



# Opening up Optical Networking

TIP and merchant optics

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27 Sept 2017



## Overview



- Open Line Systems and DCI equipment
- Telecom Infra Project
- TIP optical simulation software - OLE
- DCI equipment evaluation and field trials
- Network design using DCI

## Content providers driving disruption



Content providers are experiencing huge growth in traffic volume. They are driving innovation to ensure that their business models scale.

- The need for simple centralized controllers is driving software and hardware disaggregation.
- Started with OpenFlow, now content providers are pushing disruption through mechanisms such as TIP, OpenConfig etc.
- Hardware commoditisation drives economies of scale – pizza box form factor for datacentres.
- These changes are now moving from the datacentre into the Wide Area Network.
- This will lead to both opportunities and competitive price pressures on NRENs.

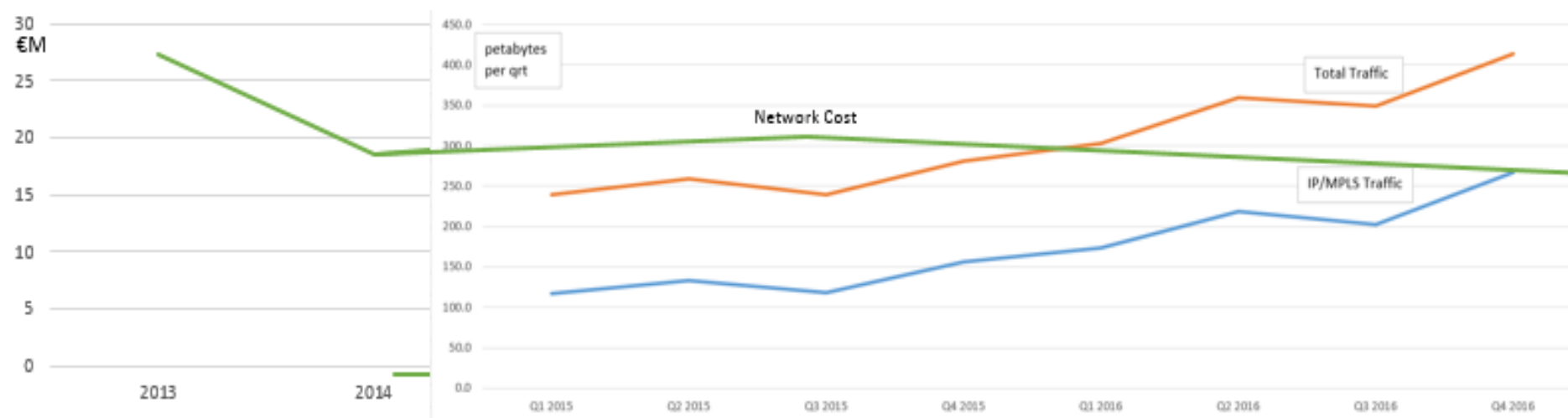
*What challenges/opportunities are there for NRENs in these changes?*

## R&E Network economics - cost of delivering data



- GÉANT funds spent on building our network have fallen since 2013.
- Annualised cost of GÉANT network excluding manpower now €16.6M.
- Total GÉANT network traffic increase from 250 to 400 Gbps from 2015 to 2016.
- Falling price of commercial Internet... we need keep up or lose out.

*We need new solutions to keep delivering rapid traffic growth with no extra revenue*



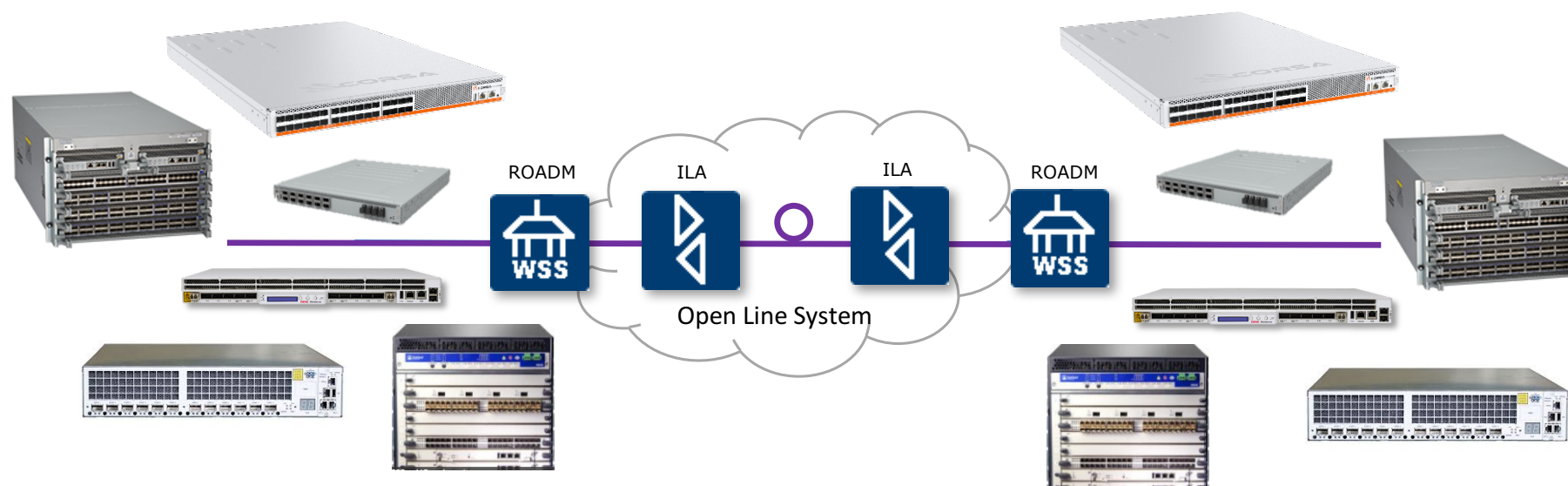
- Traditionally DWDM optical interfaces reside on the optical equipment vendors transponders
- The new generation of DWDM interfaces are being integrated in many places:
  - DWDM DP-QPSK/8QAM/16QAM
  - 2500km reach in CFP2 package
  - 4000km reach in for AC400
- Where is optimal location for CFP2?
  - Juniper/Cisco would like to sell 100G DWDM on their routers
  - Heavy reading white paper Feb 2017 suggests that external transponders/muxponders are cheaper due to cheap QSFP 100G interfaces and higher cost of using DWDM on routers consuming valuable router slots.
  - Integration of DWDM into routers blurs layer independence and Heavy Reading claims that big content providers are opting to keep DWDM off their routers.



*DCI solution brings gains of low cost DWDM while maintaining layer separation*

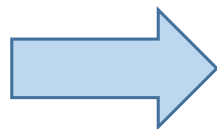
## Alien Waves

- Alien waves allow transponders from multiple vendors to operate on a single line system.
- Integrated 3rd party DWDM pluggables available in various terminal technologies and vendors.
- Still benefit from a single vendor providing end-to-end optical management: Channel & span equalization, DCN connectivity (OSC), ALS, Alarm reporting.





- Next gen of **commodity pluggable optics** has excellent performance
- Data centre style 1 RU stackable form factor.
- Up to **6 times reduction in cost** over traditional telecoms equipment architectures
- Significant increase in **density** and reduction in **power consumption**
- Modular – easy to scale up
- Easy **upgrade path** to new technology



- Loss of equipment integrity – not designed to be highly available as per ETSI etc.
  - No internal hardware redundancy
  - No in-service upgrades
  - Restricted temperature operation

# Telecom Infra Project



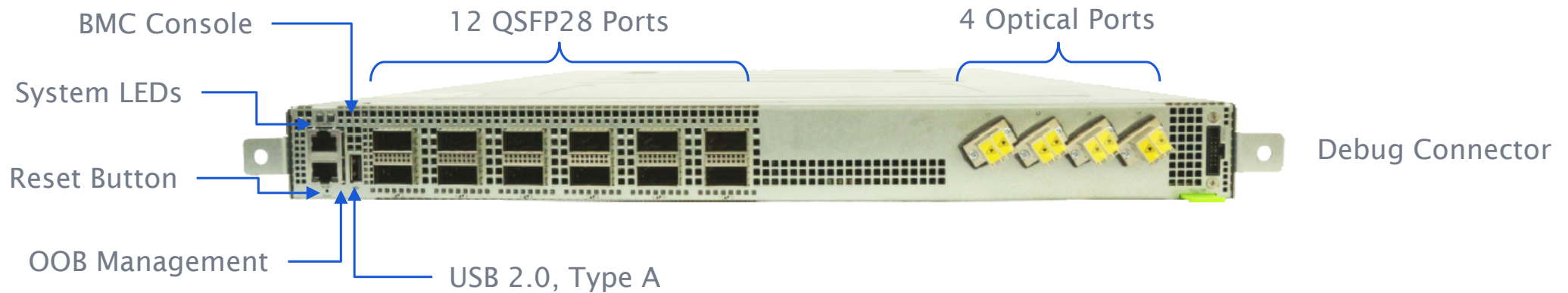
## Telecom Infra Project



- Facebook has initiated the [Telecom Infra Project](#) which aims to achieve open market for networking equipment.
- Built around components: APIs, line equipment, subsystems, software.
- Operators are the leaders, via the 'Operator Council' (OC).
- The sub-project relevant to optical transmission is Open Optical Packet Transport (OOPT)
- Facebook believes that the days of the big carrier grade router are over. The new architecture will be stackable boxes and coders to replace hardware redundancy.
- TIP also plans to develop photonic simulation environment to speed up the development.



## Voyager hardware



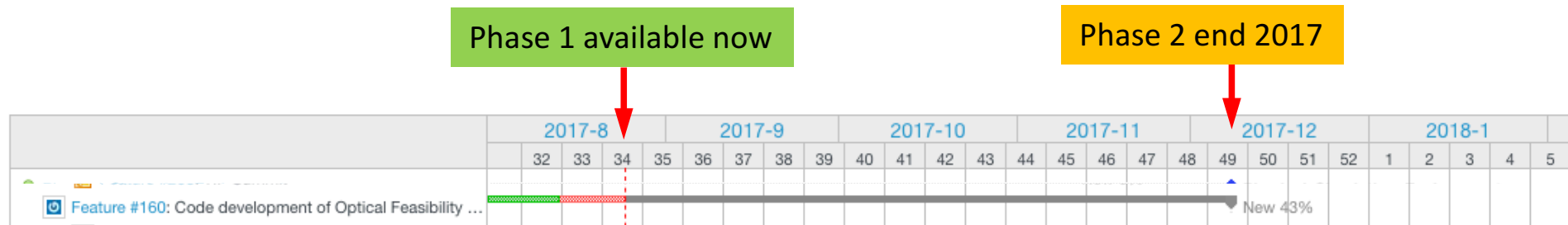
- 12 ports of 100G QSFP28
- 4 ports DWDM Acacia AC400 modulated at QPSK/8QAM/16QAM
- 2 x Broadcom Tomahawk chipsets of 400G each
- Snaproute software for L2 enterprise switching



## TIP Open Link Emulator (OLE) simulation tool



- The Open Link Emulator (OLE) emulates a point-to-point link within a network.
  - simulates fiber attenuation and NLI
  - Amplifier gain and ASE noise
  - Passive components losses
- The optical link emulator (OLE) based on github gaussian noise (GNPY).
- Target OSNR accuracy 1dB.
- Phase 1 python code available now in github for testing. Next code version late 2017.



## OLE phase 1 and 2

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### Phase 1

- Distance up to 1500 km without 3R regeneration
- Linear structure with 5 ROADMs to traverse (+2 terminal AWG)
- G.652 xor G.655 fiber type
- Any variation of span length 40-120km
- EDFA amplifier

### Phase 2

- Add utilities to interface with code outside TIP to provide GUI support
- Improve simulation capabilities: RAMAN, optimum power settings
- Improve Network modeling capabilities

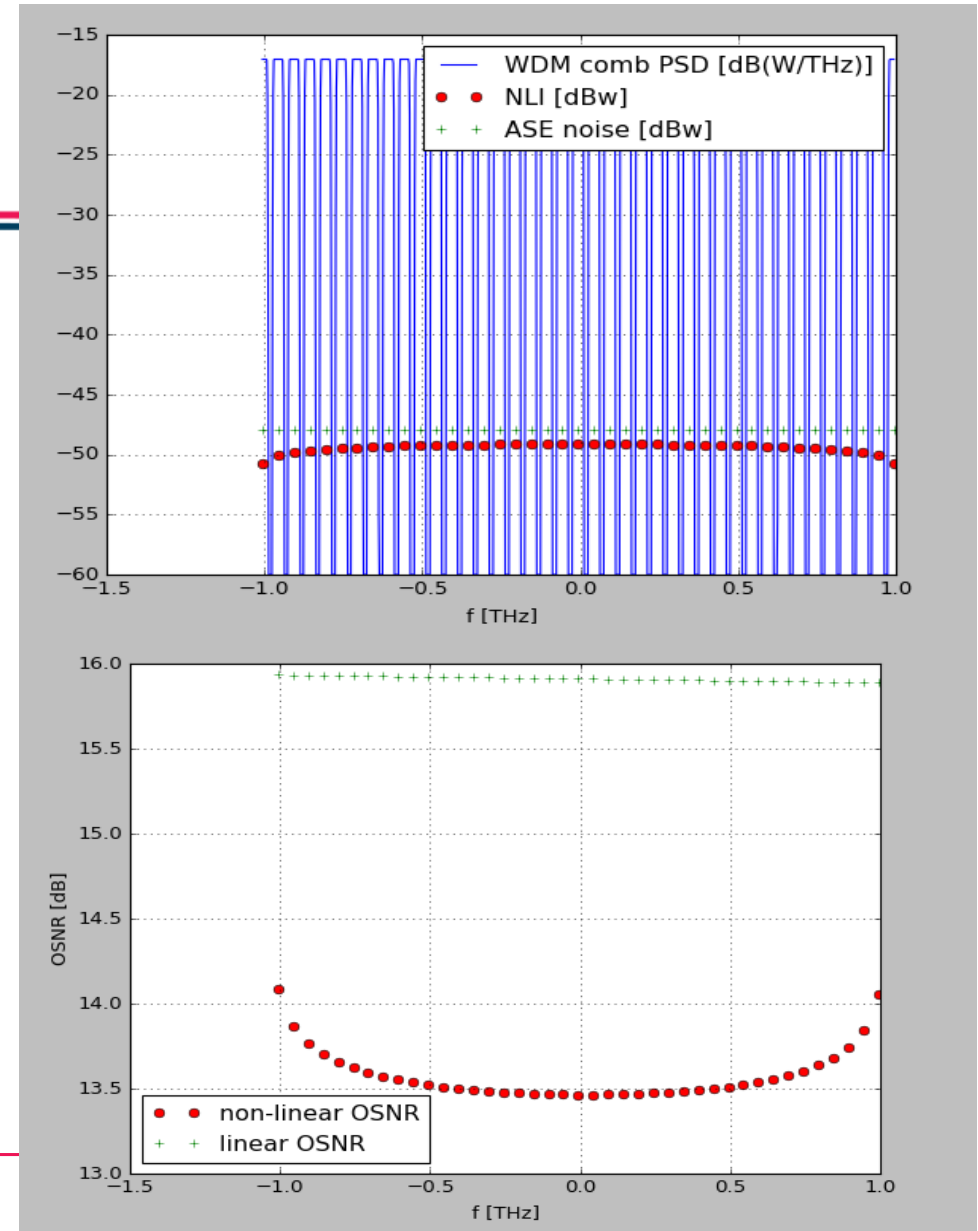
# OLE parameters

## Input parameters

- Fibre attn., length, alpha, beta, effective area
- Amplifier gain, tilt and noise figure
- Optical signal

## Output parameters

- Optical signal to noise ratio (OSNR) both linear and non-linear
- Optical noise (ASE)
- NLI Non linear interference
- Photonic Spectral Density (PSD)



## Why is modelling tool important?

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- Essential as a planning tool to understand how adding new waves will affect existing wavelengths.
- Vendors provide optical modelling tools but these are single vendor only. TIP aims to make multi-vendor operation easy with a shared simulation tool.
- Modelling tools are often expensive. More than 100,000 Euros.
- Scaling up alien waves requires a reliable prediction of performance of new wavelengths.
- When ROADMs are used OSNR predictions are needed to allow restoration decision to be made on-the-go.

# GÉANT testing

## DCI equipment testing in GÉANT



GÉANT is testing DCI boxes from several vendors. In addition tests are being carried out in collaboration with NRENs through JRA1T1. As these are effectively transponders in a data centre form-factor these have been grouped by line side optics types.

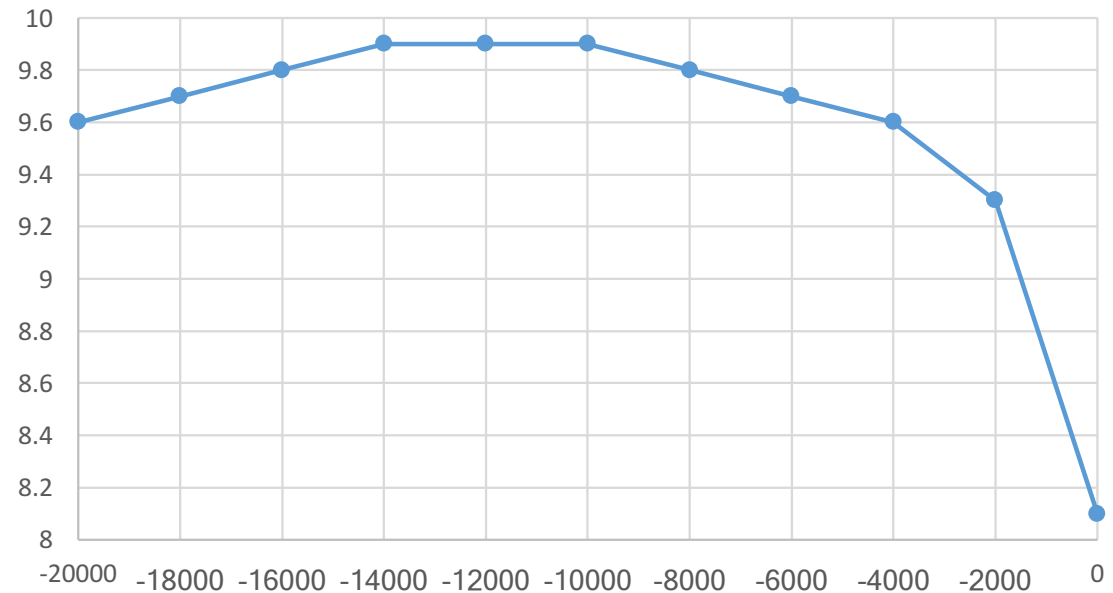
Optics	First Vendor	Second Vendor
Acacia AC400	Equipment: Facebook Voyager Status: Cambridge lab testing <b>complete</b> ✓ GÉANT field trial Lon-Bru <b>complete</b> ✓ NREN evaluation by PSNC and UNINETT <b>ongoing</b>	Equipment: ADVA FSP3000 Status: Testing under consideration.
Acacia CFP2 ACO	Equipment: Juniper DWDM CFP2 100G ACO Status: Cambridge lab testing <b>complete</b> ✓ GÉANT field trial Mil-Mar <b>complete</b> ✓	Equipment: Coriant Groove G30 Status: Lab testing in Cambridge <b>complete</b> ✓
Acacia CFP2 DCO	Equipment: Vendor in DWDM stealth mode Status: GÉANT field trial on Mil-Mar <b>complete</b> ✓	Equipment: Juniper DWDM CFP2 100G DCO Status: Testing expected late 2017
Infinera PIC	Equipment: Infinera XT3300/XT3600 Status: Evaluation in Infinera lab in Q4 2017.	NA
Ciena WaveServer	Equipment: WaveServer AI Status: Cambridge lab testing <b>ongoing</b> Field trial planned on CESNET fibre from Prague to Vienna in Q4 2017	NA



## Infinera DTN-X fixed filters

- Infinera fixed filters are offset from ITU-T grid
- -12.5GHz
- Requires DCI to tune off grid
- This is supported by Acacia pluggables

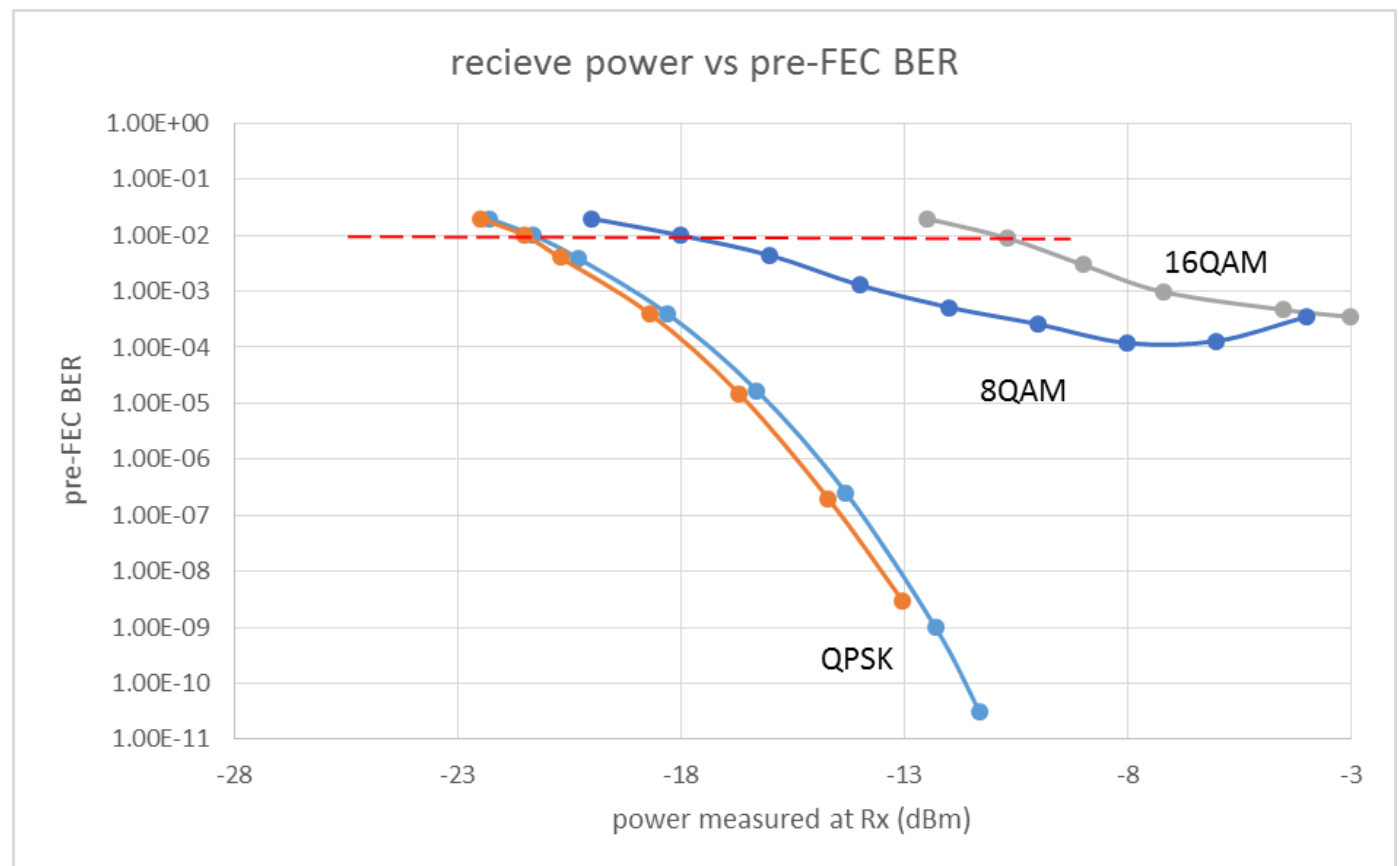
Q-factor vs. frequency offset (16QAM)



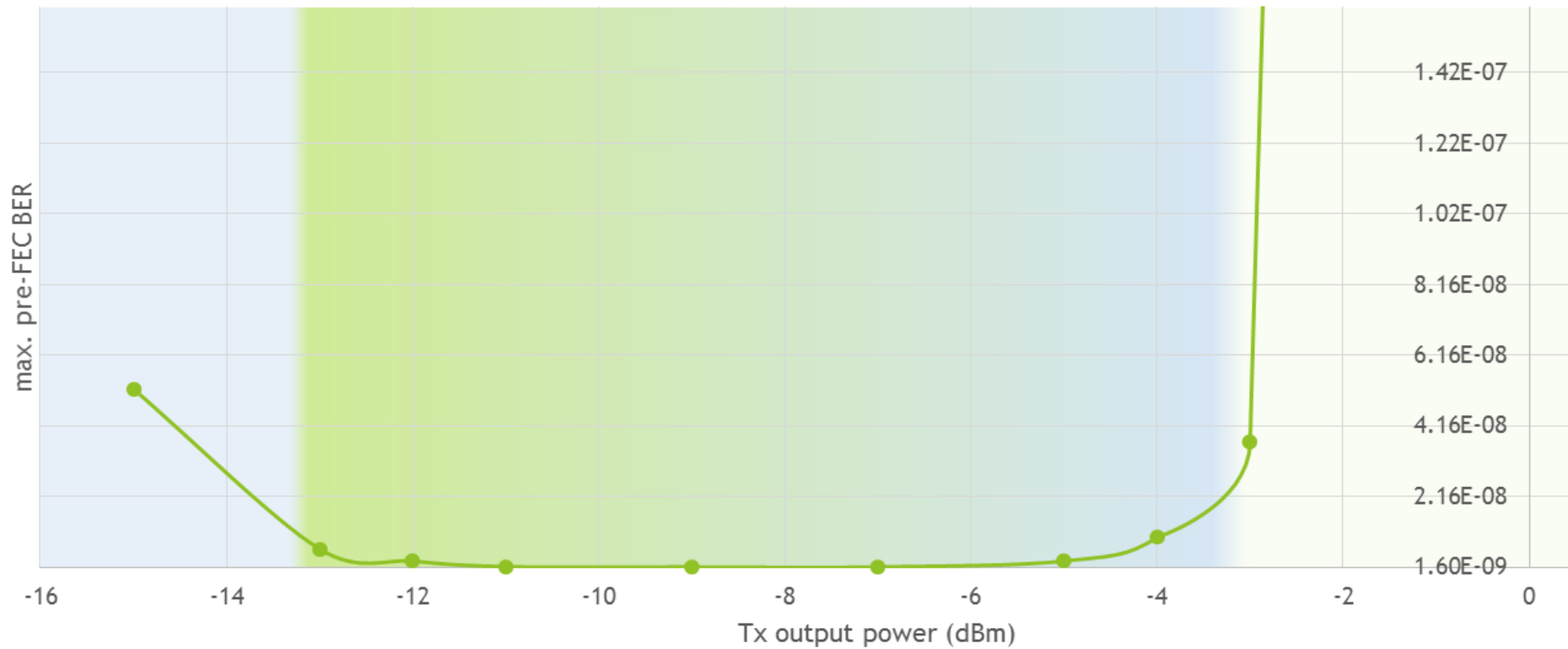
## Voyager Tx power vs pre-FEC BER (Lab test)

### Lab test results

- Tested over 100km of fibre lit with Infinera DTN-X
- Infinera's fixed filters centre frequency is offset from the ITU-T grid by 12.5GHz
- To get optimal performance wavelength needs to be de-tuned
- For QP-DPSK the system can work without de-tuning, but several dB of performance penalty.



# CORIAN Groove (lab test) maximum pre-FEC BER vs Tx output power

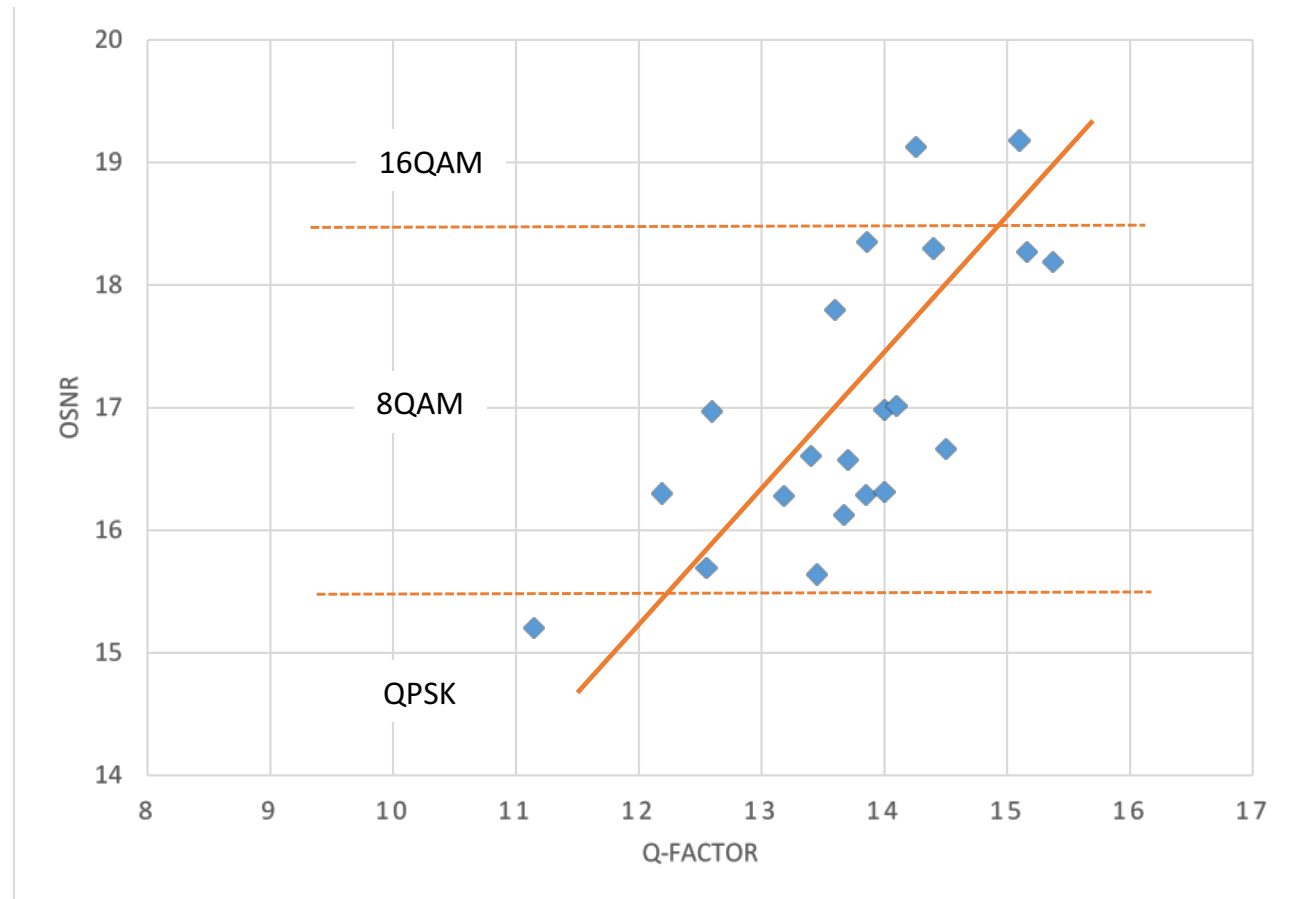


DPQPSK-SDFEC15%  
SL = 22 dB (~100 km)  
F = 194.34 THz

## All GÉANT fibre routes – modulation scheme available



- Of the 21 fibre routes in GÉANT, we can expect that most will work with 8QAM modulation.
- Only 1 route will require DP-QPSK
- At least 2 routes will work with 16QAM modulation



# Voyager field trial on LON01 to BRU



### *What have we learnt from the testing/evaluation so far?*

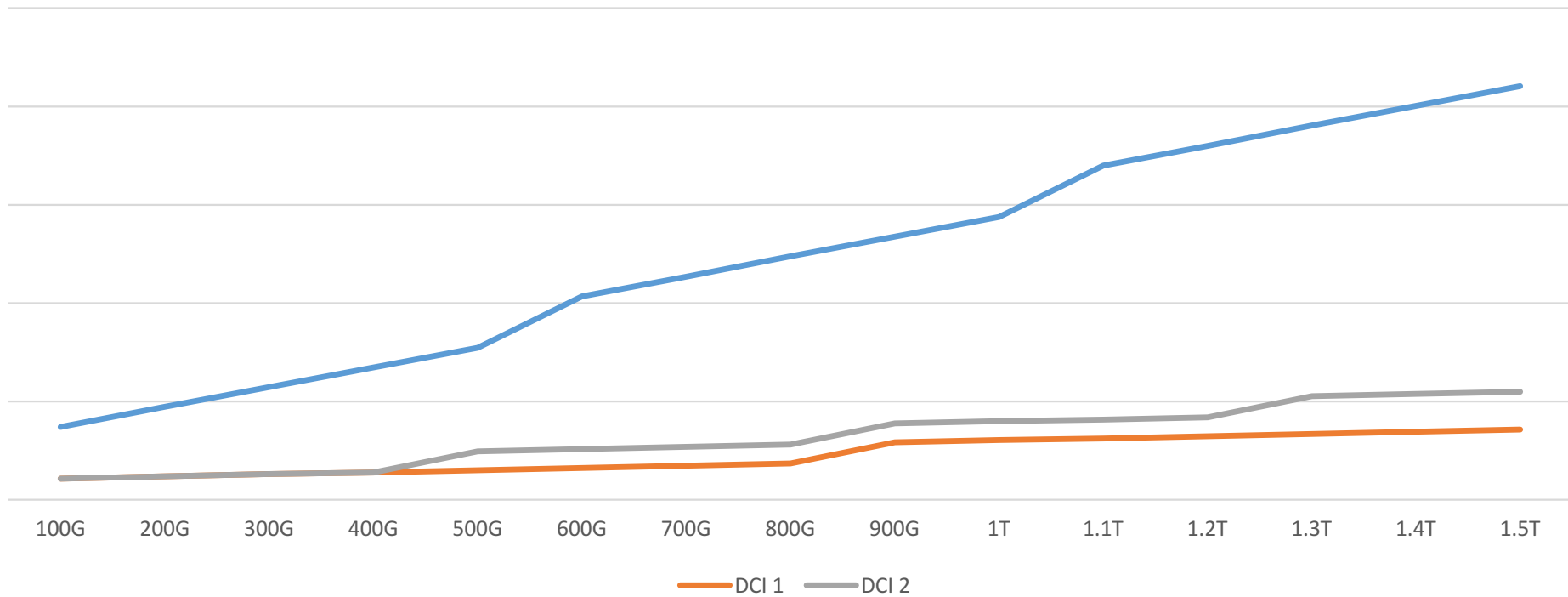
- Potential for very large cost savings in the network.
- Infinera fixed filters require tuning frequency off the ITU-T grid – this is possible with Acacia hardware.
- Performance of latest generation of DWDM pluggables is very good – Voyager 8QAM will work on most (all?) links in GÉANT network and 16QAM on several.
- Optical power management is the key.
- Software selectable modulation makes planning much easier.
- An optical modelling is needed to scale up number of AWs.
- Turning up alien waves is best done carefully!

# Network design with DCIs

## A cost comparison DCI v Infinera DTNx



HW cost of delivering capacity between adjacent PoPs over a fibre link

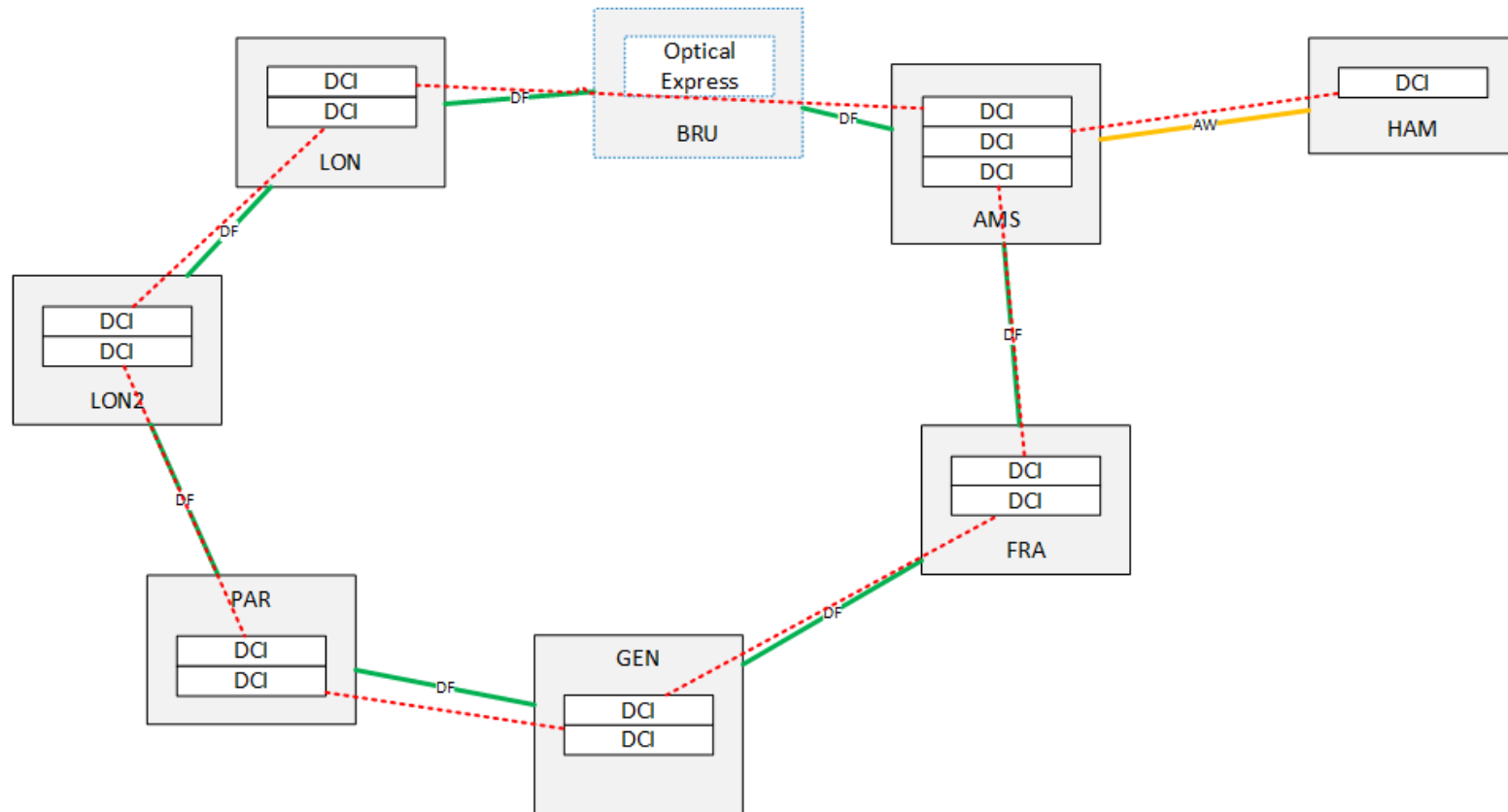


\* Analysis by Sebastiano Buscaglione and Matthew Gordon, August 2017



- In 2013 GÉANT ran the PRISM competition for Nordunet.
- Four transmission vendors were successful: Infinera, Ciena, Alcatel-Lucent (now Nokia) and Coriant.
- This framework agreement is still active and allows all GÉANT NRENs to purchase DWDM equipment at the PRISM prices.
- This is now being refreshed by the vendors to add their DCI offering.
- GÉANT plans to run a mini-competition between PRISM vendors to choose a DCI box to upgrade the GÉANT network.

# DCI deployment in GÉANT in 2018



## Summary



- New generation of data-centre type transponders will deliver the performance GÉANT needs over our existing Infinera line system.
- Testing has confirmed several DCI boxes on the market with excellent pricing cf. traditional DWDM vendors.
- TIP promises to fill the missing multi-vendor software modelling - required to scale up open optical network.
- GÉANT will purchase DCI equipment as an interim technology for transponders between now and the network refresh in 2020/21



Thank you

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