CIGRE UK B5/D2 Technical Liaison Meeting

Wednesday 22nd November

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Application of Packet Switched Networks

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D2.58 working group

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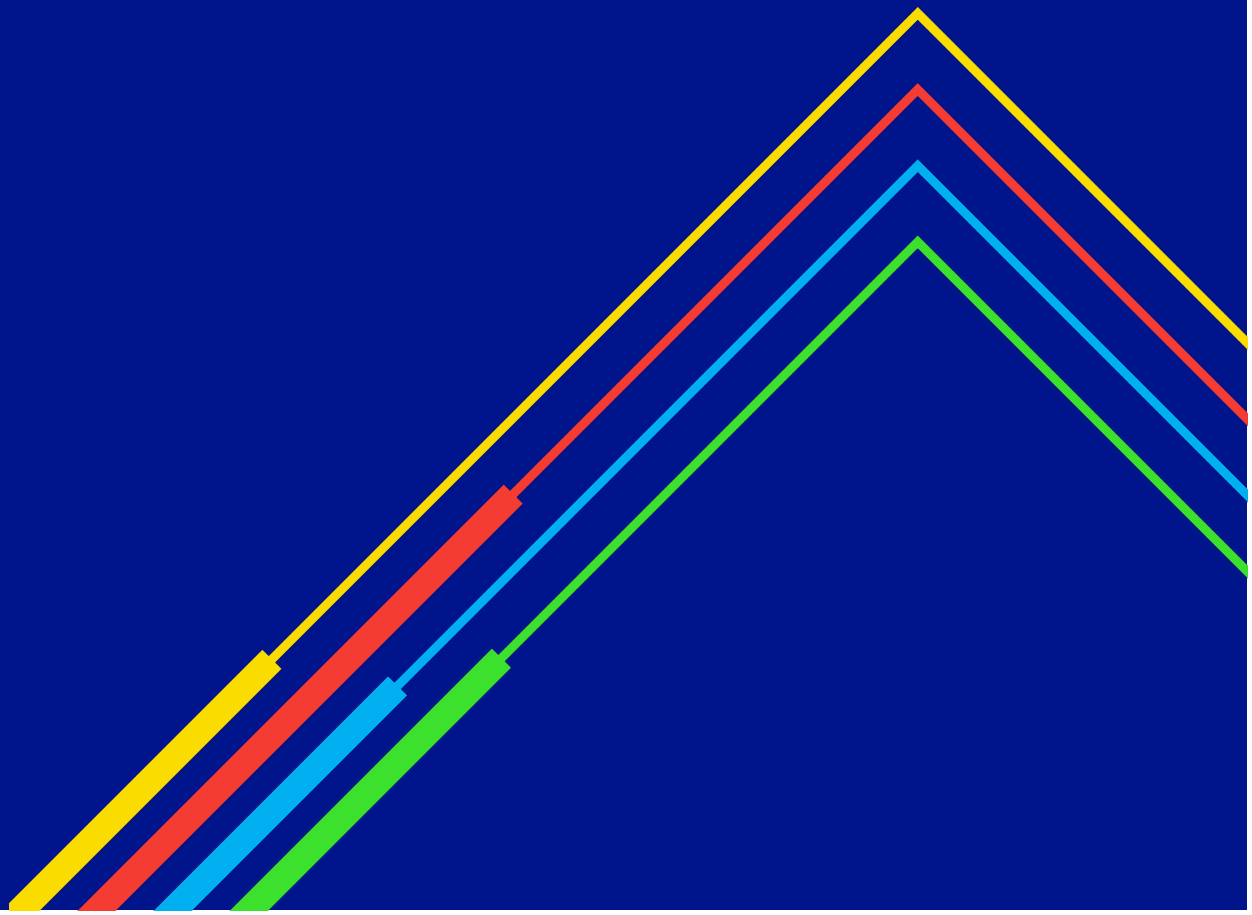
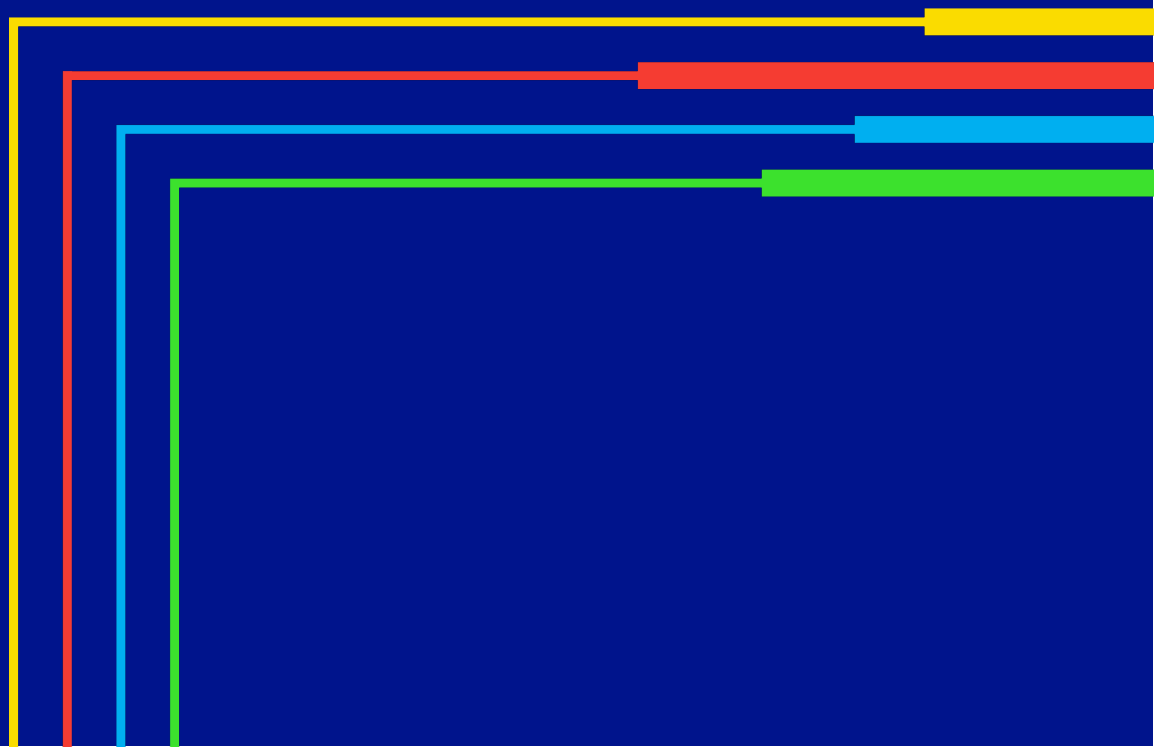


OptelGen 3 & HBO



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What is Optelgen3?

Provide New Optel Network for the transport of critical communication services

Technology refresh to replace End of Life SDH Equipment.

- Circa 700 nodes, & 5000 circuits.
- Introduce much higher bandwidth capability (Taking STM-4/16/64 to n x 10Gbps and 100Gbps.
- Introduce DWDM to support multiple high rate services over common fibre connectivity.
- Include Encryption between sites
- Maintain ability to interface with existing systems (Bearer and Access)

•STM-4 = 622.080 Mbit/s

•STM-16 = 2,488.320 Mbit/s (~2.5 Gbit/second)

•STM-64 = 9,953.280 Mbit/s (~10 Gbit/second)

Refreshed Synchronisation solution

- Introduction of accurate clocking and Synchronisation for packet-switched networks
- Increased resilience to loss of satellite(s) signal and signal jamming
- Increased security against spoofing

Fibre monitoring

- Replacement fibre monitoring solution with capabilities to support fault prevention and diagnosis

Services Carried by OpTel

Electricity Control Rooms TO & ESO

TO

IEMS, BM, Telephony

ESO N & Scot

ESO South

Data & Telephony

Scottish & Southern Electricity Networks · WESTERN POWER DISTRIBUTION · SP ENERGY NETWORKS · UK Power Networks · electricity north west · NORTHERN POWERGRID

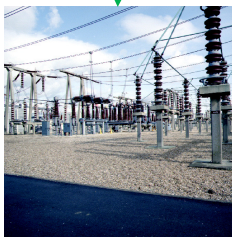
DNOs and Scottish TOs

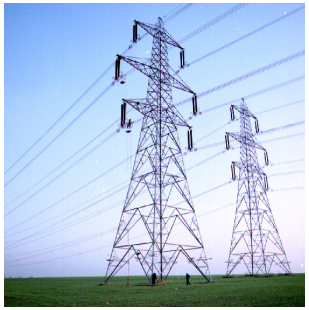
Data, Dispatch & Telephony

Power Company Control Points

Monitoring & Control, Telephony

7,200 km O/H Lines
1,400km Cables





290 Substations

>5,000 Telecommunications Circuits:

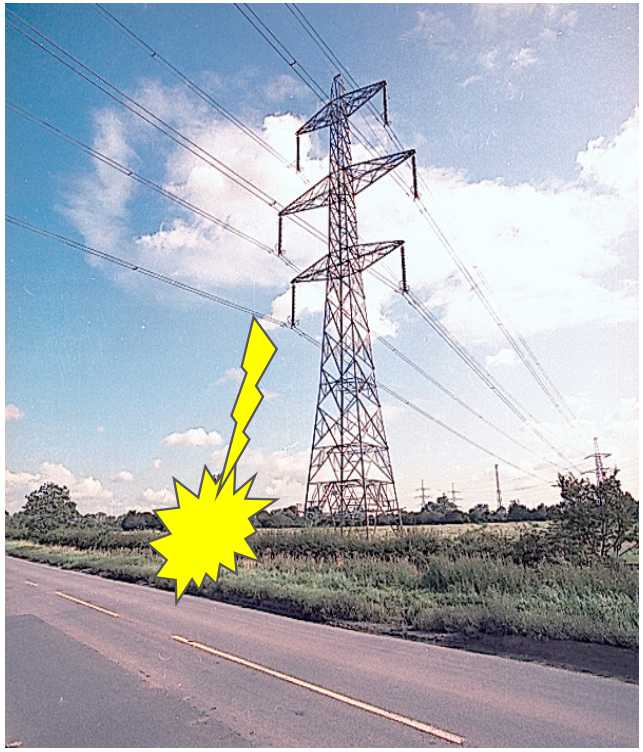
1636 Tele-protection
193 Operation Tripping
1397 Monitoring & Control
1154 Control Telephony
100 Dispatch (EDL)
23 CCTV/Physical Security
20 WAN: IEMS, BM, Data
499 Substation BWAN

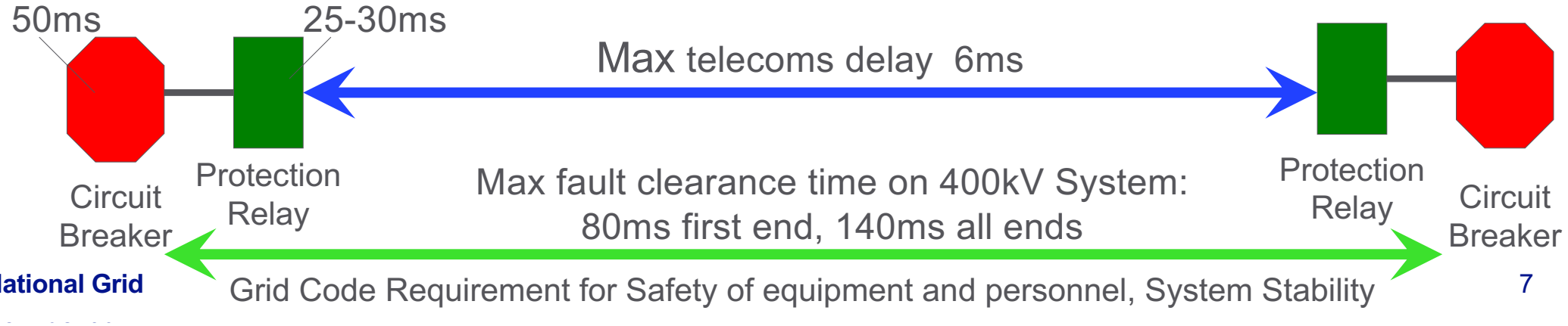
Tele-protection 6ms / 400µs

48hrs mains independence
5m end-end separation
Immune to electrical interference

Protection

- **Dependable:** must operate when required
- **Secure:** no maloperation

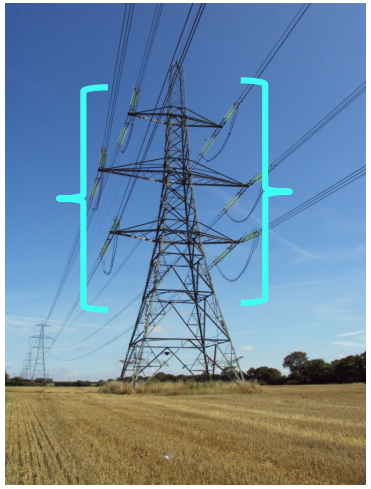




Impact of loss of protection services

- Each HV Circuit has duplicate protection services e.g.
  - 1st Main protection
  - 2nd Main protection, or Distance Protection with Blocking
- If either service fails for >2hrs then a senior manager must approve leaving the HV Circuit in service
- If both services fail, the National Grid Control Room is likely to need to remove the circuit from service to avoid the risk of damage to plant, system instability etc due to slow fault clearance times
- When a HV Circuit is removed from service this depletes the resilience of the power system, and in the worst case can lead to loss of supply

HV Circuit 1
1st MP
2nd MP or Bkg



HV Circuit 2
1st MP
2nd MP or Bkg

Double Circuit Overhead Line

Key Service Requirement Drivers

	Description	Applies to
Absolute (Propagation Delay)	Signal latency between A end and B end, or the B end and A end of a service • If propagation delay requirement exceeded, the ability of Feeder protection units to effectively identify potential faults is limited. • Fault switching commands require signalling latencies which correspond to the specified propagation delay	Teleprotection • 6ms Operational Tripping • 10ms
	To ensure 140ms transmission network fault clearance time requirements are met, Protection Services should not exceed 6ms point-to-point latency	

Key Service Requirement Drivers

	Description	Applies to
Standing Differential Delay	Standing Differential Delay is the difference in latency measured between the A-end to B-end Delay, and the B-end to A-end Delay • It is critical Feeder Protection Units do not experience Standing Differential Delay that exceed requirements set out.	Teleprotection • 400µs
	For effective Operation, Protection services require the difference between transmit and receive path latency no more than 400µs	

Key Service Requirement Drivers

	Description	Applies to
Transient Differential Delay	Transient Differential Delay is the time-period during which a split path and thus potentially excessive differential delay (>400µs) is permitted • This will happen during a bi-directional protection switching event when one end and then the other switches over	Teleprotection • 400µs
	During SDH switching the AIS signal is used to deactivate Protection switching on the Transmission link, otherwise we are risking Unit Protection maloperation	

Key Service Requirement Drivers

	Description	Applies to
Worker Path Separacy	When the worker paths of two or more associated services are kept separate. • To ensure resilience from single points of failure a 5m minimum separation for all physical and logical elements is required	Teleprotection SCADA Operational Voice EDL OTS Interstation Process Bus PTP Control Telephony All Services
	This covers cabinets, sub-racks / elements, power supplies, external and internal fibre paths. Also there shall be no common equipment in the signal path. i.e no single point of failure	

Technology testing

National Grid have actively investigated and tested potential replacement Switching Layer technologies over the past few years

Most recently three candidate technologies were subjected to the National Grid Tele-protection Tests.

Virtual synchronous Networking

IP/MPLS

MPLS/TP

Technology Evaluation

	IP/MPLS	MPLS-TP
Description	• Dynamic, network defined channel routing • Control Plane established paths • Connectionless	• Static, user-defined channel routing • Network management established paths • Connection oriented
Bidirectional Channels?	• Without special measures, unidirectional comms channels	• Bidirectional comms channels
Control Plane	• Complex control plane, services complex to set up	• No control plane, services straightforward to set up

Technology Evaluation

	IP/MPLS	MPLS-TP
Supports Protection requirements	• Questionable this it is suitable for Teleprotection traffic. (Failed Stress testing)	• Suitable for Teleprotection traffic
Routing	• Routable protocol (Cyber security)	• Non-routable protocol
Data Path	• Without special measures non-deterministic data channels	• Deterministic data channels

Technology Evaluation

	IP/MPLS	MPLS-TP
Data Channel Security	• L2 and L3 Security needed	• L2 Security only needed
	• IP forwarding, fast rerouting and MPLS forwarding • Pseudowires	• MPLS forwarding Pseudowires • Bidirectional forwarding • Static configuration • In-band OAM
Management Complexity	• Constant supervision required • Hard to troubleshoot	• Configure and forget • Easy to troubleshoot due to deterministic channels

As tested MPLS-TP can provide **Hitless Switching** which provides a safe redundant connection where no data or synchronization is lost when switching from the active to the backup path or vice versa.

On the ingress side the node duplicates each packet onto a second tunnel.

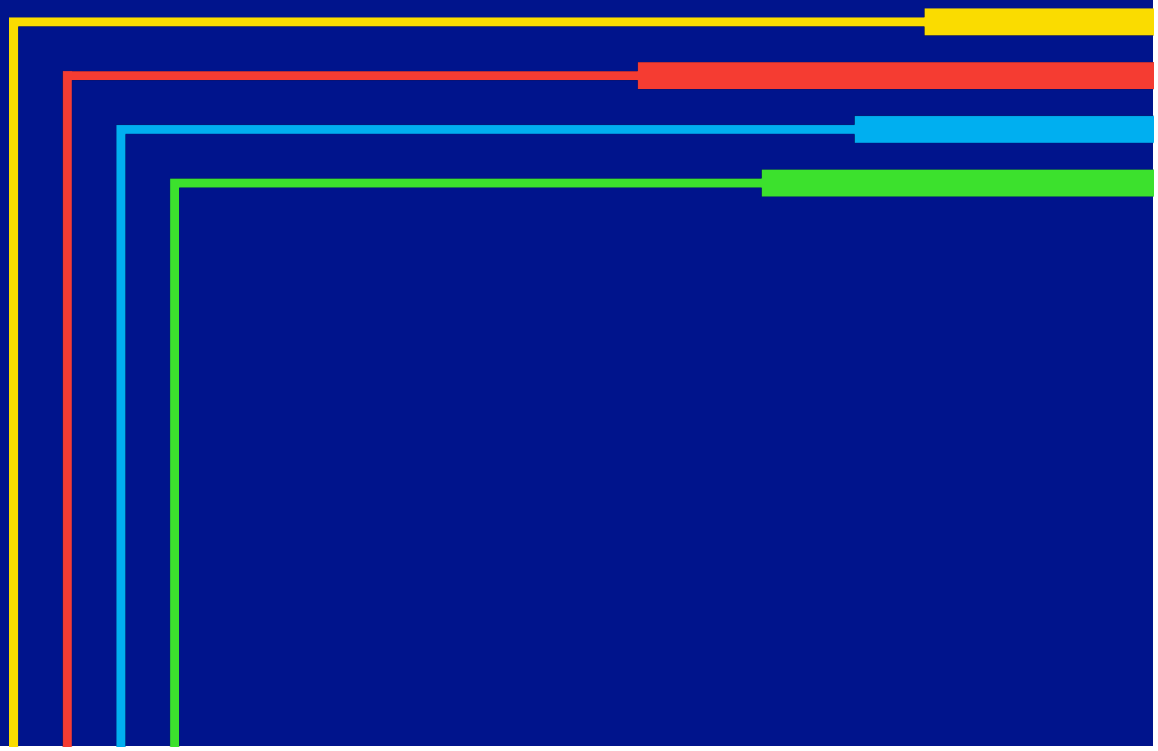
On the egress side the receiving node buffer the packets arriving over the short path so they are processed at the same time as the long path packets, sequence numbers are aligned therefore the receiver can select between packed from either path without any loss

Chosen Solution

Implement MPLS-TP transport protocol for OptelGen3 network

- Tested to meet current performance requirements
- Flexible and scalable to support legacy and future packet-switched technology
- No weaknesses identified

High Bandwidth Overlay



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High Bandwidth Overlay

Scalable, High Capacity, Point to Point Connectivity between sites, Control Centres and Data Centres

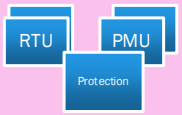
Supporting increasing packet-based bandwidth requirements for current and future demands

- Unencrypted Ethernet over DWDM point to point links
- Higher layer application networks requiring Addressing, Routing, Security and Traffic Profile Management
- HBO Access – nx1Gbps per access site. 150Mbps guaranteed, burst to 1Gbps
- HBO Transport – 10/100Gbps wavelength for through traffic

Options

	Strengths	Weaknesses
Maintain single Switching network Architecture	• Minimises network infrastructure complexity, simplifying management and reduced costs • Reduces (but does not eliminate) the requirement for fibre capacity upgrades	• May not support anticipated growth in packet-switched bandwidth requirements • Single technology is not optimised for disparate Service Layer Requirements
Dedicated Switching Layer Network Optel 3 and HBO Supporting Packet Based Services	• Separate solutions can be tailored to match the requirements of Critical Protection services and emerging packer based operational technology services • Separation simplifies security requirements • Future network growth and upgrades can be carried out independently, reducing risk aligned to technology lifecycles	• Increased multiple technologies, increasing overall network complexity and requiring additional management and maintenance • Additional fibre capacity is required to support network separation at Physical layer

Service Layer
Critical operational Services, including Protection, SCADA, Control Telephony, ICCP, PMU and other emerging energy grid management systems will utilise dedicated Service Layer interfaces



OTSN / RAMM Service Layer
Services utilising the HBO will require an additional Service Layer solution such as RAMM or OTSN to provide the Service Layer interface, network routing, traffic management, security (including encryption) and failover

Switching Layer
MPLS-TP over a combination of fibre pairs, CWDM and DWDM, providing:

- Packet switched connectivity between all sites
- Circuit Emulation Services
- Hitless path protection
- Encryption

Physical (fibre) Layer
CWDM upgrades prioritised to provide additional capacity for Switching Layer, High Bandwidth Overlay and DWDM. DWDM over fibre used where route amplification required or CWDM capacity exceeded

Summary

By deploying separate solutions in parallel, over separate **Physical Layer** connectivity each can have focused capabilities to match the **Service Layer.**

Complex control plane protected point-to-point comms path, security and disparate interfaces met by dedicated **Operationally Critical Solution** whilst a simpler bandwidth only network can effectively support the future evolution of other packet based **Operationally Important Services**.

Transformation Approach

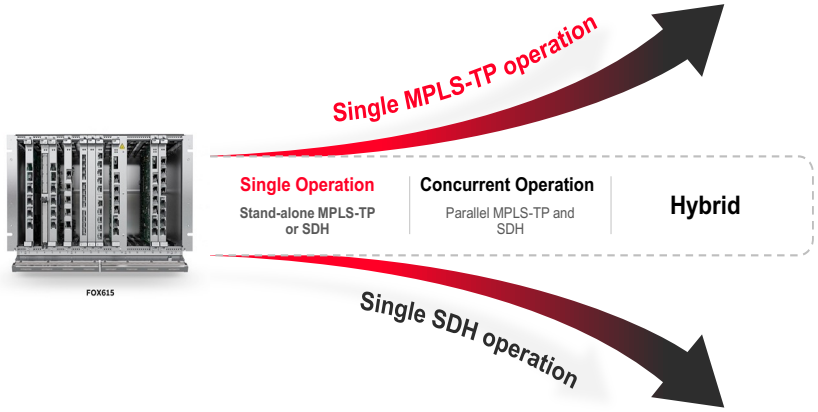
Avoid Parallel Optel Network Build

- Minimise new Cabinets – Space and Power
- Minimise new Cabling to Protection and Communication Systems
- Minimise the requirements for dual ended service cutovers
- Minimise resource requirments

Transformation Approach

Undertake a multistep transformation to maintain network and operational integrity

- Utilise technology benefits of Hybrid Operation of SDH and MPLS-TP
- Adopt a node by node swap minimising loss of resilience
- Process driven with simple controllable steps, with full reversion capability at each stage
- Maintain network visibility on a single management platform



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