Network Upgrades
SubOptic Guide Workshop #3

Presenter: Colin Wallace
Company: Ciena
Presenter Profile

Colin is responsible for Engineering Design and Technical Optimization of Ciena’s submarine solutions offerings. Previous to this role, Colin worked as the Product and Systems Engineering Manager for Ciena’s sales to two major operators. Prior to joining Ciena, Colin held senior roles at Corning including, Systems Engineering Manager, Business Development Manager and Service Development Manager. Colin holds a BSc in Physics and a PhD in Fibre Optic Sensors from the University of Strathclyde.

**Presenter Name:** Colin Wallace  
**Title:** Director of Submarine Systems Engineering  
**Email:** cwallace@ciena.com
GUIDE Session 3 - Upgrades

- **Phase 1 (Planning):**
  - Explosion in Bandwidth
  - Economics of Upgrades
  - Technology
  - Design considerations
  - Future Technologies

- **Phase 2 (Procurement):**
  - Considerations

- **Phase 3 (Construction):**
  - Coupler Insertion
  - Migrations
  - Critical Paths

- **Phase 4 (Owning & Operating):**
  - Training
  - Sparing
Explosion in available bandwidth

- Primarily coming from system upgrades
- 100G coherent driving unheard of increases to capacity
Implications

• The Customers are changing
• Content providers, SDN and Cloud Computing are driving the bandwidth requirements across Submarine Cables
• A fundamental change in the business economics because system upgrades are providing a much larger capacity and re-setting the cost point
• Drives end to end networks and datacentre connectivity
The Economics of Upgrades over a System Lifetime

- First install ultimate capacity determines the initial cost per Gb for the cable owner / owners
- Newer cables tend to have higher capacities and hence lower cost per Gb but large initial CAPEX
- Lit capacity becomes expensive as time passes (high underlying CAPEX and OPEX)
- An upgrade on an existing cable will take advantage of the latest SLTE technology, significantly increasing the ultimate capacity.
  - Cost per Gb is significantly reduces after the upgrade
- This process can happen multiple times
Examples of Improvement to Ultimate Capacities

Reference: Ciena
Conventional Optics

Morse Code:
Dumb receiver.
Power (on/off) carries info.

Digital Radio:
Amplitude, Phase & Polarization carry info.
Tunable receiver. Digital Enhancements.

DCF: Dispersion Compensation Fibre
A: Optical Amplifier / Repeater
PMDc: Polarisation Mode Dispersion Compensation
Tx: Transmitter
Rx: Receiver
MUX: Optical Multiplexor
DEMUX: Optical Demultiplexor

Optical complexity replaced by
digital signal processing

DCF: DCF
A: A
PMDc: PMDc
Rx: Rx

MUX: MUX
DCF: DCF
PMDc: PMDc
Rx: Rx

Tx: Tx
Tx: Tx
Managing Dispersion on Cable Systems

Multiple Fiber Types

Periodic Dispersion Compensation

Repeater

Type1

Type2

Repeater

Type3

x N

x1
Advantages of Coherent Technology

Non-Coherent Terminal

→ Pre/Post Optical Comp for each channel!
→ Adds latency at high dispersion
→ Incremental cost for each new band
→ Large footprint
→ Needs constant maintenance

Coherent Terminal

→ CD Compensated Automatically
→ Simplified Design
→ Smaller footprint
→ Less maintenance
Why consider removing existing technology?

10G On Off Keying (OOK) vs 100G Phase Shift Keying

100G co-existing with 10G OOK
- Erodes performance margins of 100G
- Requires guard band on spectrum – reduces ultimate capacity
- Will ultimately need to be removed – just delays the inevitable
Fiber Evolution

<table>
<thead>
<tr>
<th>Year</th>
<th>Type</th>
<th>Dispersion ps/nm.km</th>
<th>Effective Area um²</th>
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<tbody>
<tr>
<td>1994-1997</td>
<td>Dispersion Shifted Fiber</td>
<td>-0.185</td>
<td>52</td>
</tr>
<tr>
<td>1997-1999</td>
<td>Non-Zero Dispersion Shifted Fiber</td>
<td>-2 to -3</td>
<td>52</td>
</tr>
<tr>
<td>1998-2008</td>
<td>50% Large Core Fiber 50% Reduced Slope Fiber</td>
<td>-3 to -4 -2 to -3</td>
<td>70 to 80 52</td>
</tr>
<tr>
<td>2005-2013</td>
<td>66% P-Type 33% N-Type</td>
<td>18 to 20 -36 to -40</td>
<td>100 to 120 25 to 30</td>
</tr>
<tr>
<td>2012 on</td>
<td>100% P-Type</td>
<td>20</td>
<td>100 to 140</td>
</tr>
</tbody>
</table>

- High Dispersion and High Effective Area Is good for Coherent Transmission
- Dictates how upgradeable the cable is
- All cables are upgradeable regardless of fibre type
Submarine SLTE ROADM

Power management channels added locally

Submarine SLTE ROADM

Terrestrial Backhaul Route

PoP

Submarine Tx/Rx

λ₁  λ₂  ...  λₙ

λ₁  λ₂  ...  λₙ

Cost / Opex Reduction
Reliability Improvement

Submarine transponders are relocated directly into the PoP
Removes four terrestrial backhaul transponders for each inland wavelength

Redundant Terrestrial Backhaul Routes

Terrestrial Backhaul Route

PoP

Submarine Tx/Rx

λ₁  λ₂  ...  λₙ

λ₁  λ₂  ...  λₙ

Know your traffic matrix
Photonic Cable Landing Station

Know your traffic matrix

Express Wavelengths

Flexible wavelength routing between express and drop ports

- Remove REGENs for express wavelengths
- Fixed channel filters for connecting client ports
- Power management added/dropped in both directions
100Gb is now table stakes
200G per wave is only 1 or 2 years away
400G and 1Tb channels will be available in the next 4 years
Requires new use of spectrum

Gridless
Can recover spectrum on already deployed channels

Note: The timing of technology availability is the authors personal opinion of the industry and not a Ciena Roadmap
• Instead of buying capacity or wavelengths, buyers will be able to purchase spectrum.
• Enables the purchaser
  • To choose any SLTE vendor and transmission rate
  • Upgrade to newer technology at will
• Has commercial implications
  • Need to ensure interworking
Procurement

- Need to have good documentation of existing wet plant to enable the upgrade supplier to estimate upgrade potential
  - Need Fibre specifications
  - Straight line diagrams with what fibre is where
  - Repeater details (Noise Figure, gain, Output Power, bandwidth)
  - Existing transponder types and launch powers
  - Spectral shots
- Fibre characterisation is essential, especially on older cables where there may be repairs and out of date documentation
  - Allow a reasonable period of time for this
  - May require some traffic downtime
- Review Contract Document For Upgrade (i.e. Durations)
  - What was non critical in the initial deployment can be on the critical path in an upgrade (i.e. Design Review before commencing manufacturing)
Need to know
- Fibre type
- Current Loss
- EoL Loss
- Attenuation in first 25km
- Lump losses in first 25km
• Coupler Insertion essential
• Ideally installed with initial deployment
• Usually requires up to 1 hour of downtime
• Adds 3dB loss to original SLTE (equivalent to a cable repair)
Supervisory

- Passive Supervisory
  - Try to re-use existing supervisory system
  - Generally only requires a 90:10 coupler
  - New Passive supervisory is expensive

- Active Supervisory
  - Can generally re-use existing while incumbent has > 50% of the spectrum
  - After this, new supervisory system is required.
  - Majority of upgrade suppliers have supervisory capability

- Ideal solution would be to have supervisory supplied by the wetplant manufacturer that is independent of the SLTE and can remain in place throughout life of cable regardless of SLTE supplier
• Migrations
  • The closer to original ultimate capacity, the harder and longer the migration will be
    • Multiple soak tests
    • Guard bands
    • Maybe only able to test against commissioning limit at last stage
  • Original Wavelength re-tuning can sometimes help but needs co-operation of OEM supplier

• Timeframe
  • Depends on size of upgrade
    • Single DLS on a dark fibre – 2 to 3 months
    • Large consortium – 9 months to 1 year
• **Training**
  - Required because new equipment and new NMS
  - Timescales much shorter – shift working impacts scheduling
  - Should consider web based training with hands on knowledge delivered by the commissioning team

• **Sparing**
  - Hot spares and Hot chassis is often a requirement
  - Hot chassis is un-manageable due to large quantity of fibres
  - Ages cards prematurely
  - Should consider on site testing then cold sparing in ESD cabinets
Key Takeaways

- Have detailed specifications and past history of repair operations of the cable you want to upgrade in advance of issuing an RFx
- Accept the premise that Coherent Behaviour is very different to traditional SLTE systems
- Know your traffic matrix
- Be prepared for an outage in order for the upgrade to vendor to characterise the cable
- Be prepared for surprises in terms of upgradability (i.e. Tilt on the system)
Slides Will Be Available Online, With backup material, including a glossary of terms