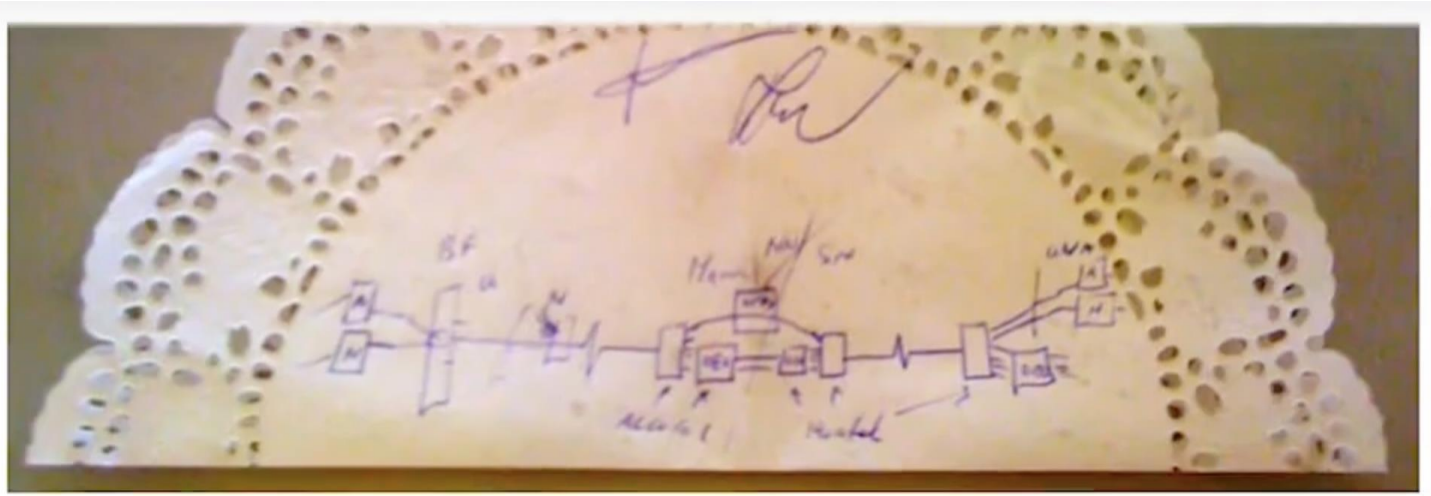
Spectrum sharing in the Nordic NREN's

DEVELOPMENT & EXPERIENCES

NORDUnet
Nordic Gateway for Research & Education

SIG-NGN April 2024 Rasmus Lund

THE IDEA

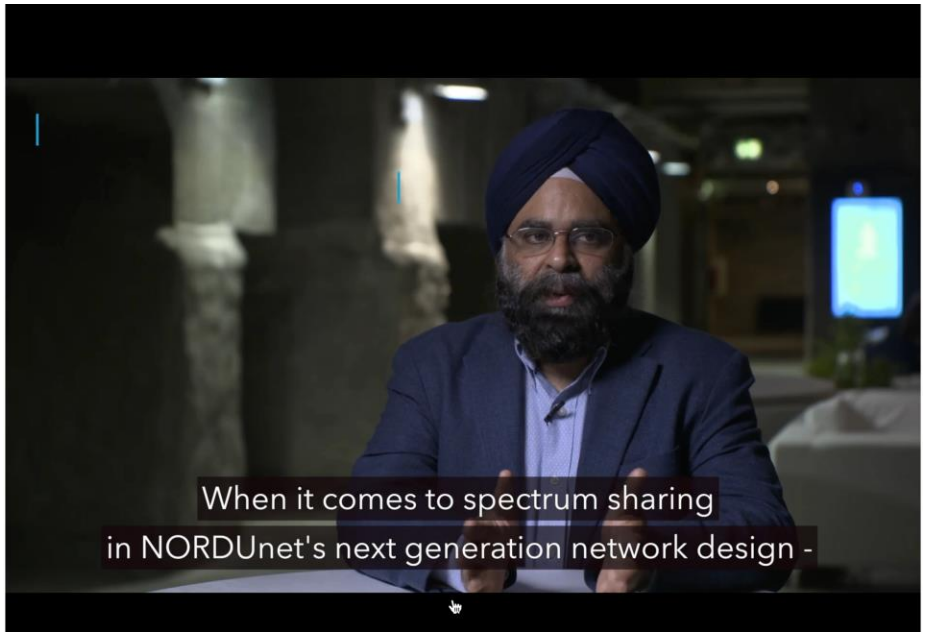


Captured On a Napkin

During one of the breaks of TNC2008, in Bruges, Belgium, cookies were served on paper napkins. After eating the cookies, four persons (attendees) decided to solve a major challenge, using the napkin.

They defined a way to engineer a foreign wavelength on an optical system, without being restrained by the usual control systems managing the optical system.

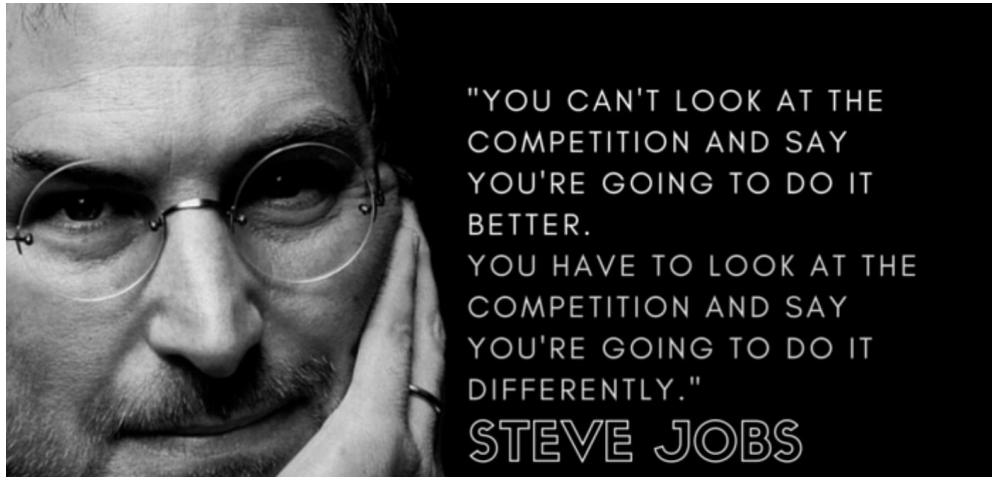
WHY?



COST IS SIGNIFICANTLY REDUCED

The Nordic NRENs and NORDUnet agreed upon an incremental cost sharing model for the new network, that allows everybody to save money.

According to this model, the Nordic NRENs provide NORDUnet with the needed spectrum in their respective country-wide optical networks. NORDUnet covers the cost of getting access to the spectrum, leaving the cost of housing equipment to be the only additional expense on the transmission layer.



2017 5NORDIC NRENS DECIDE NORDUNET NGN TO BE BUILD BY SPECTRUM SHARING?

RHnet

ICELAND

FIRST AND FOREMOST BY COLLABORATIVE EFFORT (4*50Ghz spectrum From all)

NORDUnet
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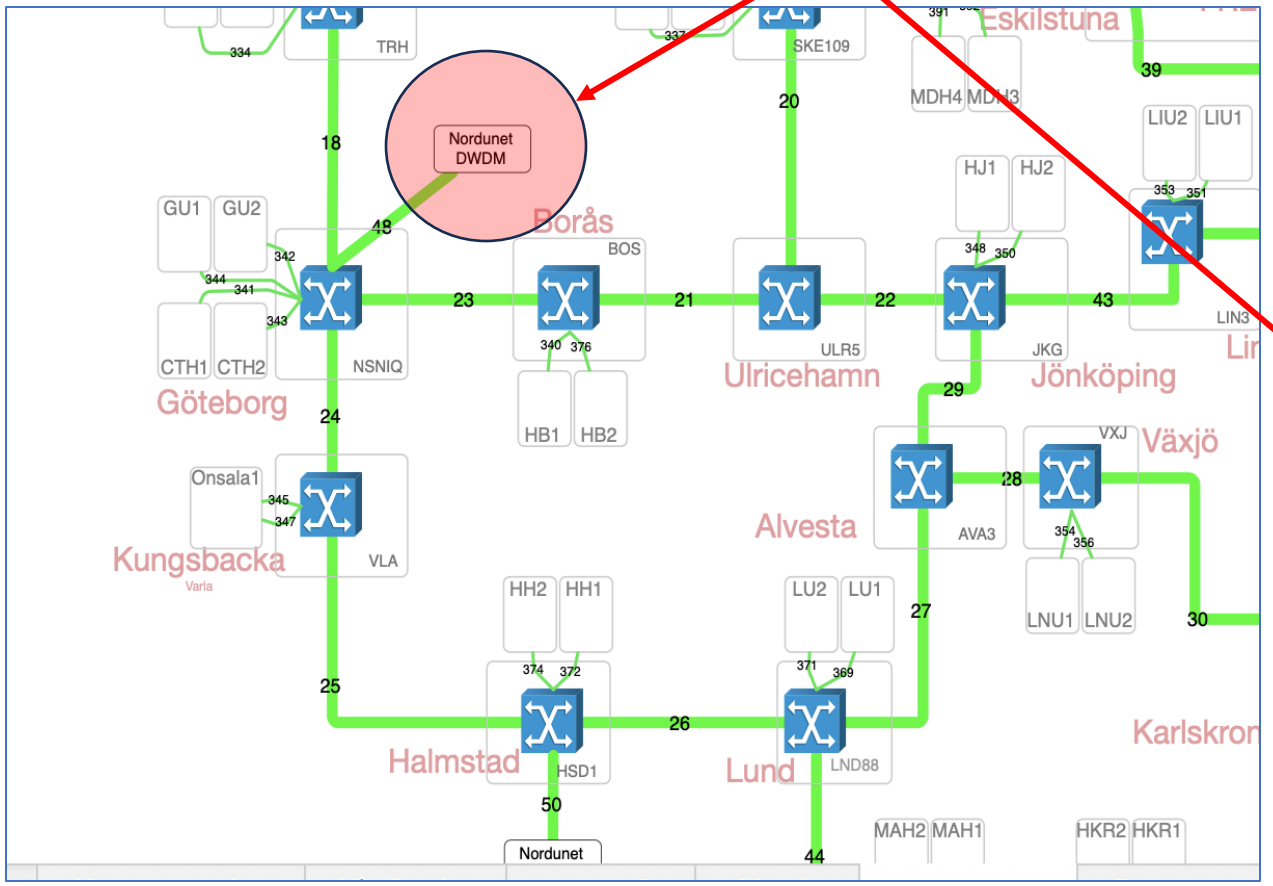
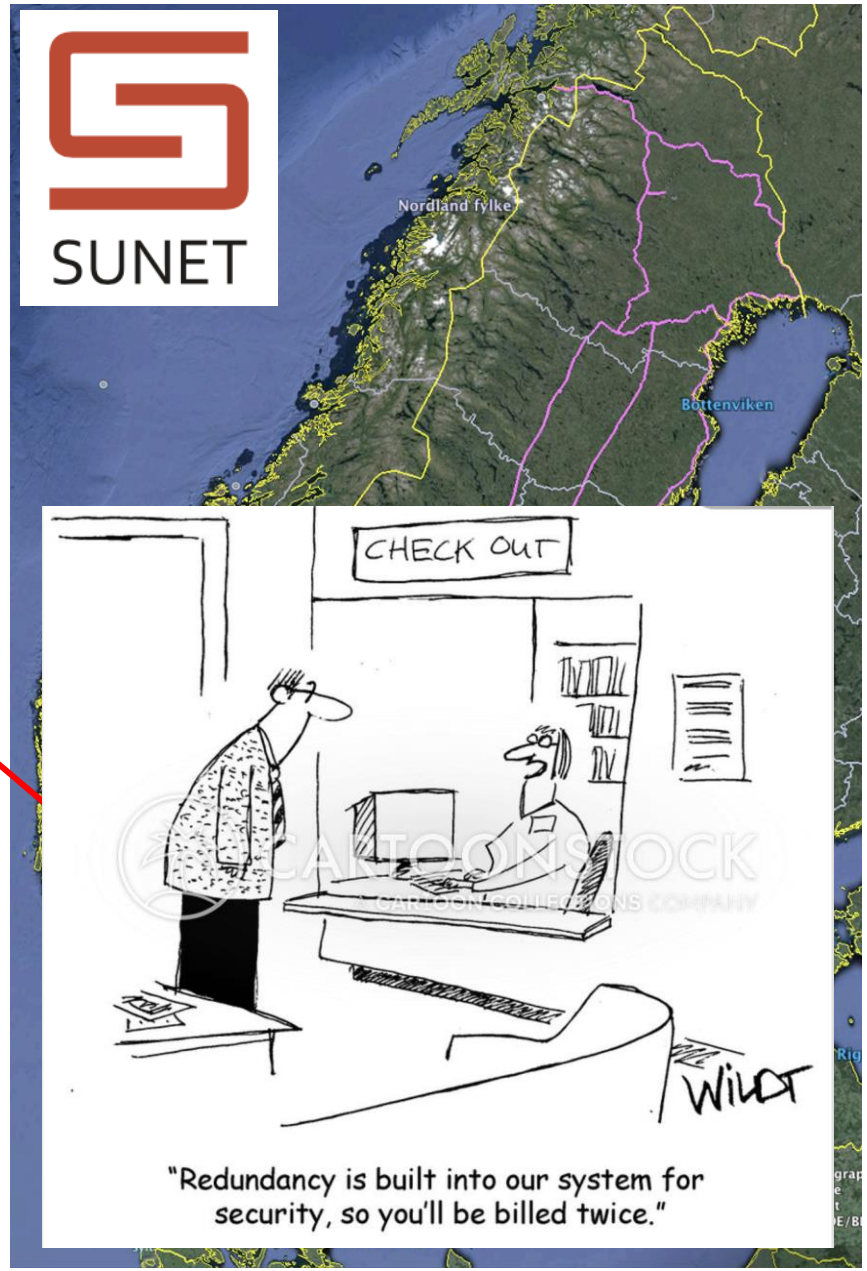
REDUNDANT OR ABUNDAND?

Shared infrastructure. (used same fiber ducts and conduits)



SUNET optical network .



HOW?

By building confidence from Test Results in live production network.

AND WITH THE USE OF ALIEN WAVES..

Alien wavelength

From Wikipedia, the free encyclopedia

This article **may be too technical for most readers to understand**. Please help improve it to make it understandable to non-experts, without removing the technical details. *(July 2020)* (*Learn how and when to remove this template message*)

In the context of wavelength-division multiplexing, an **alien wavelength** is a "colored" optical signal that is originated from equipment not under the direct control of the transmission network operator. This technique was first mentioned in 2009.[1]

Alien Wave transport involves transparent transmission of colored optical channels over pre-existing third-party physical infrastructure. In other words, Alien Wave transport implies an innovative spectrum utilization arrangement between an optical infrastructure owner and a bandwidth crippled customer. The fact that multiple providers co-exist and utilize the common fiber and optical layer infrastructure turns out to be a viable and cost-effective way to scale-up network capacity through minimal capital and operational investments.

A practical example of an Alien Wave implementation is one where network resources owned by one carrier are being utilized to transport optical channels that are in the control of a secondary carrier. The possibility of Alien Wave insertion without any impact to existing services has resulted in a rapid acceptance of this technology by the telecom service provider community.

References [edit]

1. ^ "FOM (Figure of Merit) for dark fiber links" (PDF). SURFnet, 5th Customer Empowered Fibre networks meeting, Prague. Retrieved 2009-05-15.

See also [edit]

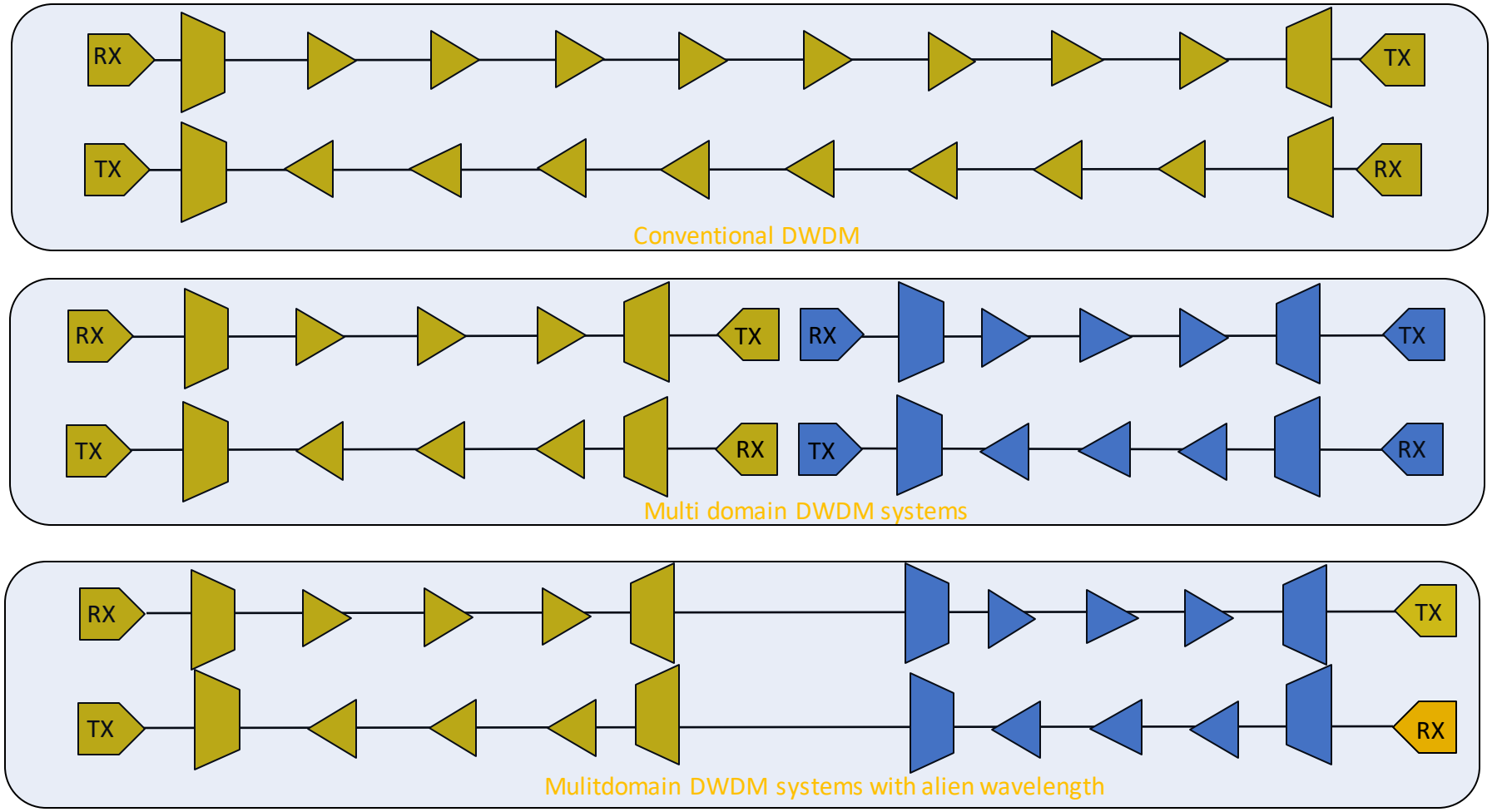
- Dark fiber

I. INTRODUCTION

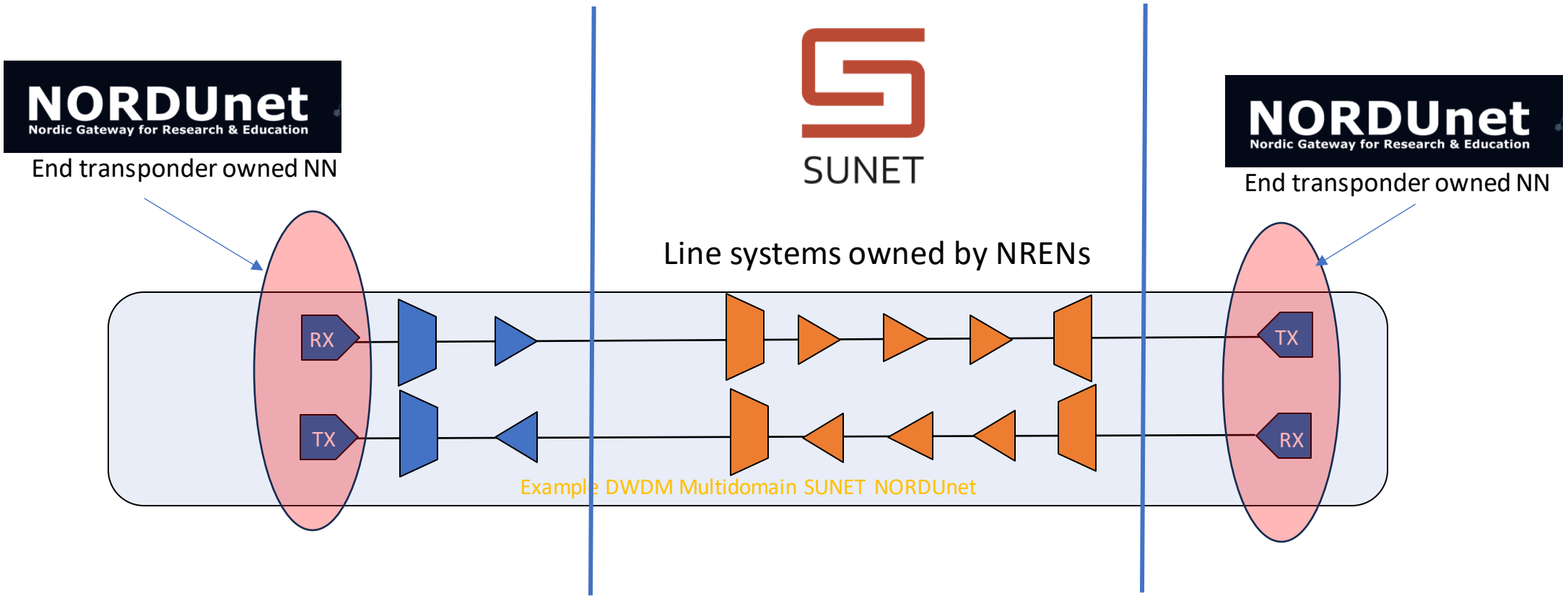
among NRENs, reducing CAPEX [3] (the need for electrical regeneration), and allowing transponders from several vendors to be deployed in the NREN infrastructure. The AW concept is being utilized both within single NREN envi-

HOW?

ALIEN WAVE CONCEPT



HOW?


NORDUnet
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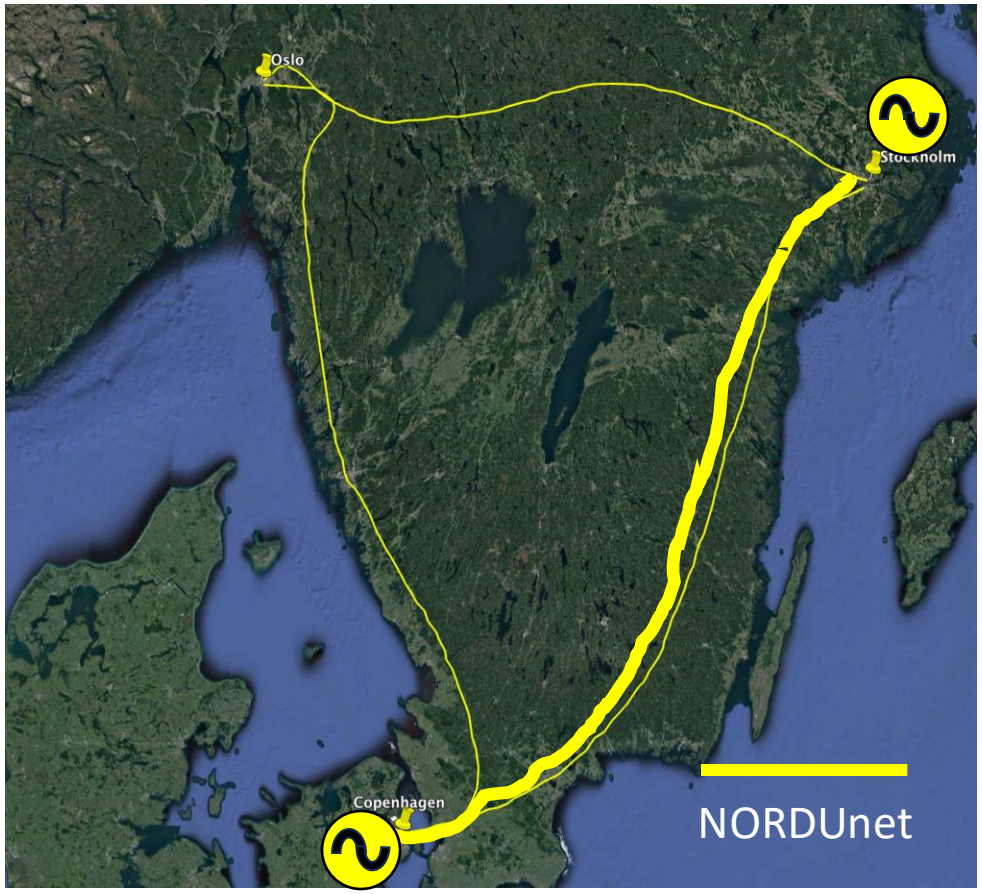
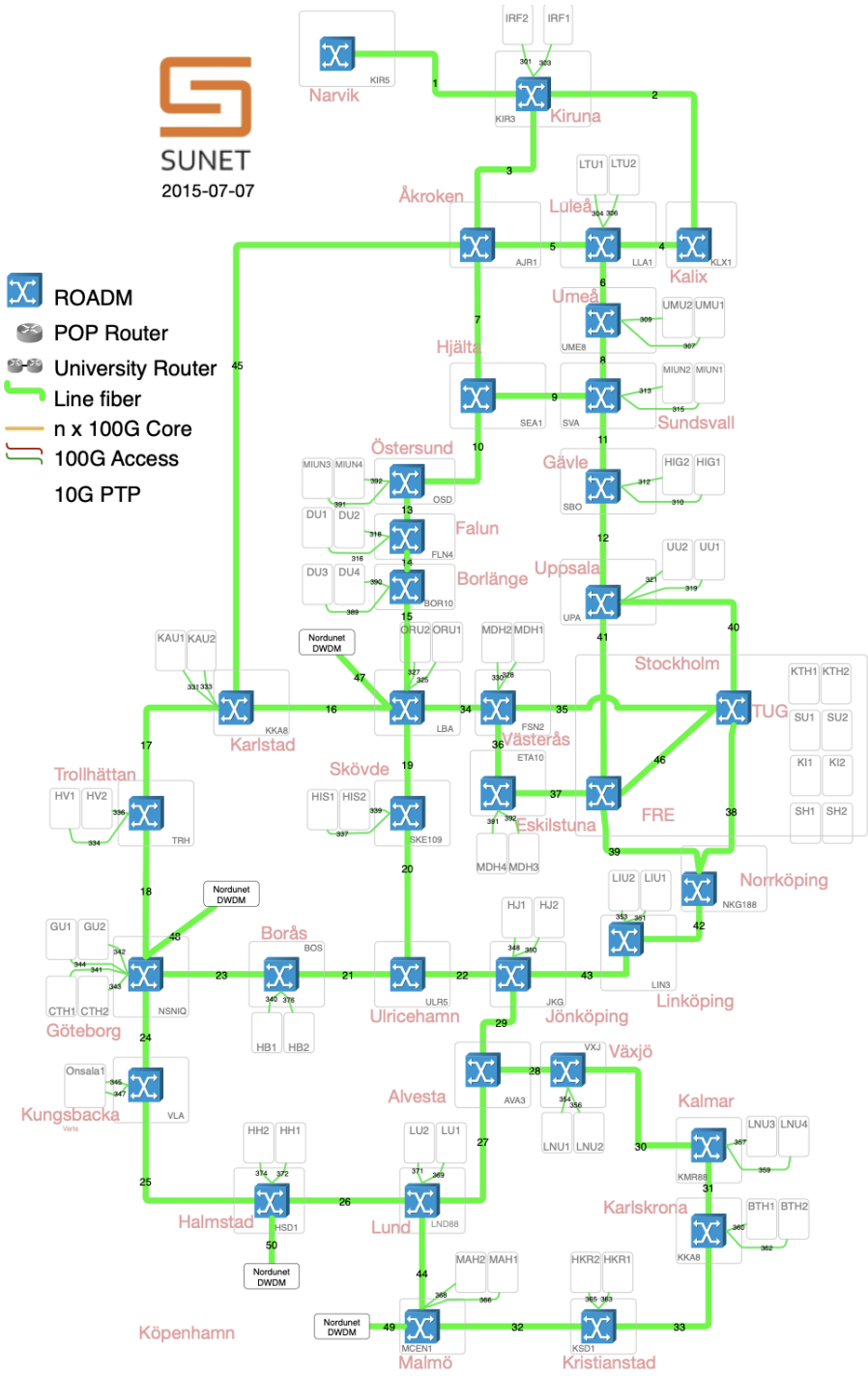
End transponder owned NN
SUNET
Line systems owned by NRENs
NORDUnet
Nordic Gateway for Research & Education
End transponder owned NN
RX
TX
TX
RX
Example DWDM Multidomain SUNET NORDUnet

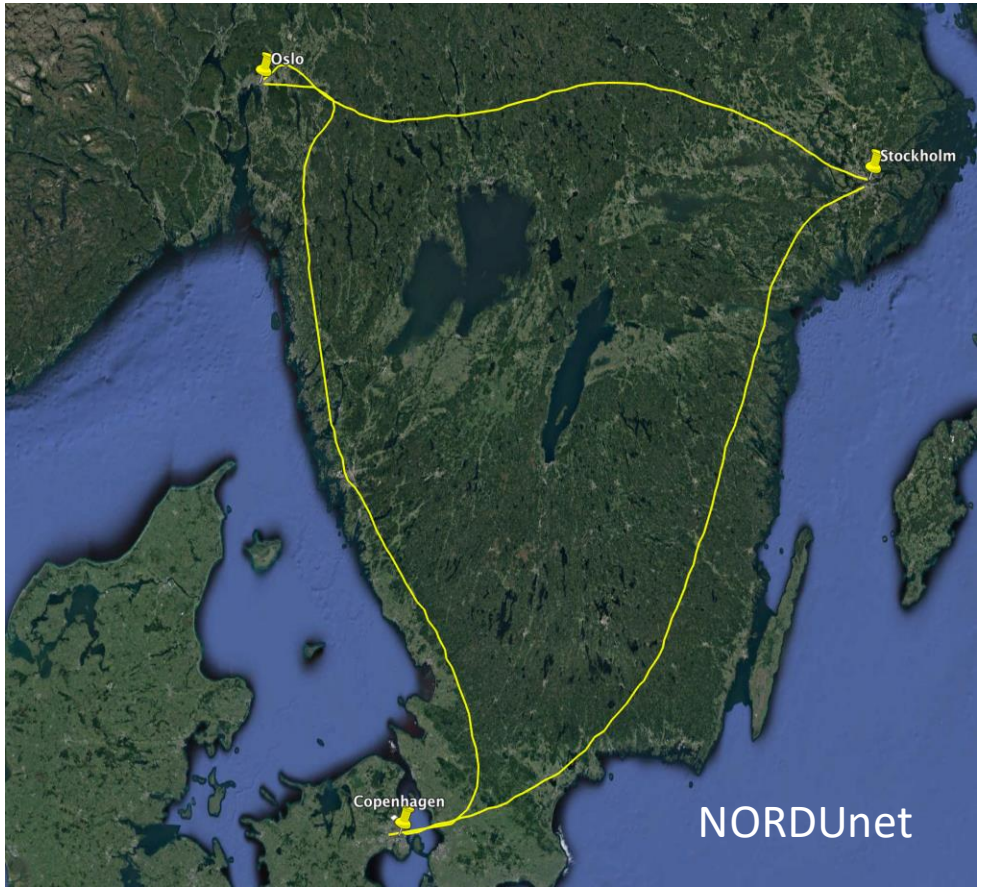
HOW? (EXAMPLE)

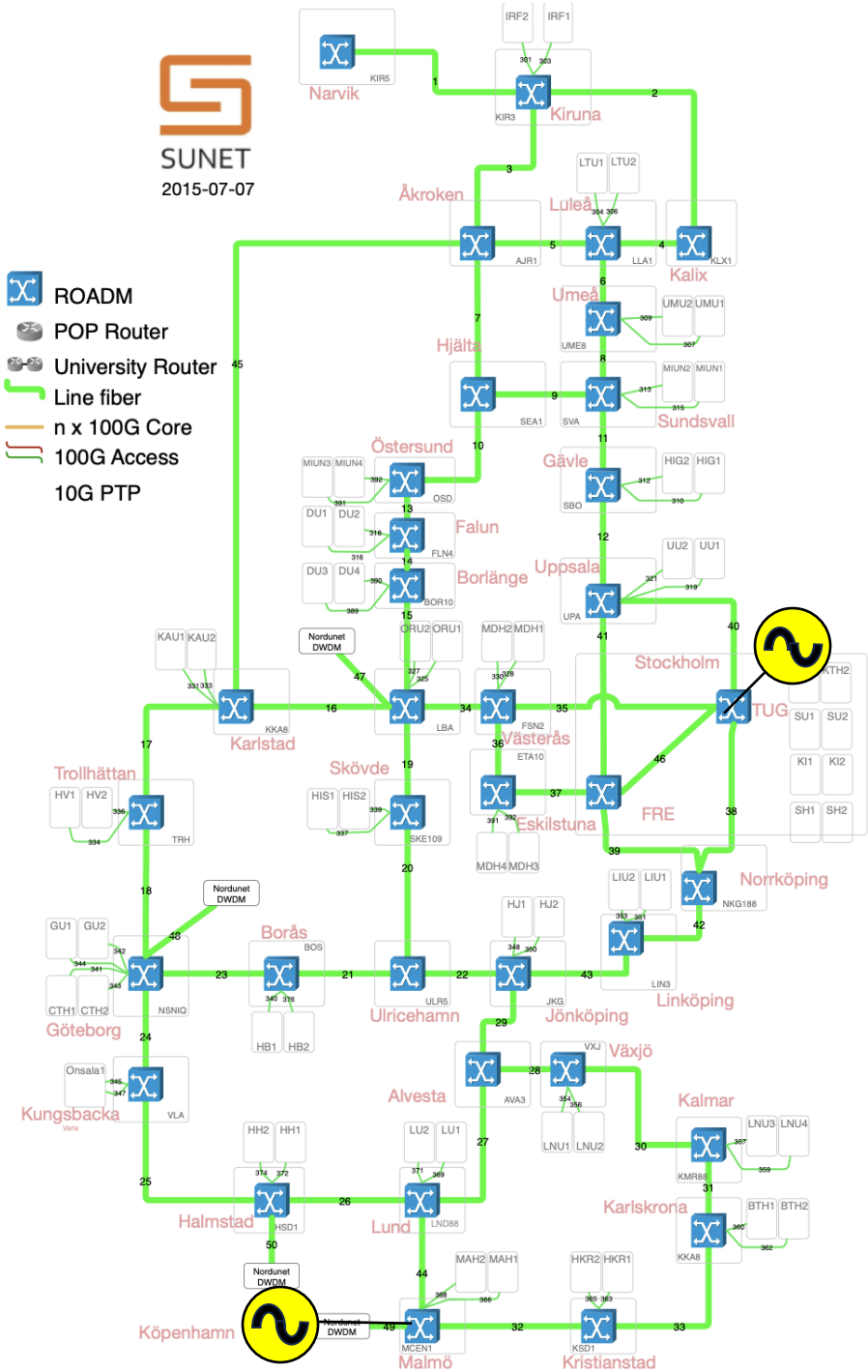


NN transponders /Modems



HOW? (EXAMPLE)


Oslo
Stockholm
Copenhagen
NORDUnet


SUNET
2015-07-07
ROADM
POP Router
University Router
Line fiber
n x 100G Core
100G Access
10G PTP
Narvik
Kiruna
Åkroken
Luleå
Kalix
Umeå
Hjälta
Sundsvall
Östersund
Gävle
Falun
Borlänge
Uppsala
Stockholm
TUG
Karlstad
Västerås
Trollhättan
Skövde
Eskilstuna
FRE
Norrköping
Borås
Linköping
Ulricehamn
Jönköping
Växjö
Göteborg
Alvesta
Kalmar
Kungsbacka
Halmstad
Lund
Karlskrona
Köpenhamn
Malmö
Kristianstad

TESTING & SIMULATION

HOW?

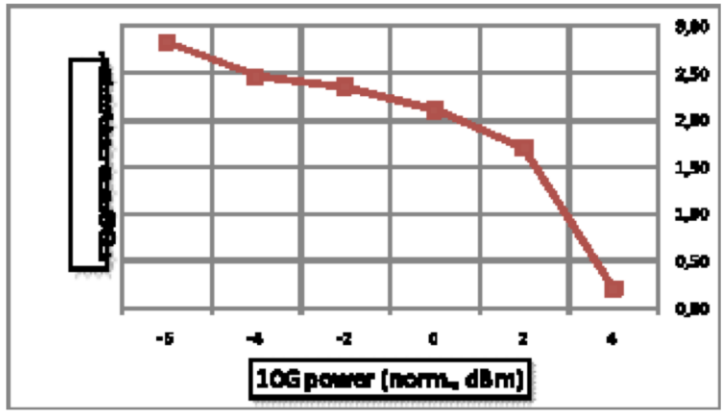


Figure 2. VPI simulation results showing how the 40Gb/s PM-QPSK signal quality changes with 10 Gb/s channel power.

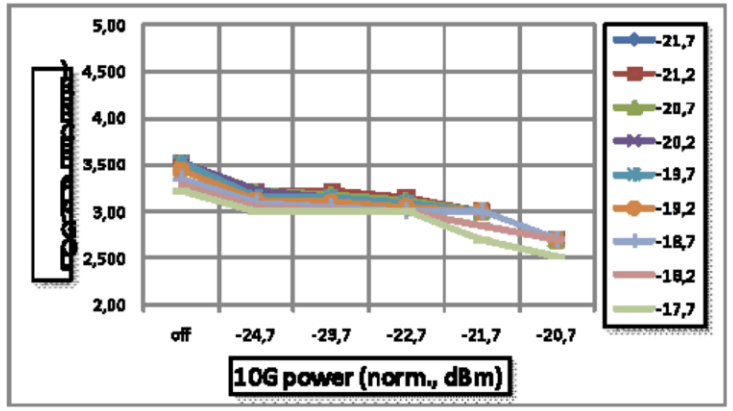


Figure 3. Experimental results showing how the 40Gb/s PM-QPSK signal quality changes when 10 Gb/s channel powers are varied.

VPI simulations

First 10GNRZ & 40GPM-QPSK trial Copenhagen Hamburg Amsterdam. (total 1056km)

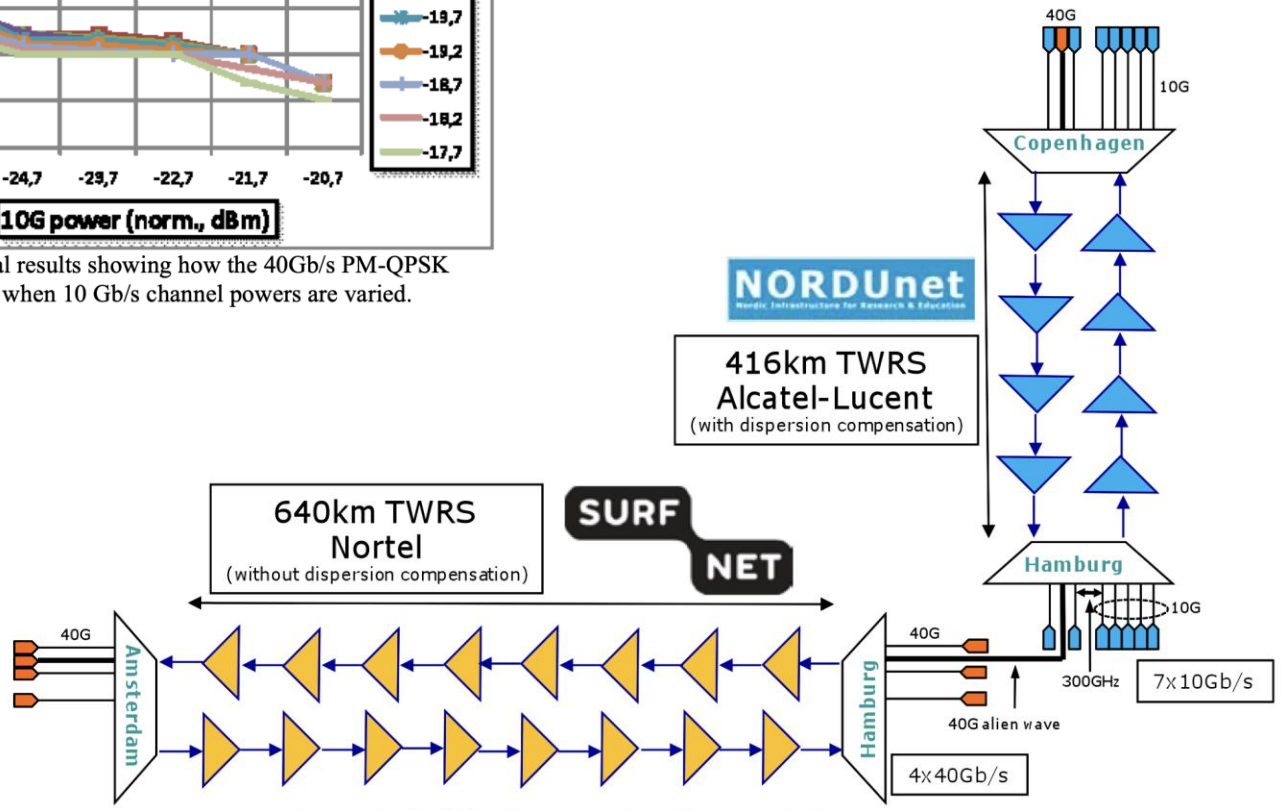
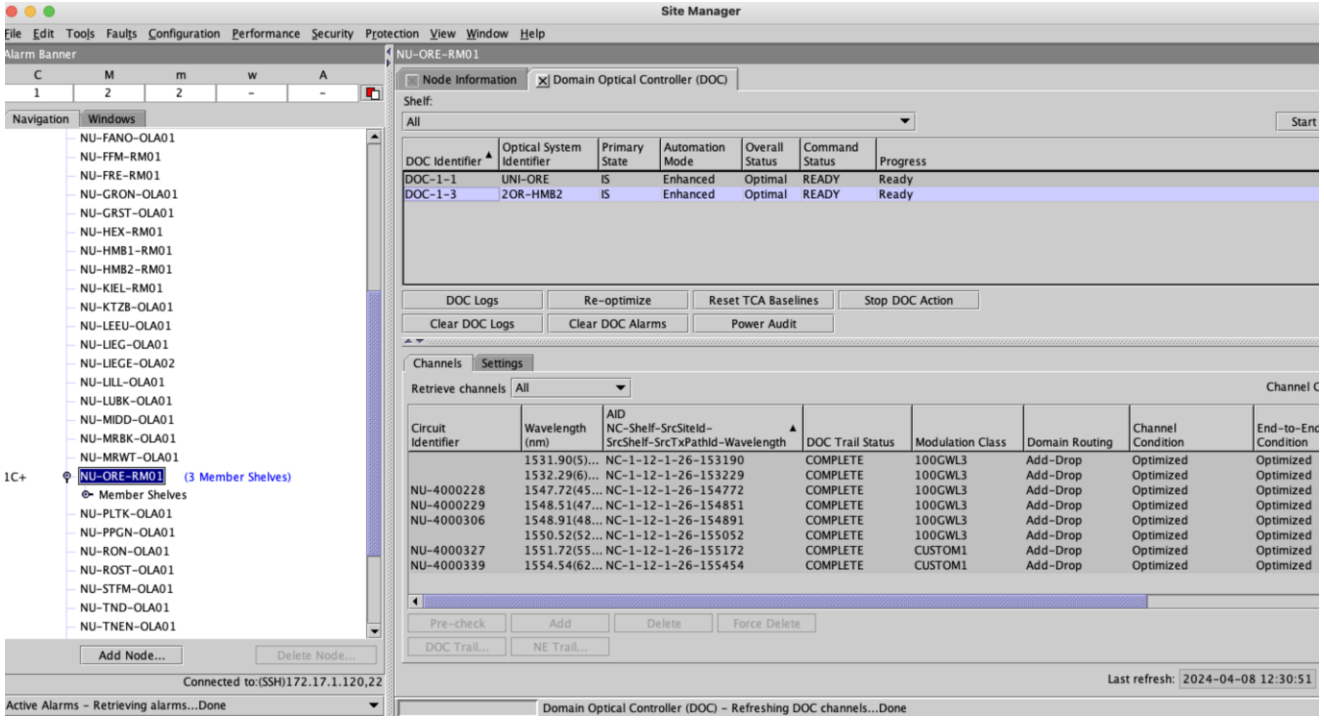


Figure 1. 40Gb/s alien wavelength transmission system setup

HOW?



- Ciena optical control system (DOC).
- Licensed ”foreign wavelength” control that deals native and foreign waves in same manor
- Protection for phase modulations (Amplifier optimisations)

TESTING & SIMULATION

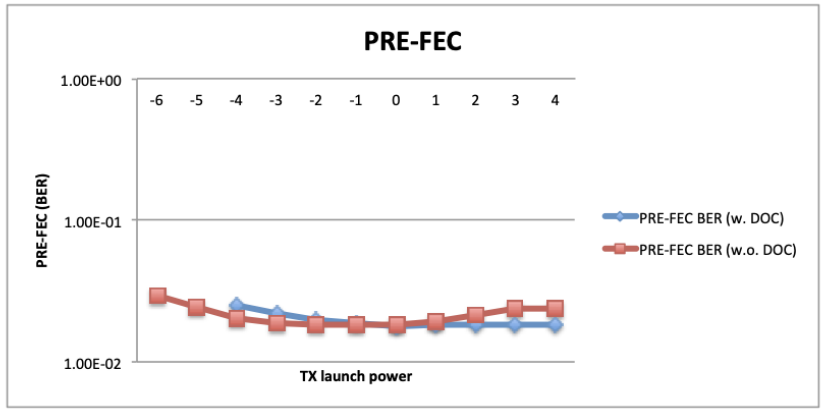


Fig. 9

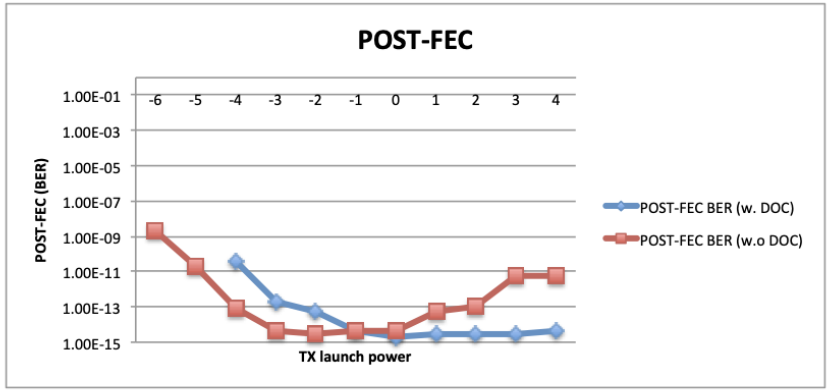


Fig. 10

The importance of Optical controllers

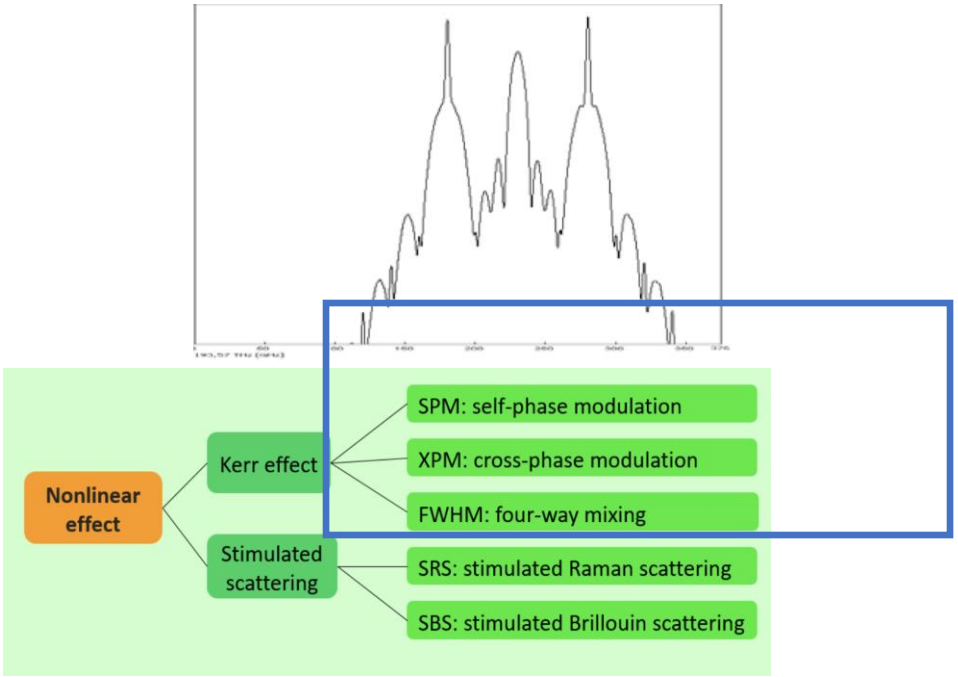
HOW?

TESTING & SIMULATION

CONCLUSIONS?

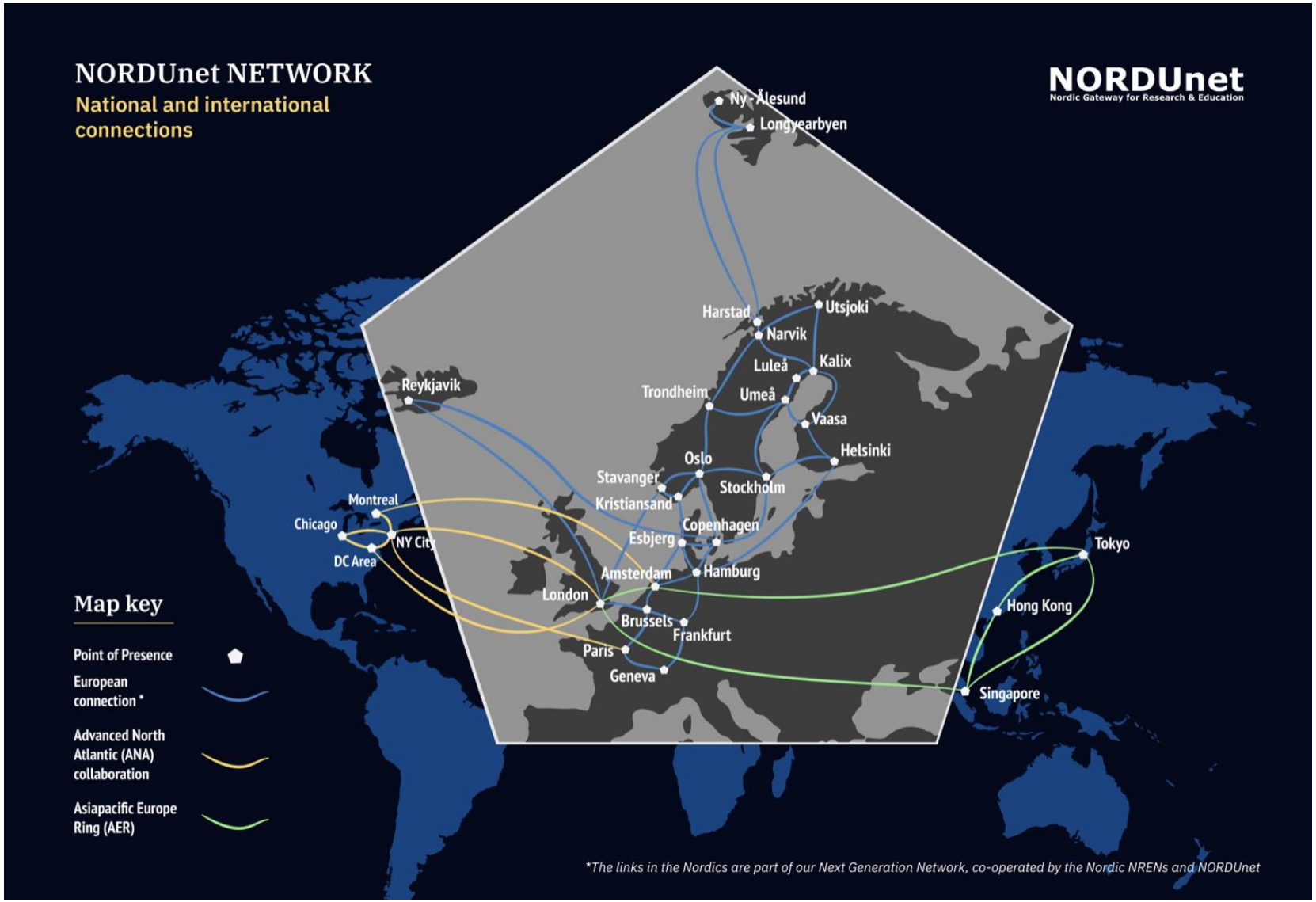
Guess what, the behaviour was as it usually is when we mix signals

WHICH WE LIKE ☺



- **XPM in particular when mixing NRZ OOK signal with Coherent.**
- **Decision 10G i production needs ”at least” 4*50Ghz channel space from neighbouring coherent (related to the launch powers).**

STARTED 2017 NOW THE NETWORK LOOKS LIKE THIS:



MIXING NETS, WHAT IMPACT? DOWNSIDES?

High visibility to own network

OAM SEPARATION ☹

BUT

To each other

Publish the results: (specmon.nordu.net)

QUICK (& DIRTY) SOLUTION


DAILY NEWS
Monday
SPORTS p.32
WEATHER p.4
Business - Politics - Editorial - Obituaries - TV and radio - Horoscope - Food - City life
50 cents
Your headline

NORDUnet Transponder data

PRE-FEC and OSNR Refresh

Sikt

Stoelen to Oslo & Oslo to Stoelen link #1 Week Month

SUNET

Oslo to Stockholm & Stockholm to Oslo link #1 Week Month

Stockholm to Ballerup & Ballerup to Stockholm link #1 Week Month

Stockholm to Ballerup & Ballerup to Stockholm link #2 Week Month

Stockholm to Oerestaden & Oerestaden to Stockholm link #1 Week Month

Stockholm to Oerestaden & Oerestaden to Stockholm link #2 Week > Month

Ballerup to Oslo & Oslo to Ballerup link #1 Week Month

FUNET
by CSC

Stockholm to CSC & CSC to Stockholm link #1 Week Month

Stockholm to CSC & CSC to Stockholm link #2 (OTN) Week Month

Public server, but no ”real” data only using png image files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Nordic OLS Status
Zoom in to:
Nordic Region
ALMs off
Services
LONG
• Not pub
• Mixed S
From 4
• Not yet
Link up
Link maint
Link down
Link N/A
Fiber 1: joensuu 2-4-N → 1-4-N ila-lieksa RAMAN
ALM Port: joensuu-otdr 1-3 ila-lieksa-otdr 1-2
Port Status: Ok (active) Ok (inactive)
Port Remark:
ALM link: JOENSUU Tx -- ILA-LIEKSA Rx ILA-LIEKSA Rx -- JOENSUU Tx
Fiber 2: RAMAN joensuu 2-4-N ← 1-4-N ila-lieksa
ALM Port: joensuu-otdr 1-4 ila-lieksa-otdr 1-1
Port Status: Ok (active) Ok (inactive)
Port Remark:
ALM link: JOENSUU Rx -- ILA-LIEKSA Tx ILA-LIEKSA Tx -- JOENSUU Rx
Link power details in the Grafana OLS and ALM dashboards
Vestfjorden
ICELAND
Reykjavik
Trondheim
NORWAY
Oslo
SWEDEN
Helsinki
Saint Petersburg
Tallinn
ESTONIA
Morze Bałtyckie
PARIS
Munich
VIENNA
AUSTRIA
SLOVAKIA
HUNGARY
MOLDOVA
Volgograd
Perm
Ufa
Samara
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2024-04-05 16:43:31
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WHAT ABOUT THE "NON NREN" WORLD?

- Lot of shipment problems during the pandemic (Disaggregation concepts started).
- Separation of line system and end modems, facilitated multivendor scenarios for multi sourcing.
- Automation open API's and standardisations is maturing.
- Advantages beyond sourcing: Customers getting the right prices, faster implementation of new and better technologies.
- CMOS, Si Photonics, Indium phosphite (InP), advanced fabrication tech all help scaling down electronic footprints.
- Future coherent pluggable's will mature even more and supplement, (or perhaps), eventually take over traditional transponder market thus merging the optical and IP domain…

FUTURE

- DSP and photonic developments downscale (size and power) enable IPoDWDM
- Juniper Mx304, (support eg. 400GZR are now exchanging old routers (being deployed atm)
- 2nd main optical vendor selected in NN (multisourcing) being deployed on new fiber stretch from Copenhagen -> Berlin via Bornholm.
- Funding freed up for investments in e.g. optical sensing, time and frequency, RAMAN and inbuild OTDR systems.

Thank you

THE END

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