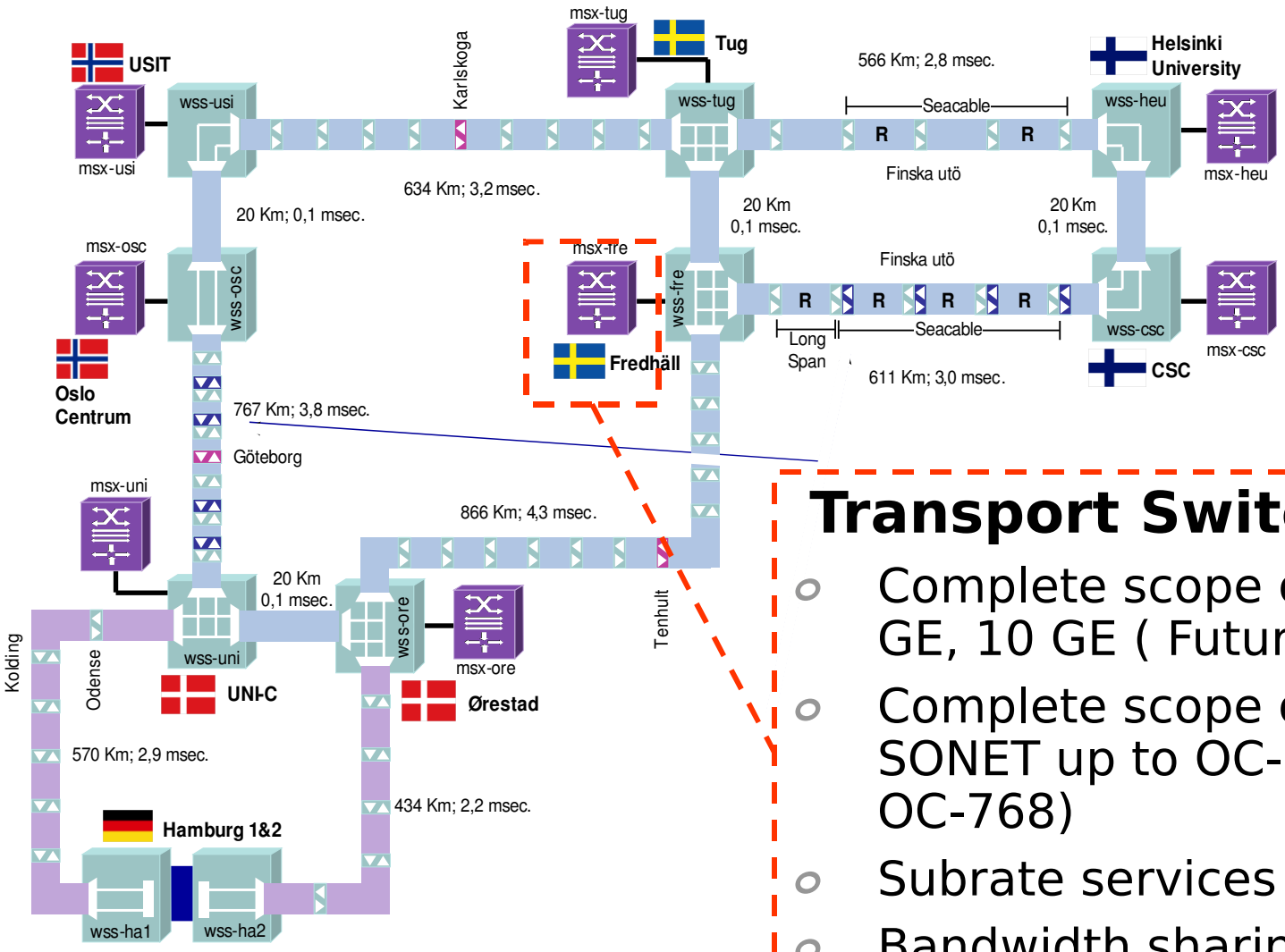
Distributed Switch Fabric



Transport Switching

- Complete scope of Ethernet 1 GE, 10 GE (Future 40 & 100G)
- Complete scope of SDH / SONET up to OC-192 (future OC-768)
- Subrate services
- Bandwidth sharing, dynamic capacity allocation

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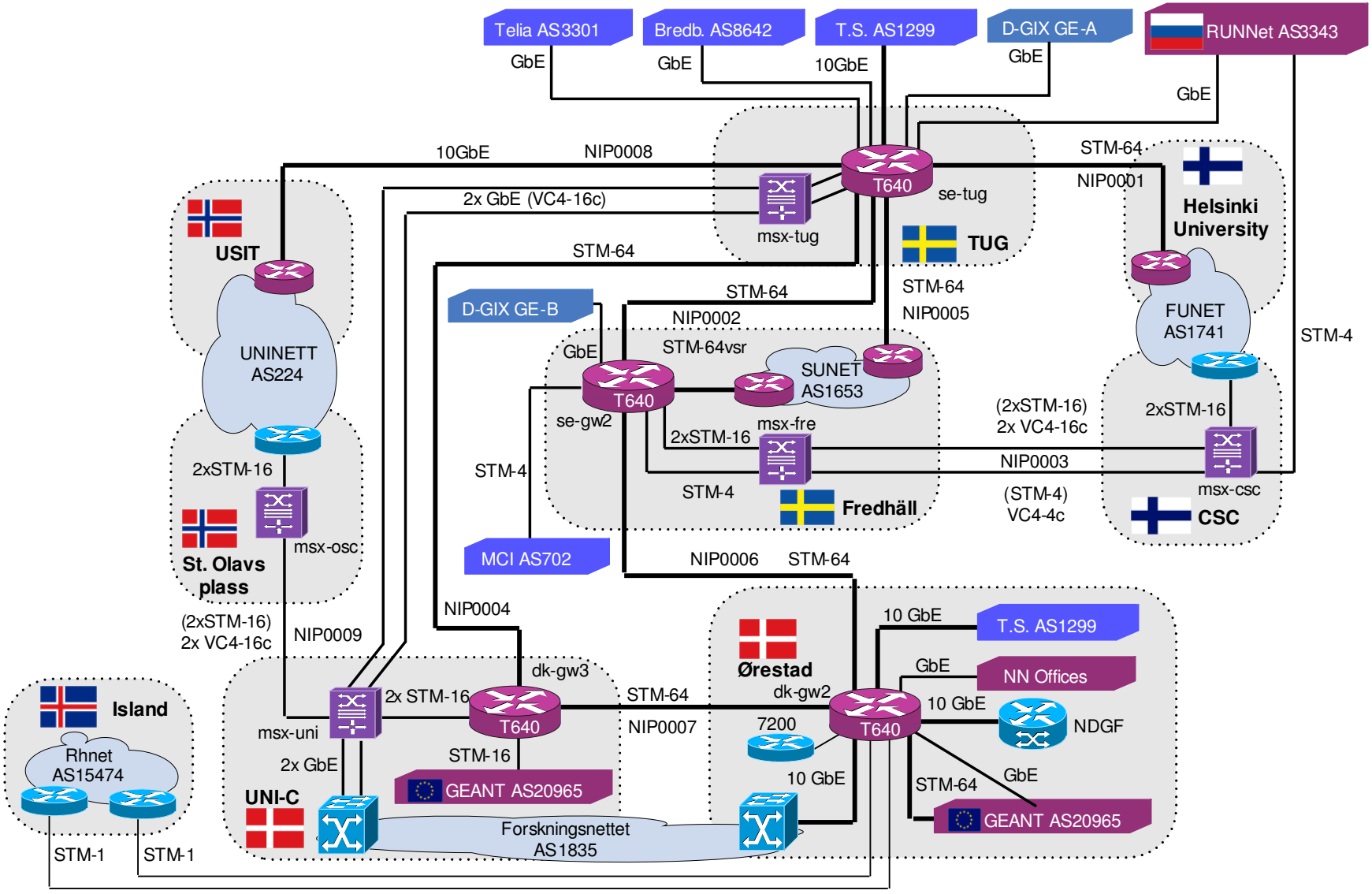
NORDUnet IP Network



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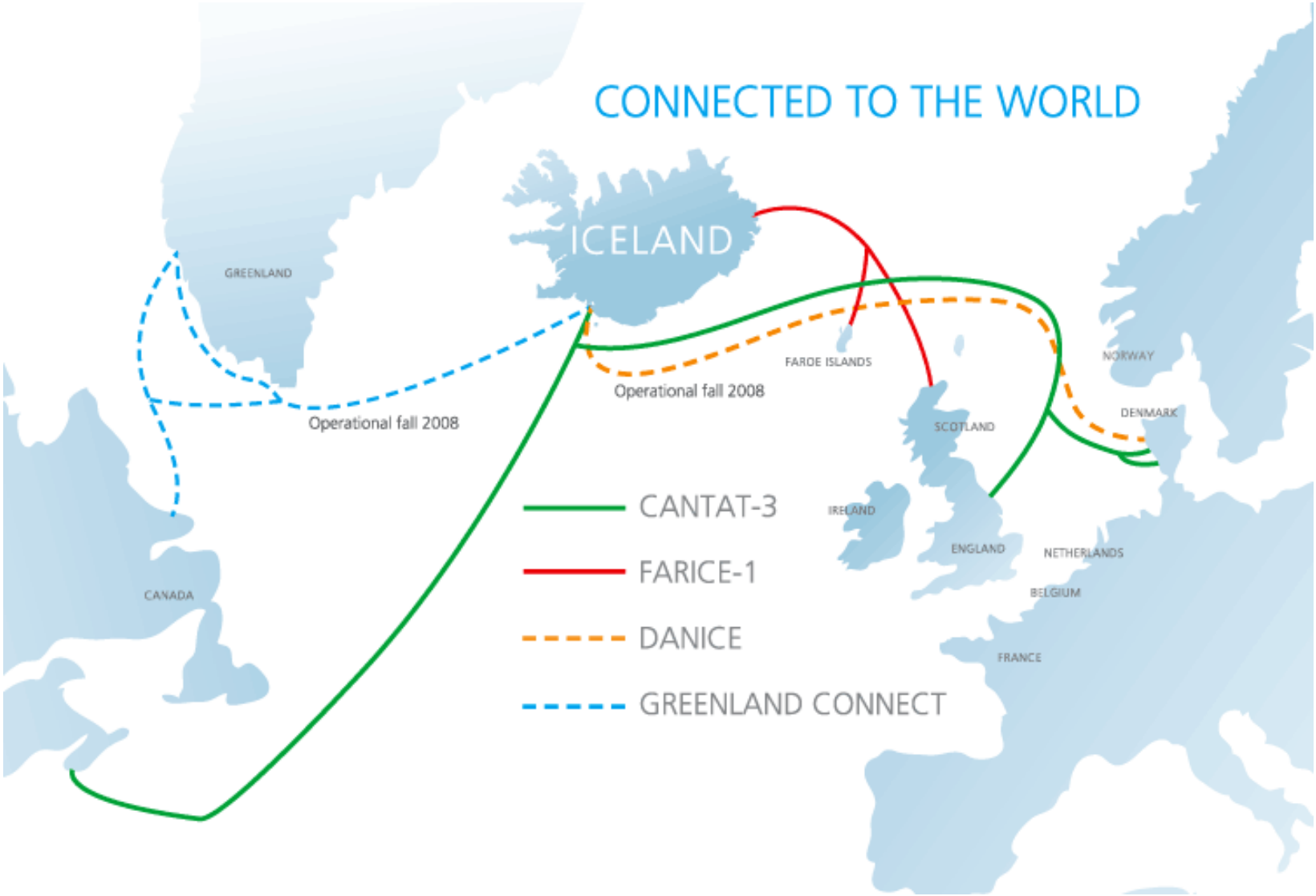
North-Atlantic Connectivity



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Nordic NREN Optical Networks

- Sweden: SUNET
  - Dark Fibre & DWDM acquired
  - Ligthpath service in operation
  - Ciena
- Denmark: Forskningsnet
  - Dark Fibre & DWDM acquired
  - Lightpath Service being deployed
  - AlcatelLucent
- Norway: UNINETT
  - Dark Fibre & DWDM acquired
  - Ligthpath service in operation
  - Siemens
- Finland: FUNET
  - Dark Fibre & DWDM acquired
  - Lightpath service being deployed
  - NokiaSiemens Networks
- Iceland: RHnet
  - Dark fibre network in Reykjavik area

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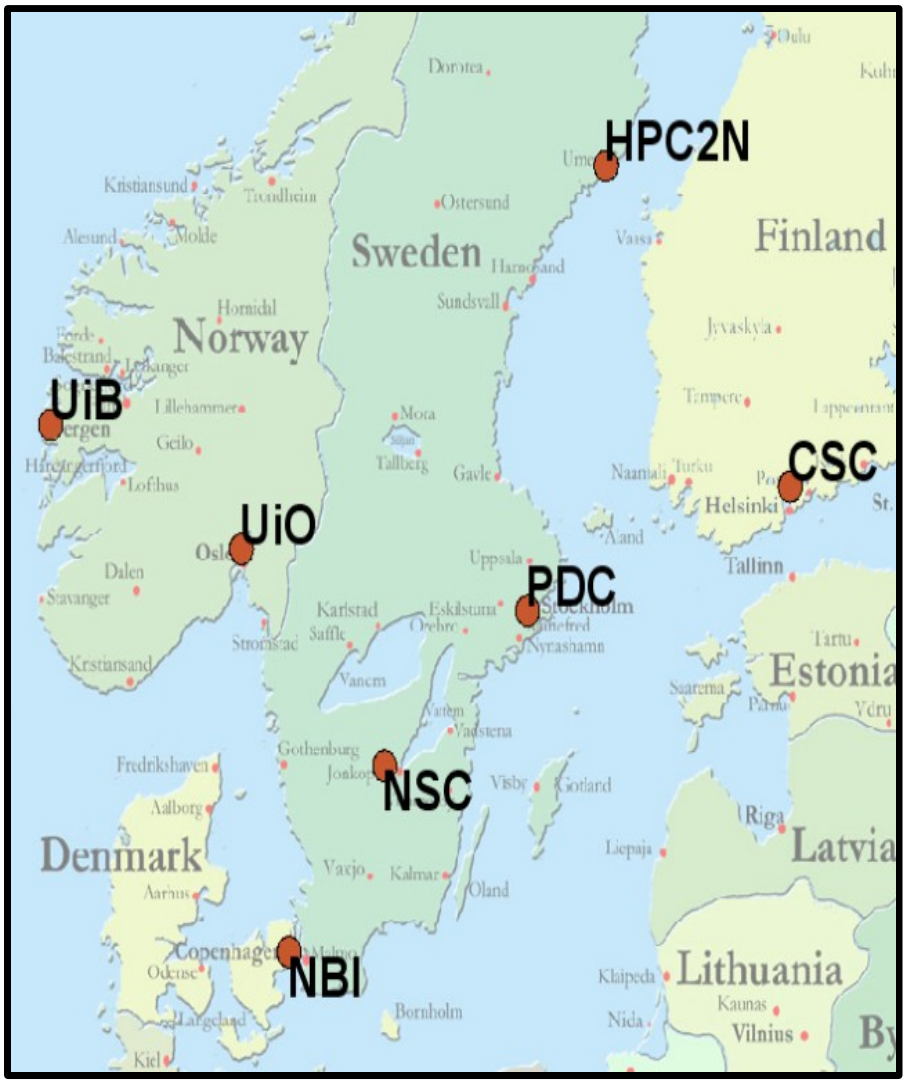
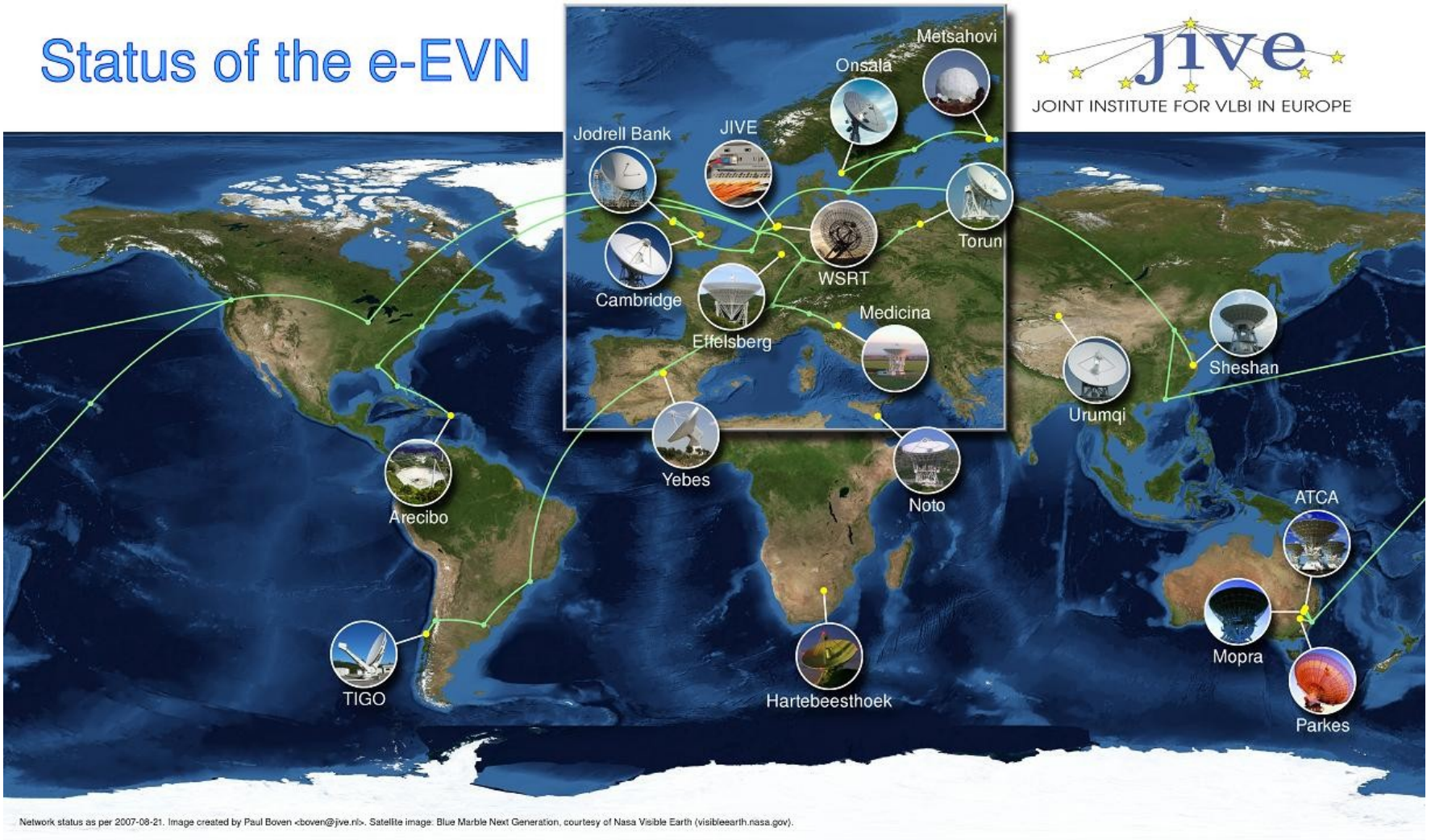
Nordic Tier-1 for LHC Grid

- A virtual HPC centre, made of resources from major Nordic HPC sites
- Resources (Storage and Computing) are scattered
- 10G Private Network + 10G connections to LHCOPN (CERN, Amsterdam, Ljubljana)



Astronomy: e-VLBI, LOFAR, ...



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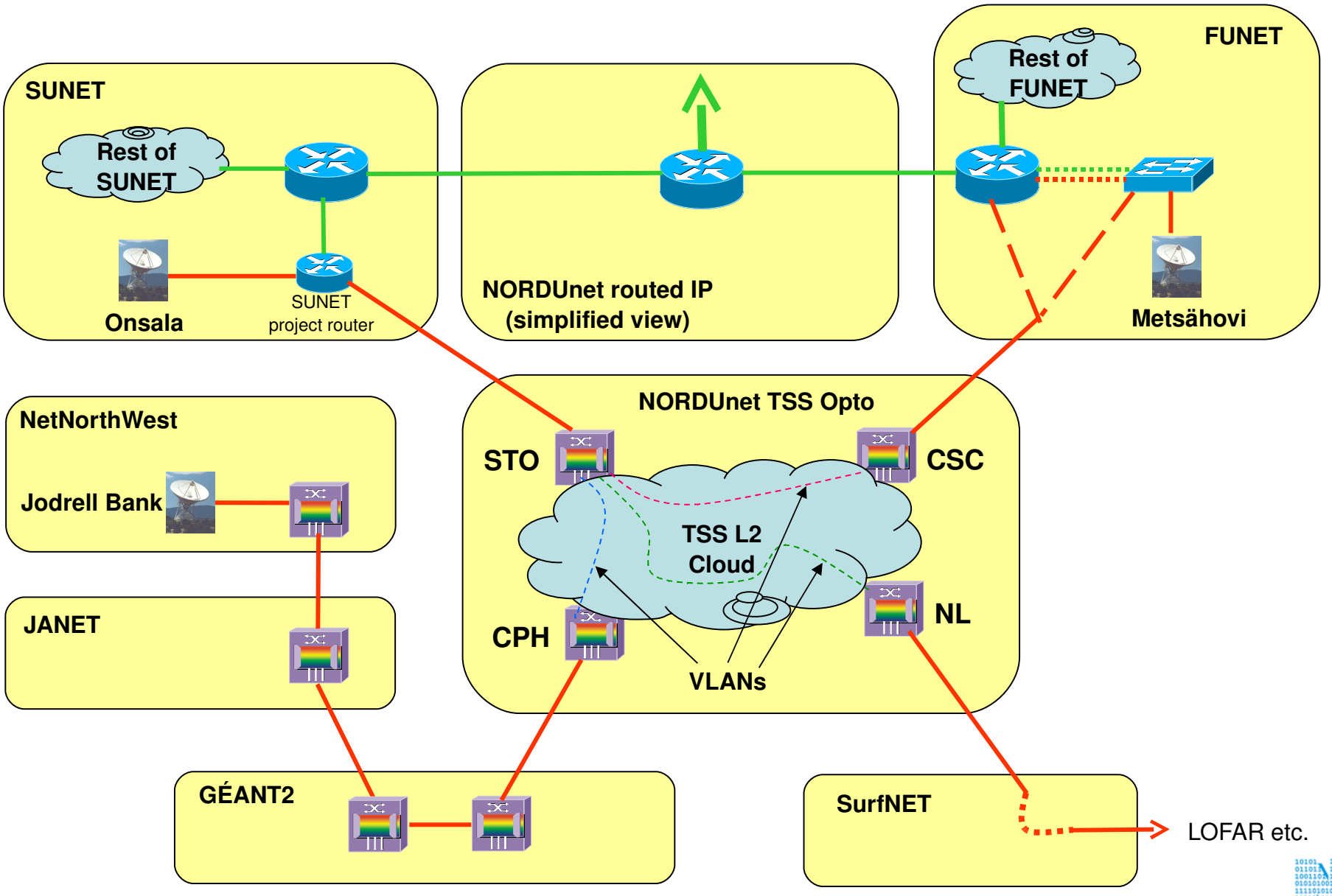
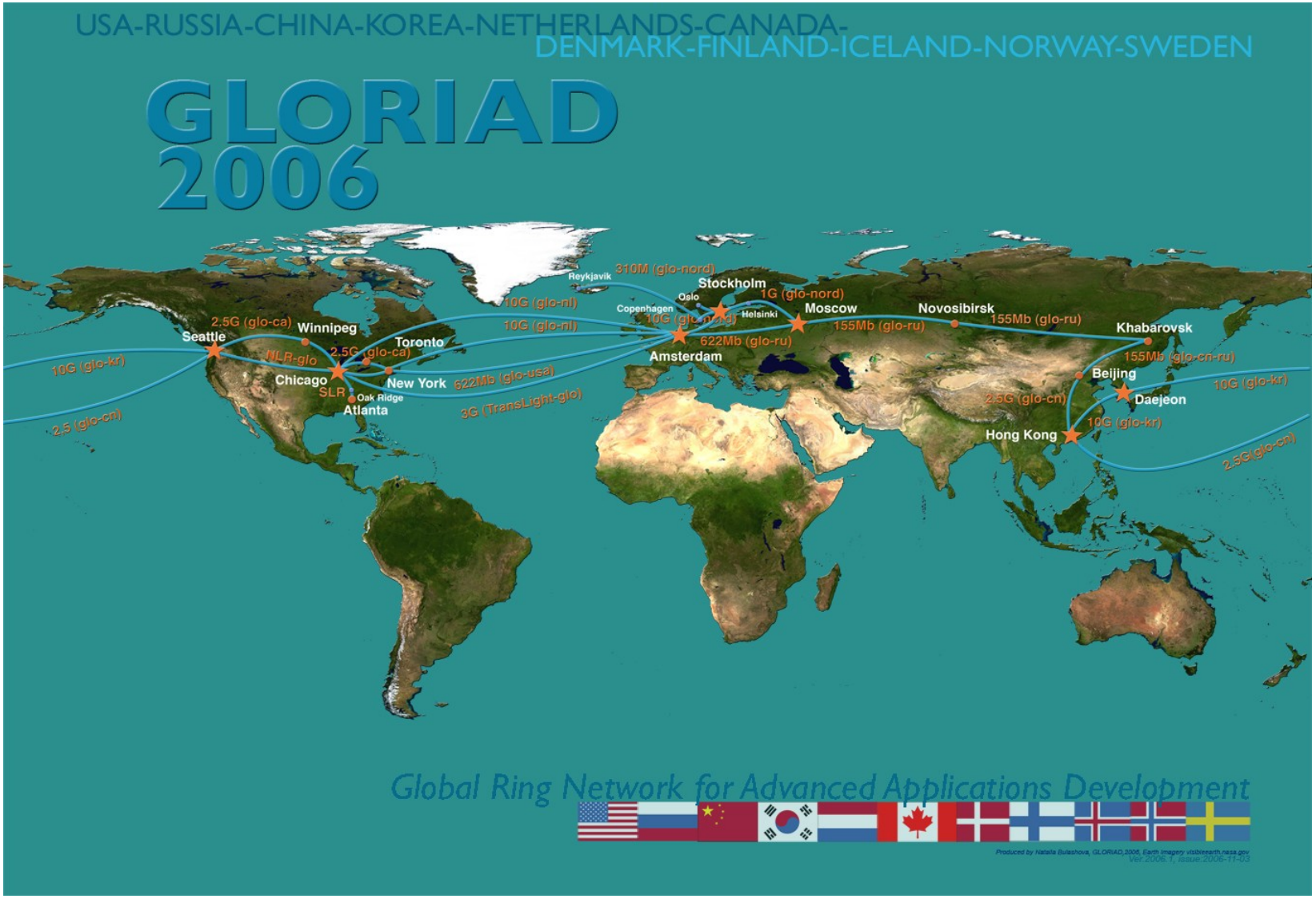
Nordic Astronomy OPN



Some Next Steps

- More connections, additional cross-border fibre
- Dynamic Circuit Networking
  - Nordic DCN solution – NORDUnet and Nordic NRENs Interoperable with major DCN approaches
  - NORDUnet will participate strongly in GN3, GLIF developments
  - Interoperability trials
- (Network) Virtualization
  - FEDERICA: European testbed for network and service virtualization
  - MANTICORE: Logical IP networks
- Transmission
  - Cross-border alien waves, multi-domain WSS
  - 40G, 100G trials

International partnerships



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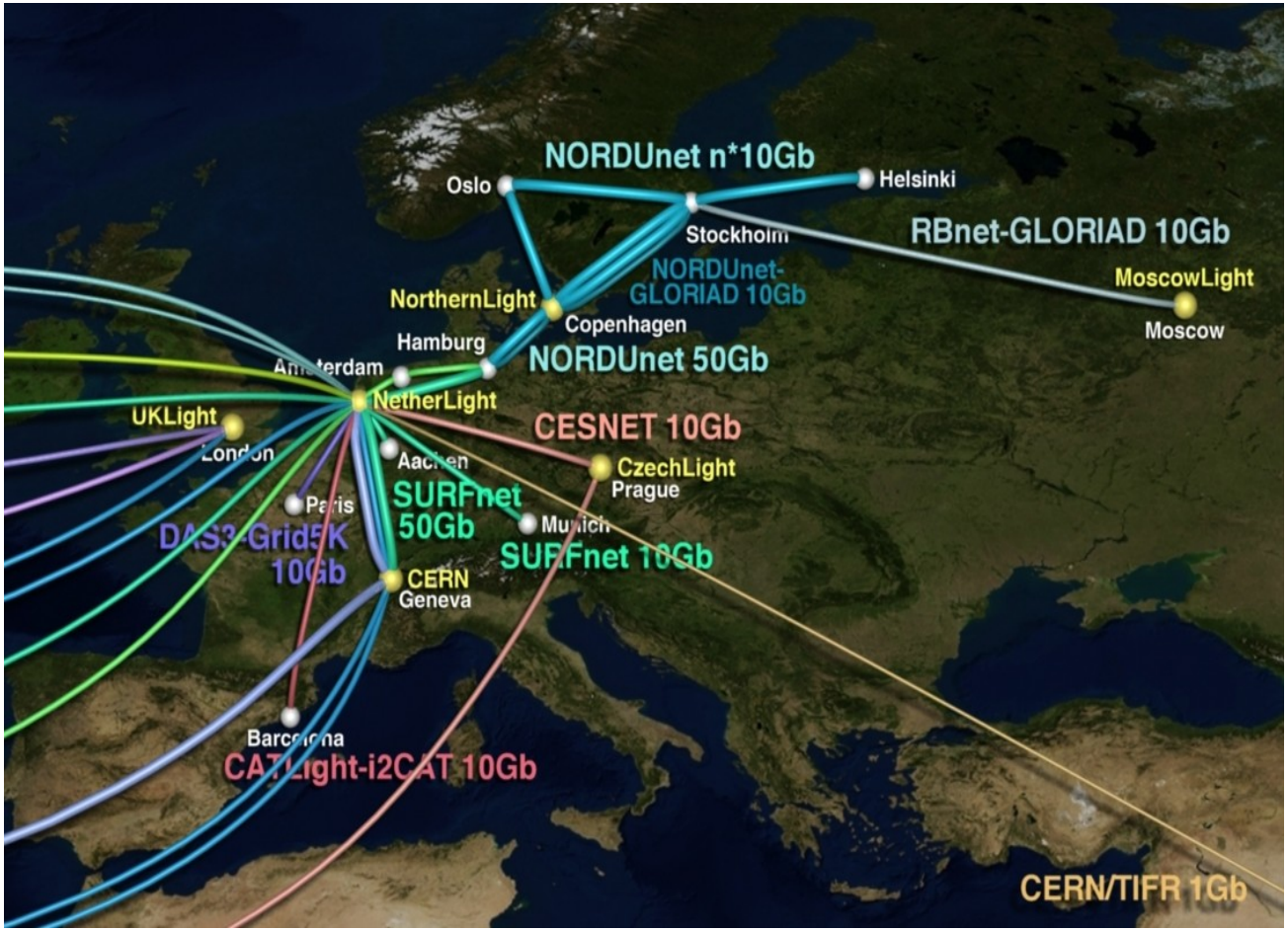
Thank you!



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