

Building a resilient optical transport network (OTN) transporting critical applications

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Company & Network Information

Eletrobras

The largest generator of electricity in Brazil, with 10.618 MW of installed power



- Eletrobras has six subsidiary companies: Eletrobras Chesf, Eletrobras Furnas, Eletrobras Eletrosul, Eletrobras Eletronorte, Eletrobras CGTEE and Eletrobras Eletronuclear

- Six distribution companies: the Electric Power Research Center (Eletrobras Cepel) and Eletrobras Participações S.A. (Eletrobras Eletropar)

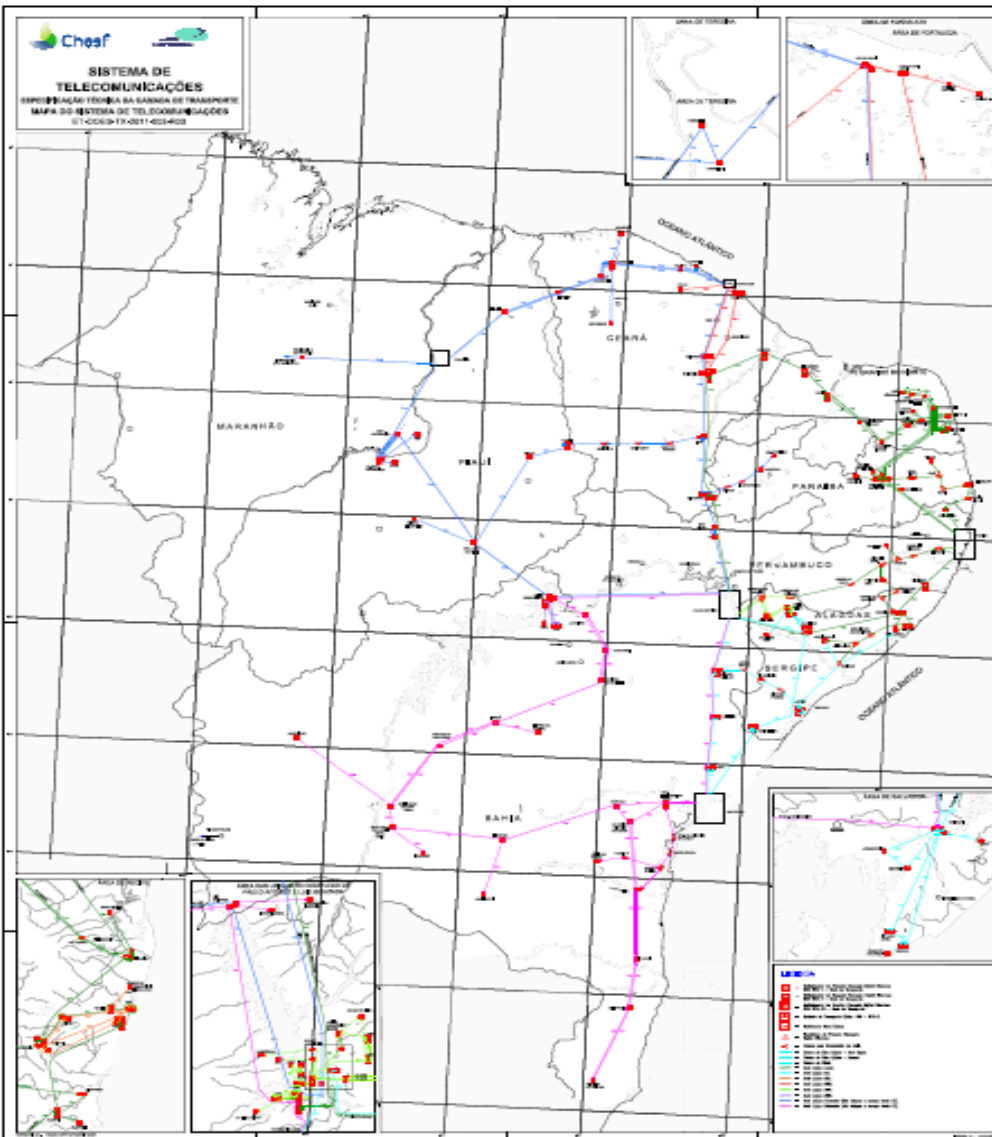
- Holder of 50% of the capital stock of Itaipu Binacional.



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CHESF and its existing network

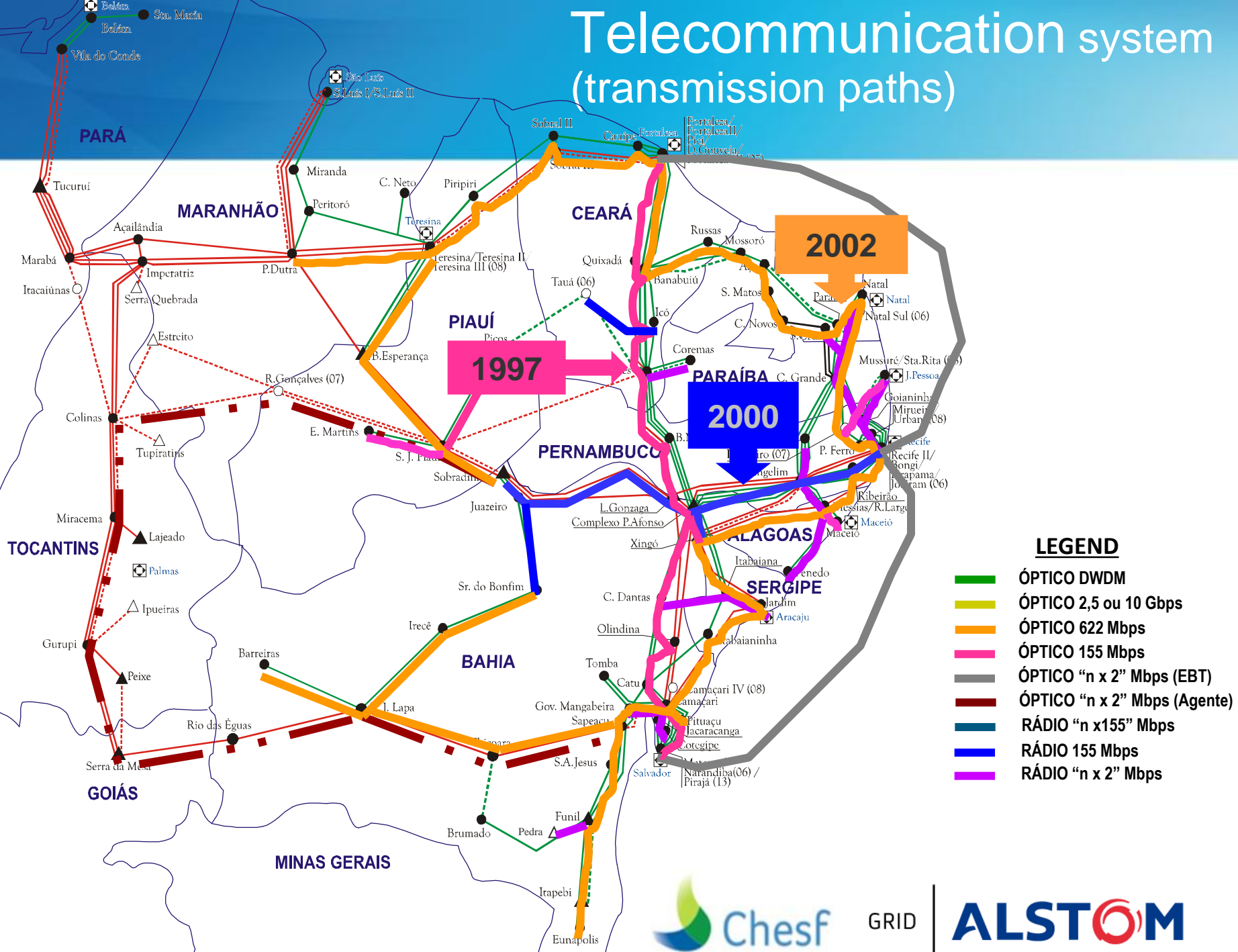


Chesf is one of the largest Brazilian power grid Companies dedicated to energy transmission, the current transmission network is in the Northeast area of the country, having presence in 9 states of Brazil.

Their transmission network is based on:

- SDH rings
- Ethernet rings
- Amplifiers/DWDM

Telecommunication system (transmission paths)



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Backbone project motivation

New administrative and operational applications:

- Transport Network
- Synchronism
- Wide Area Network (WAN)
- Unified Communications (UC)
- Video Surveillance
- Wireless Network (WiFi)
- Security
- Quality of Service

Strategic Planning for the Eletrobras System:

- The need to improve the quality of service delivery of generation and transmission of electric energy,
- Make the Operation and Maintenance Processes more efficient;
- Improve and modernize the Automation Systems
- Implement the Program of Remote Operation for Installations;
- Improve and modernize the Telecommunications System, including the necessary support to Business Management.

Planning for the actual systems obsolescence in the 2018 horizon (the evolution of technology and the end of the equipment life cycle);

Phase out of manufacturing equipment



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DWDM and OTN technologies



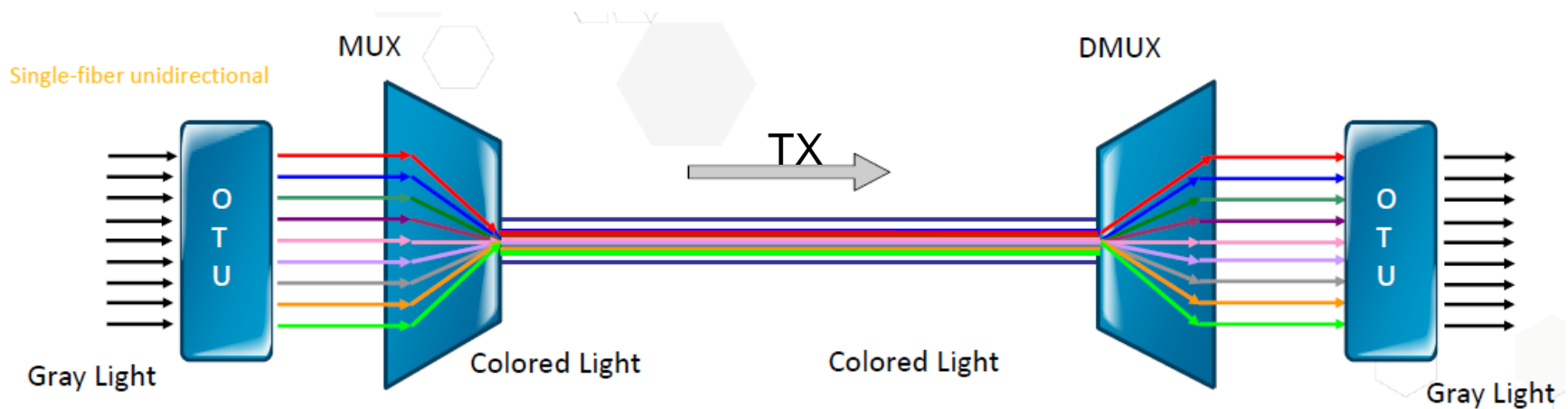
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DWDM explanation

- Definition:

Multiplexing optical signals of different wavelengths into a single fiber for transmission is known as wavelength division multiplexing; the transmitting MUX device will multiplex different wavelength into one optical fiber transmission, vice versa for the receiving DMUX



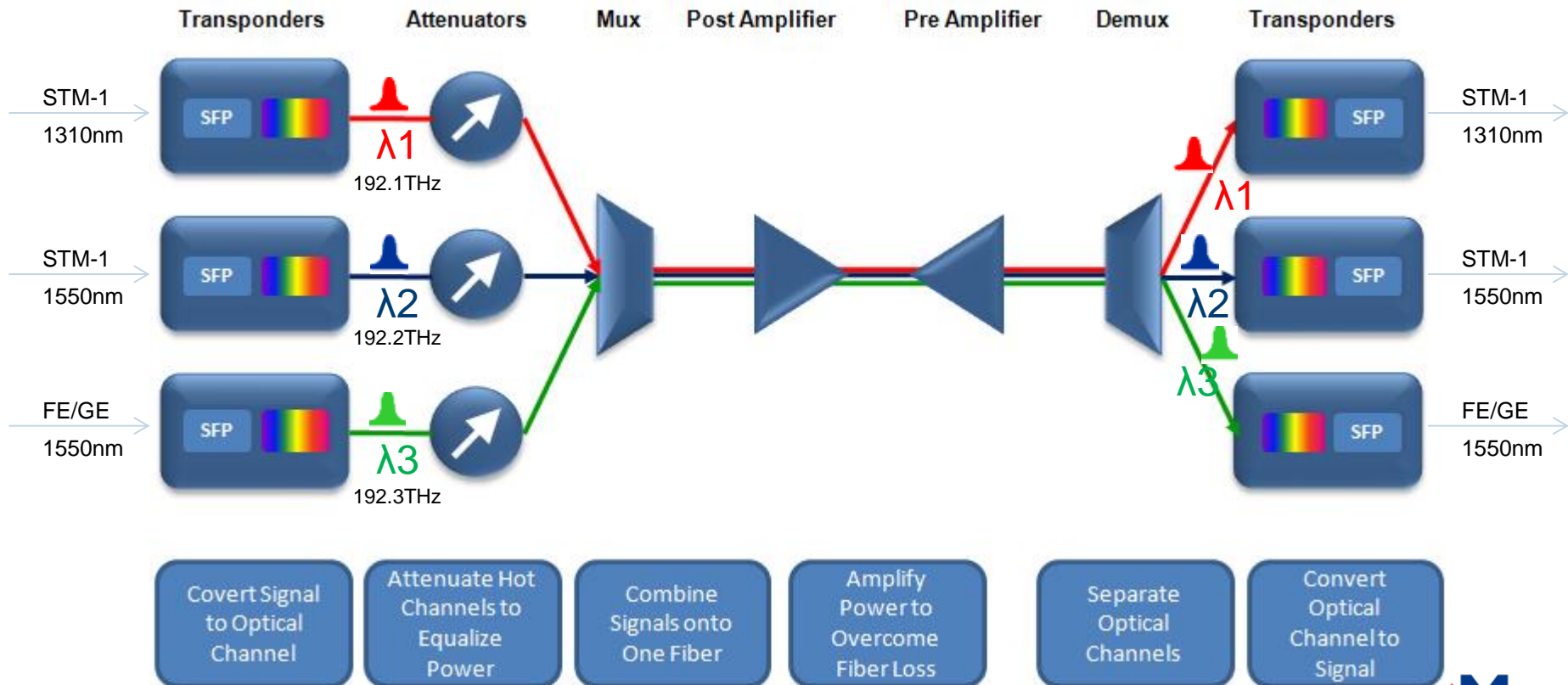
- High capacity

- Wavelength number: 2/8 -> 32/40 -> 80/96 -> 160/192 ...
- Line rate: 2.5G/10G -> 40G -> 100G -> 400G/1T -> 8T...

DWDM wavelength

In a typical fiber optic network, the data signal is transmitted using single light pulse (e.g 850nm, 1310nm or 1550 nm wavelengths)

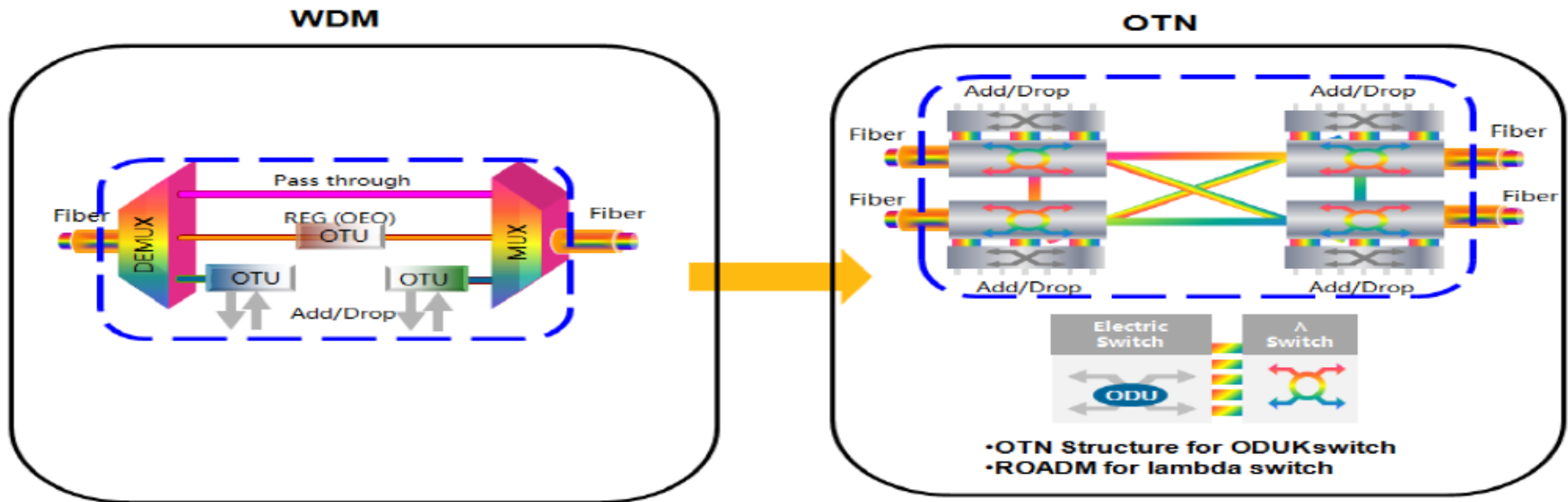
WDM architecture is based a simple concept – instead of transmitting a single signal on a single wavelength, transmit multiple signals, each with a different wavelength. Each remains a separate data signal, at any bit rate with any protocol, unaffected by other signal on the fiber.



OTN explanation

- Definition:

OTN technology inherits the advantages of WDM (e.g., large capacity and long distance), meanwhile, **adds flexible optical/electrical cross-connect and rich overheads. OTN, with both advantages of WDM and SDH**, is the mainstream technology of backbone transmission

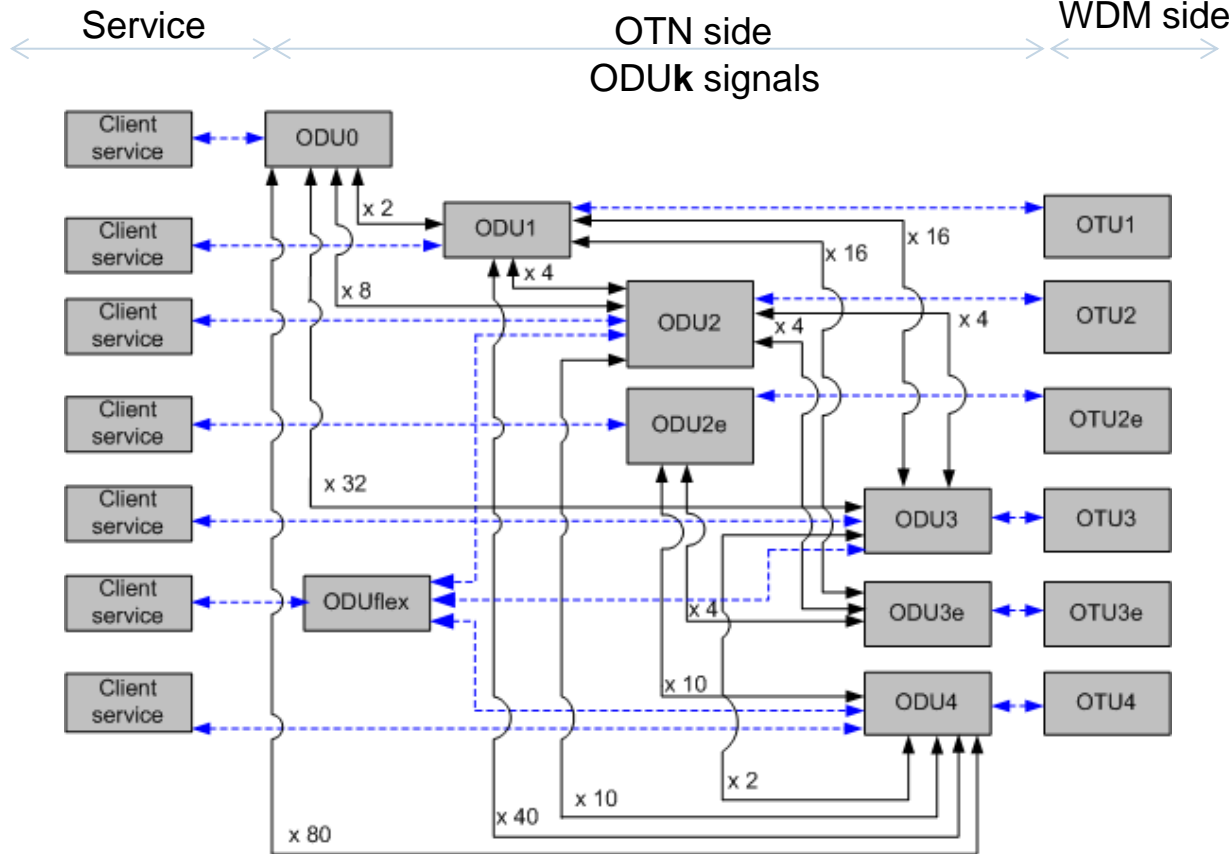


- Leading transformation

- From simple P2P WDM to E2E automatic switching OTN, solves many difficulties in terms of service change and networking functions

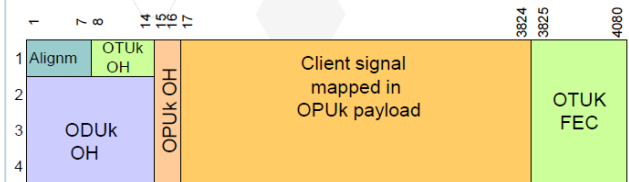
OTN multiplexing and mapping ODUk signals into OTUk signals

Mapping Structure



OTN frame formats (k=1,2,3,4)

Client signal -> OPUk -> ODUk -> OTUk

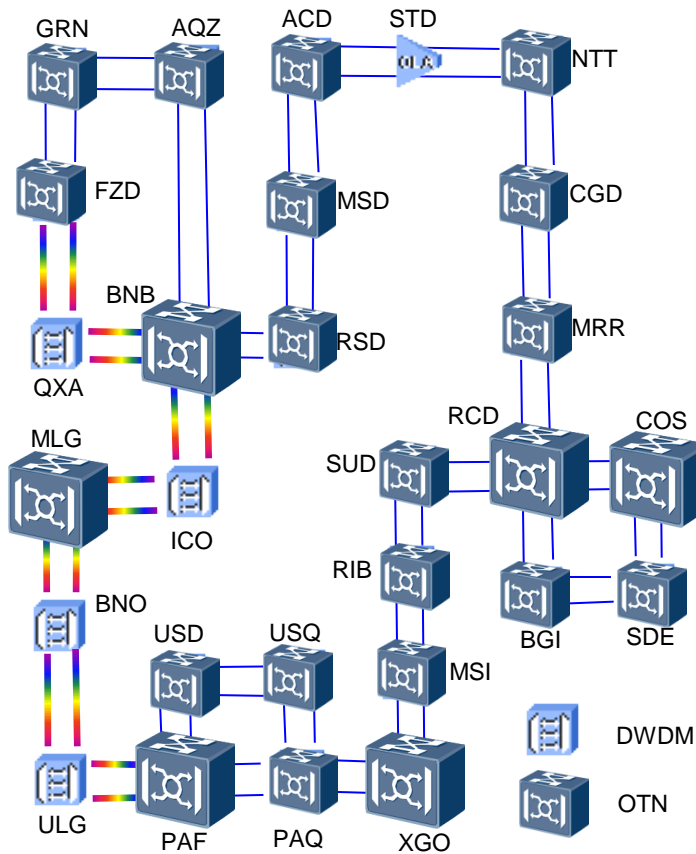


- Client signal
- OPUk - Optical Channel Payload Unit
- ODUk - Optical Channel Data Unit
- OTUk - Optical Channel Transport Unit
- Alignment

K=0 -> 1,25G
 K=1 -> 2,5G
 K=2 -> 10G
 K=3 -> 40G
 K=4 -> 100G

CHESF solution

CHESF Solution: OTN+DWDM layers



3 Layers:

- OTN (10G): 23 nodes
- DWDM (8 λ): 8 nodes
- SDH: 32 nodes

Long distances: 227km, 200km, 190km...

DWDM Layer

- From FZD to PAF sites
- Traffic shall be increased in the future (16 λ)
- Carrying 10G and 2.5 services in the same line
- Working and protection paths for each wavelength.

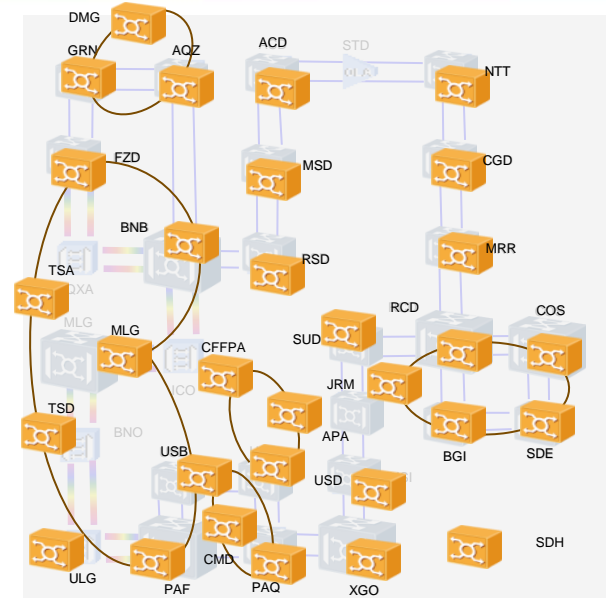
OTN Layer

- Transporting traffic in 10G lambda (OTU2)
- OTN has a higher grooming capacity (ODUk, k:0,1,2) for low rate services (<10Gbps)
- Cross-connection protections benefits in ODUk SNCP.

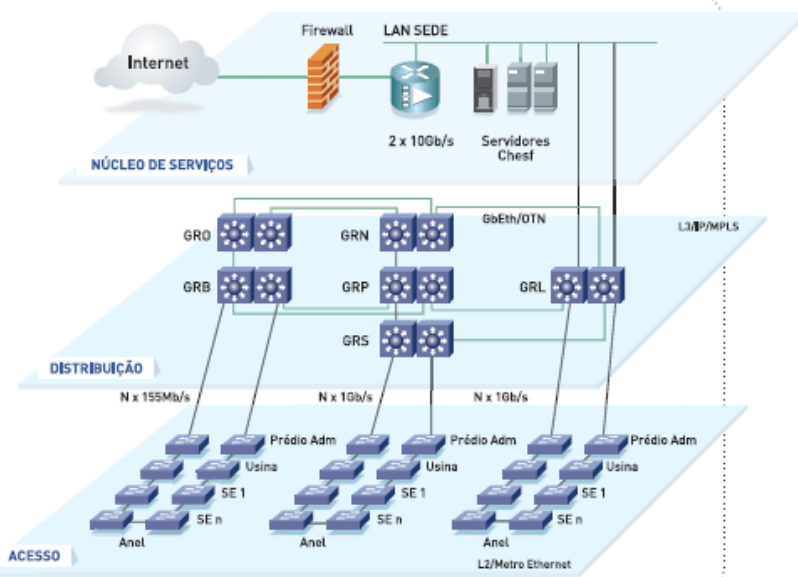
CHESF Solution: Other layers connected on OTN layer

SDH Layer:

- Low rate interfaces such as E1, GE, STM-1, STM-4
- Maximize the bandwidth utilization to upper OTN/DWDM layers by aggregation different substations traffics
- Protected rings and boards to ensure the high
- Critical services transport: IEC-61850, synchrophasors and time synchronization



ARQUITETURA DA NOVA REDE WAN



Future: Carrier Ethernet Layer

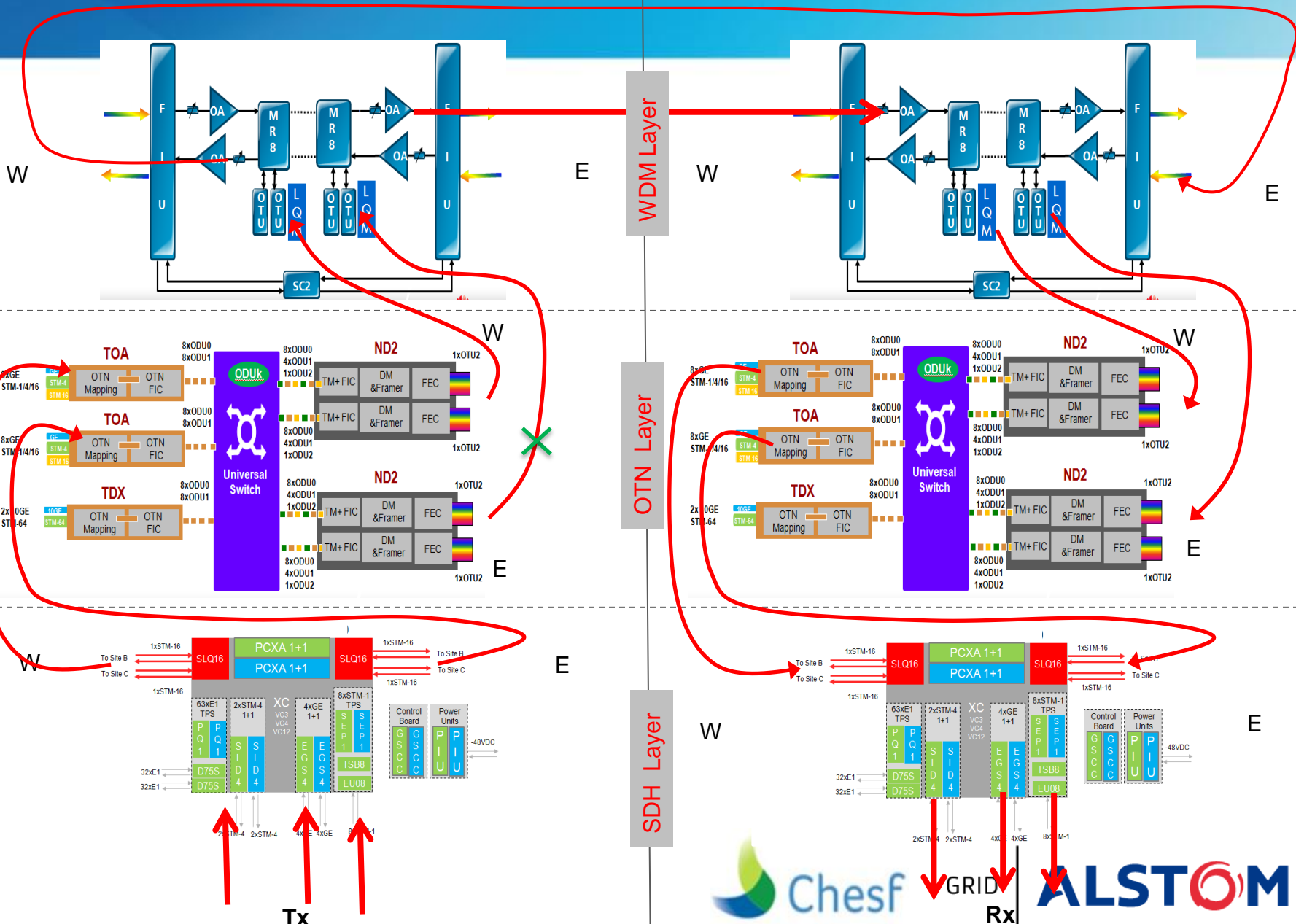
- Isolate logical networks: Vlan
- Cyber security: zoned networks, firewall, IPSec, VPN



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Equipment connection between layers and protection scheme



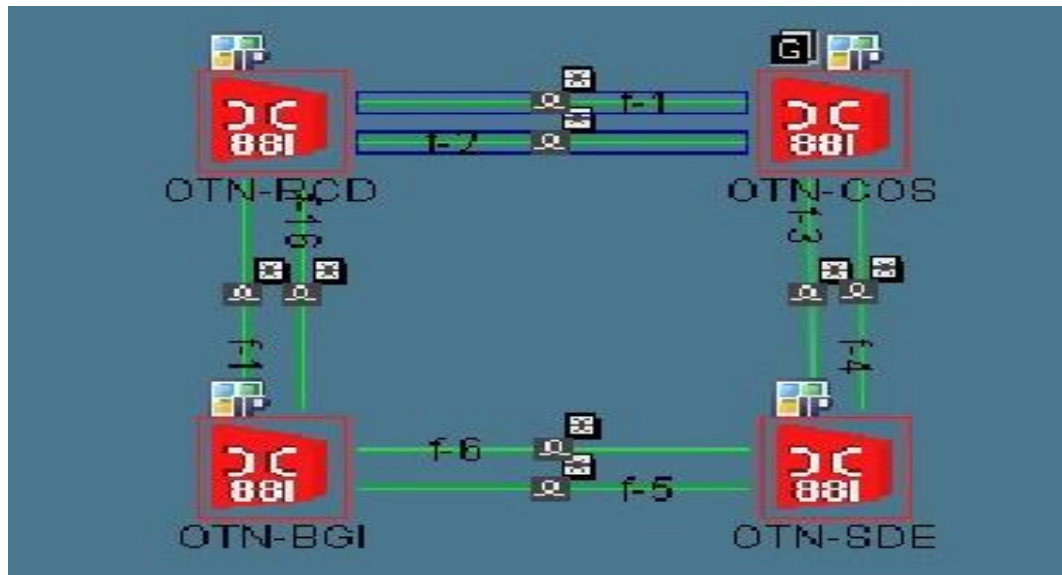
Pilot Test

Date: February 2015

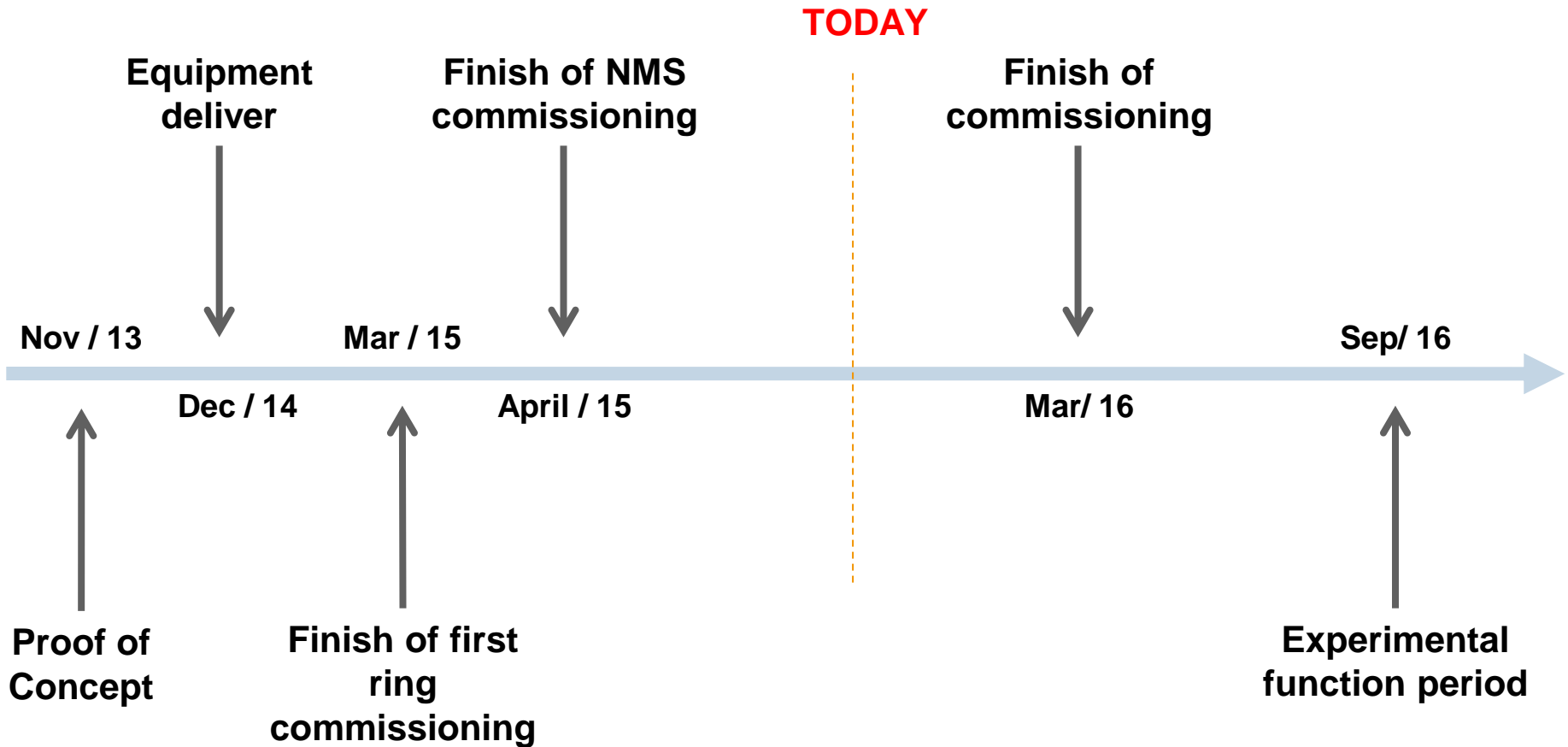
Pilot ring tests: SDH and OTN functional and systemic testing on the actual installation environment

Capacity: 10Gbit/s

Protection: ODUk-SPring (two fibers)



Project schedule



Challenges faced during the project

- First implementation of new technology
- Tight coordination between integrator and equipment manufacturer
- Some iterations in system design causing delay
- Ramp-up of technical skills in the project team
- Training effort for deployment and operation teams
- Tight schedule to deliver project milestones

Questions of the Special reporter

Q1-3:

- What is your experience using OTN to support critical services such as IEC-61850, synchrophasors and time synchronization?
- *As it is the first implementation of this kind of technology in power utilities, we did some tests to ensure that our standard services and critical*
- *Applications would not suffer any problem to be transmitted by OTN technology. During the tests, we simulated some STM and Ethernet data flow, measured the transfer and delay time, protection schemes and so on. OTN has been proved to be a reliable technology to transmit those services and also increase the network capacity.*

Questions of the Special reporter

Q1-4:

- One of the mentioned requirements is 'Isolate logical networks' (the concept of cyber security using zoned networks). How do you reach this using OTN and what is your experience realizing it?
- *OTN is a technology for signal transport over optical networks, the signals are transported transparently thanks to the service-agnostic mechanism mapping several and distinct services into the same data frame level. It means it is optimized for multi-services transport. In addition, it provides a deterministic QoS, similar to SDH, ensuring guaranteed QoS for critical applications.*

Thank you !

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