



Open and Extended Systems

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- Pros and Cons
- What the Open System has to do
- How to ensure that it all works
- How to improve on the simple solution



Definitions, Benefits and ...

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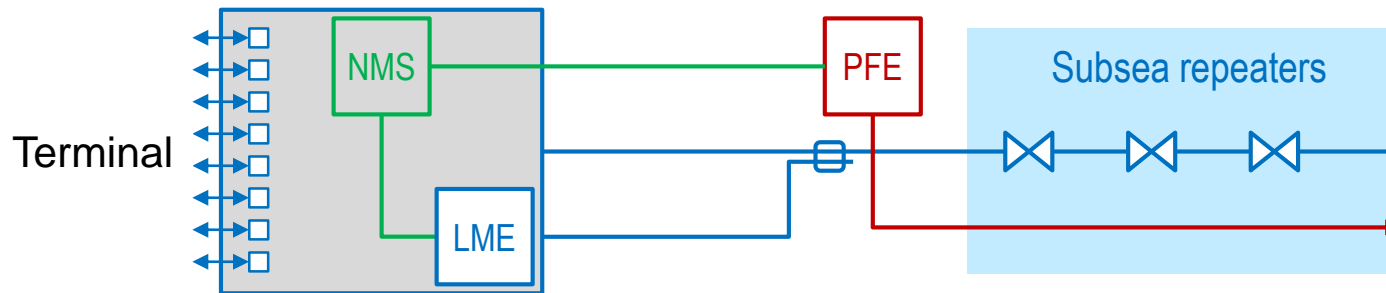
"Open" (from on-line dictionaries)



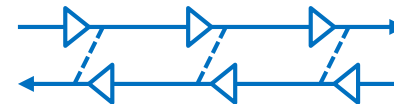
Allowing access, passage, or a view through an empty space; not closed or blocked up; exposed to the air or to view; not covered

Traditional system

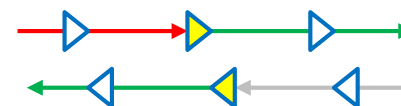
- Terminal equipment monitors Line (LME) and Power Feed Equipment (PFE)
- There are around four types of PFE
- There are two flavours of Line Monitoring



1. **Passive:** loops / reflective filters
subtleties e.g. BU switching

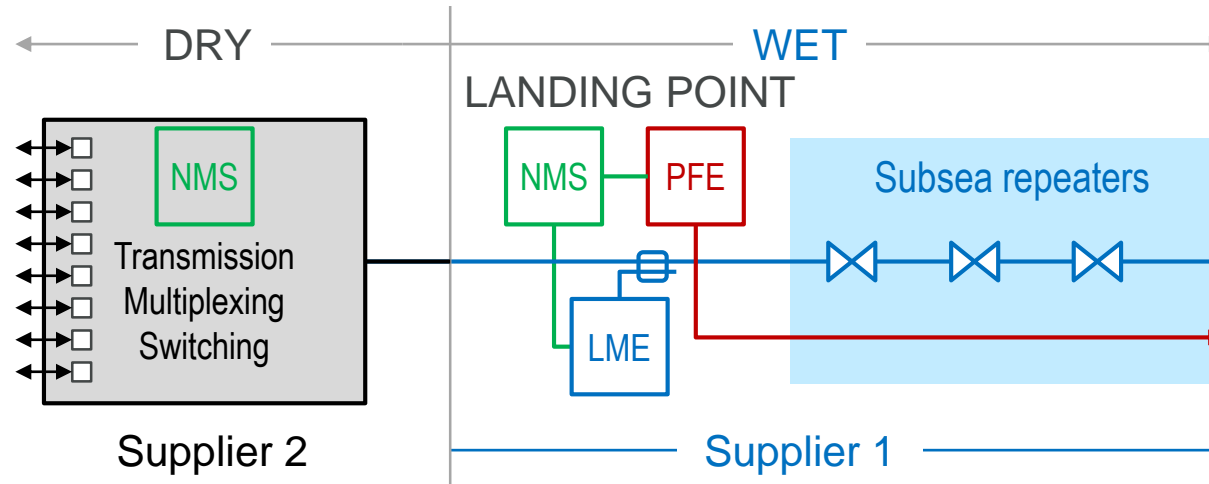


2. **Active:** send a **command**, get a **response**



Open system – one definition

- Wet-plant (incl. PFE and LME) designed to accept any Terminal
- Terminal can ignore power-feeding and line monitoring



- Any terminal should work, providing it can tolerate the Line Dispersion, Noise etc. from the subsea cable

Open systems – the Pros and Cons



PROS

- Competition
- Optimisation – can pick the best individual units
- Long-term flexibility – not tied to a particular supplier

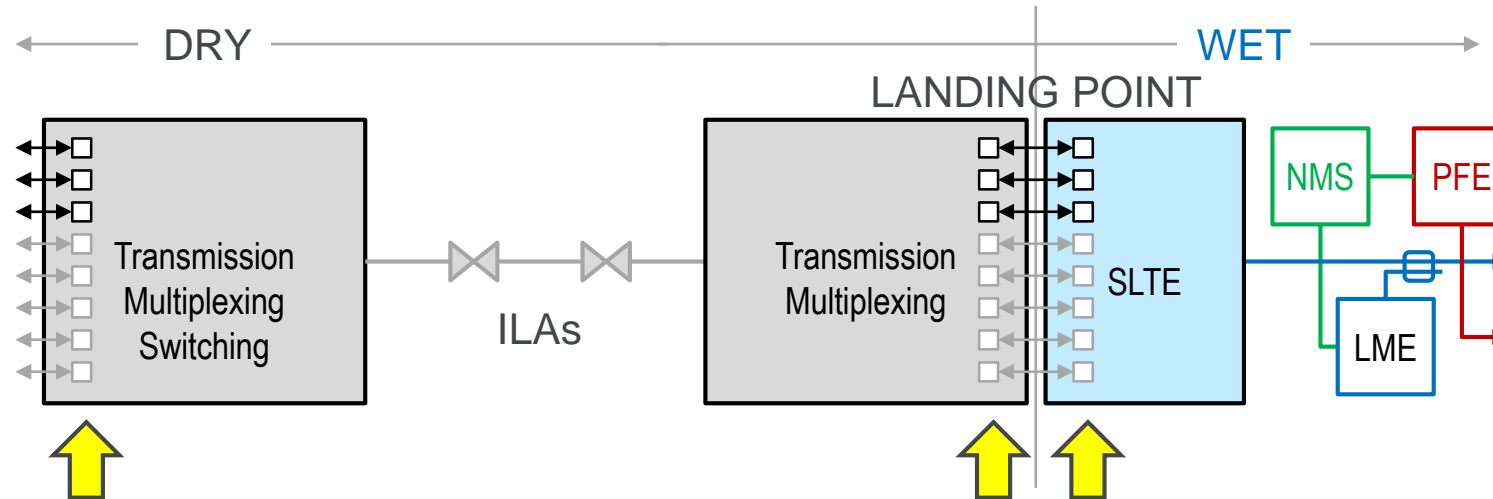
CONS

- More complex contractually
- More technically demanding
- More complicated Network Management



Traditional system

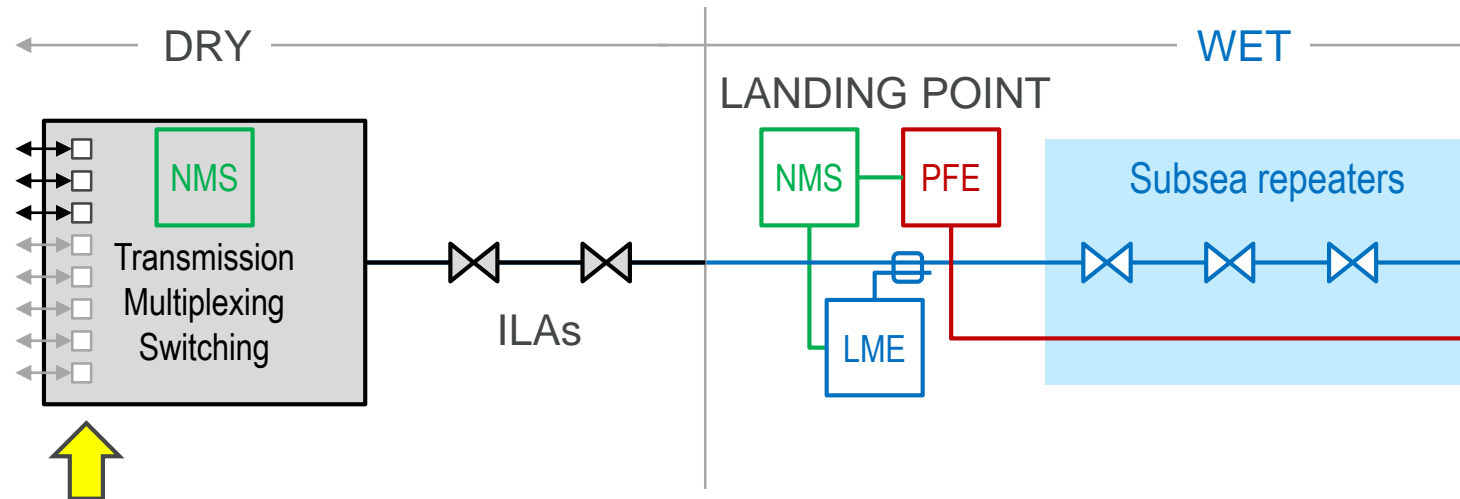
- Back-to-back terminals at Landing Point
- Full regeneration – minimises noise



- Requires lots of back-to-back connections
 - Expensive
 - More complex to increase capacity

Extended system

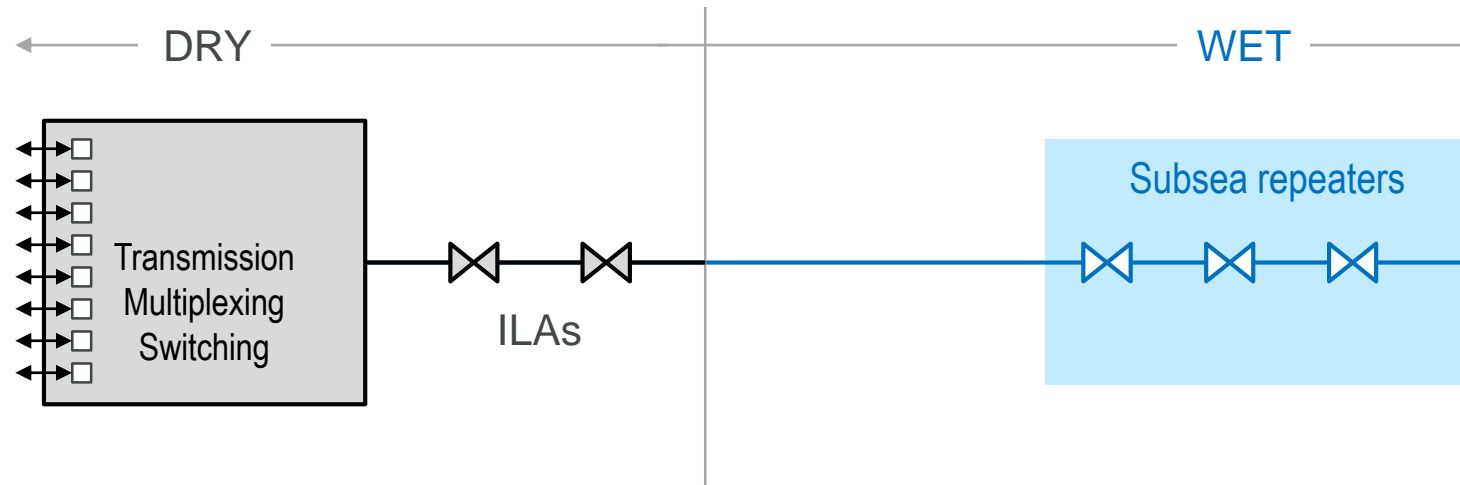
- Transmission goes directly from source to delivery point
- DRY part includes Intermediate Line Amplifiers (ILAs)



- Significantly less equipment – lower cost / faster capacity increase
- Extra noise from ILAs

Extended system – the transmission challenge

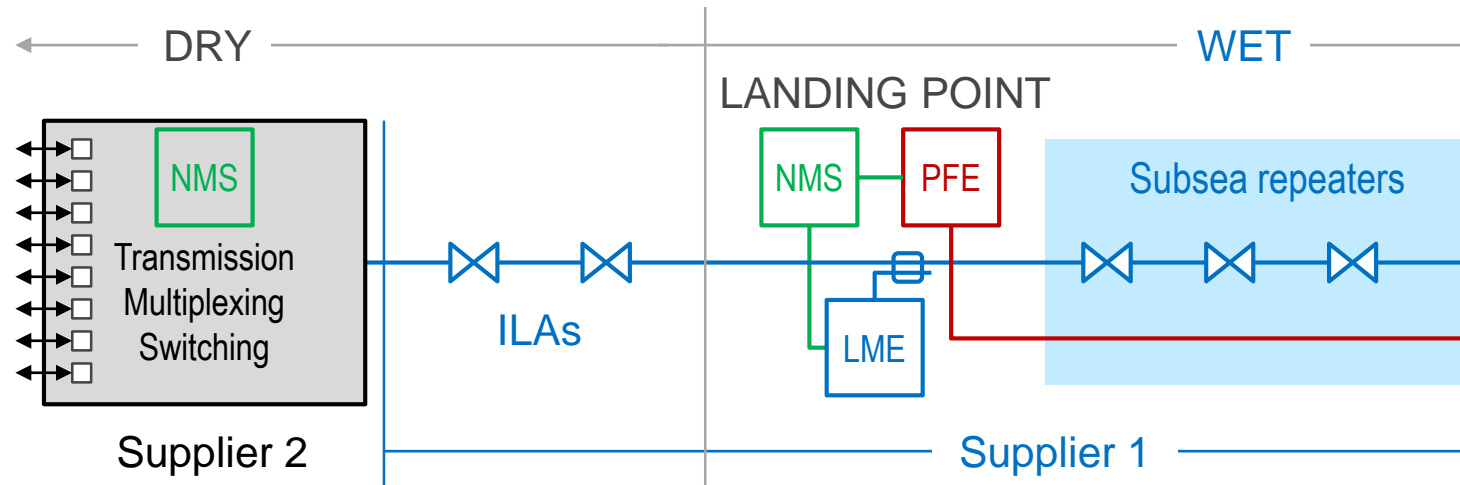
- The noise and distortion of wet and dry parts are effectively added
- Each amplifier section contributes noise and distortion



- Noise contribution of an amplifier = $\text{Constant} \times \text{Noise Figure} / \text{Input Power}$
- Reduce noise by:
 - Closer amplifier spacing cost increase
 - Lower noise figure not always possible
 - Higher output power will increase non-linear distortion

Extended system – a different supply split

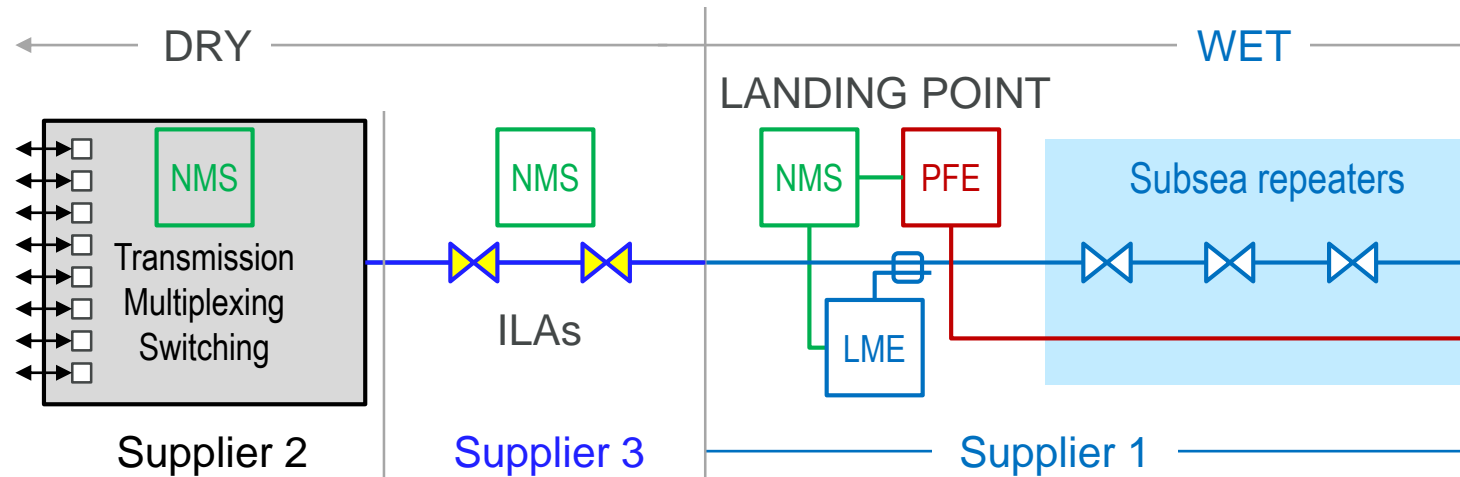
- Intermediate Line Amplifiers (ILAs) could be part of "wet" supply



- For example to get lower noise amplifiers in the dry part

Extended system – split three ways

- Intermediate Line Amplifiers (ILAs) could come from a third supplier



- For example if the terrestrial link already exists
- Has three NMS



Commercial / Contractual issues

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The DRY and WET parts must inter-work at the traffic level

- Need to have correctly designed interface specifications
- Need to consider acceptance criteria

The NMS must give unambiguous fault indications

- Important for warranty and technical support to work
- Need to consider fault conditions

It's no different to a third-party upgrade?



- Almost true

Build and upgrade

1. Build a system with terminals
2. Test and commission
3. Operate
4. Test / Assess system
Can use some operational data
5. Add third party terminals

Open Solution

1. Build a system without terminals
 2. Test and commission
 - 3.
 4. Don't want to delay contract
No operational data
 5. Add third party terminals
- **How to commission and accept without terminals?**



There are other solutions



Use just one supplier initially

- No third-party equipment, but extra ports for later connection
 - Initial supplier SLTE used to validate wet-plant performance
- + Only a single supplier
- Hard to be sure that the system is really open

? Use an independent test service

Use two suppliers initially

- Includes third-party equipment, contractual requirement to work
 - Third party SLTE used to validate wet-plant performance
- + Can choose "best" suppliers
- ? Easier to be sure that the system is really open



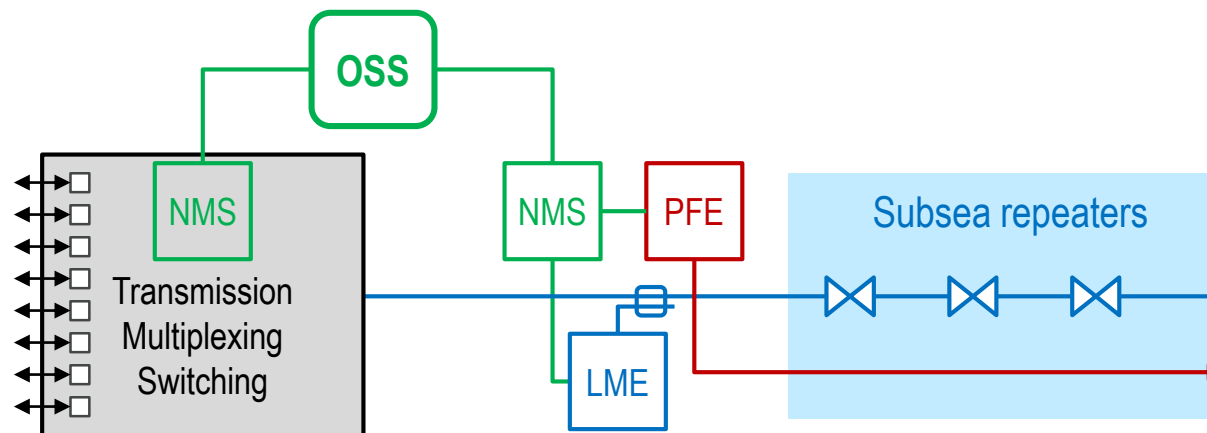


Network Management

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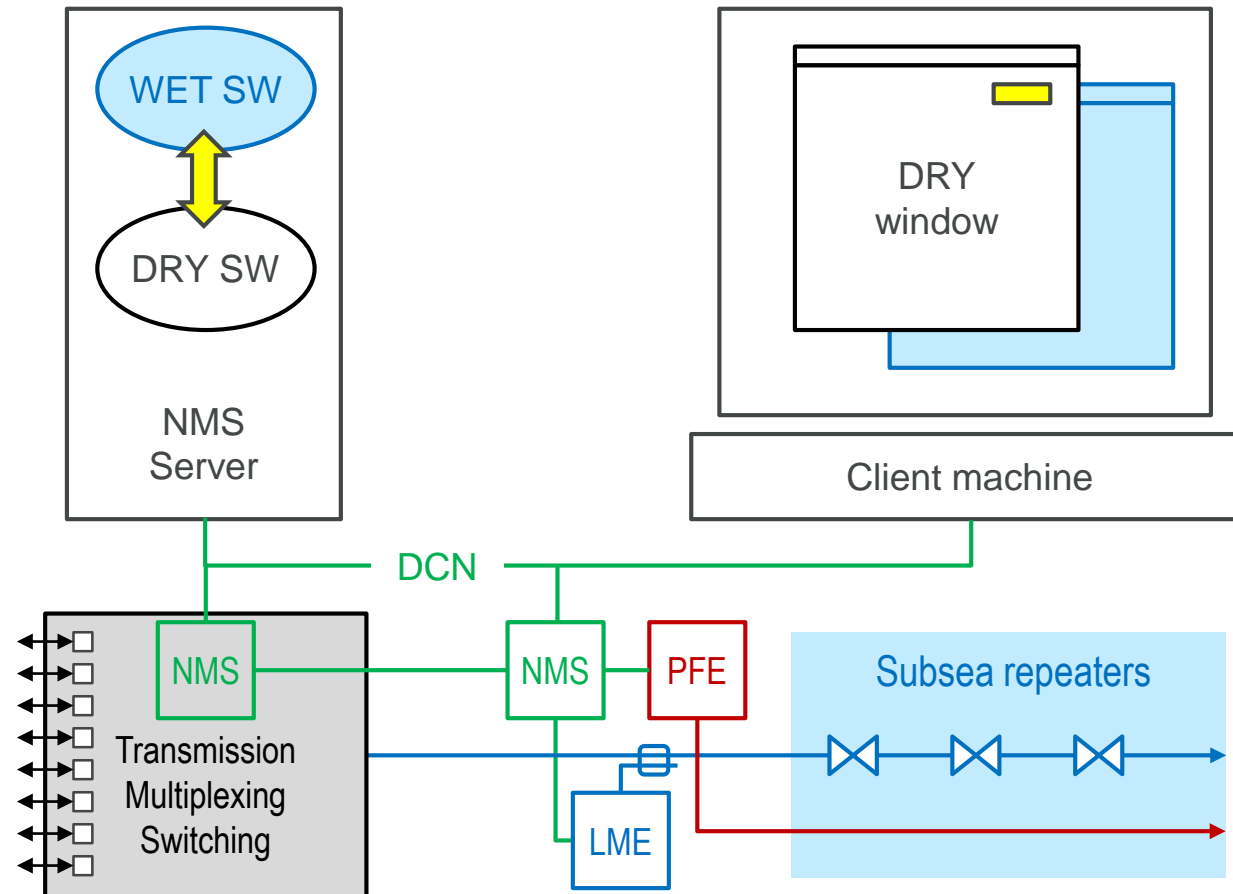
What to consider regarding NMS

- DRY equipment much more complex than WET
 - Performance data for many wavelengths
 - Configuration changes are likely
- WET equipment simpler
 - Periodic repeater scans; PFE voltage & current
 - Configuration is likely to be static
- Will be two, or more, NMS
- Could have an higher level system – or shared hardware (next slide)



Virtualisation to share NMS resources

- Need a mechanism to see alarms in other windows



- Or the lack of it ...?
- Virtualisation only compartmentalises the software elements
- Should consider if there is good system-level protection
- Do third-party SLTEs have subsea control capability?
Especially important with switchable Branching Units
- Are there any specific issues to be addressed?



Testing / Validation

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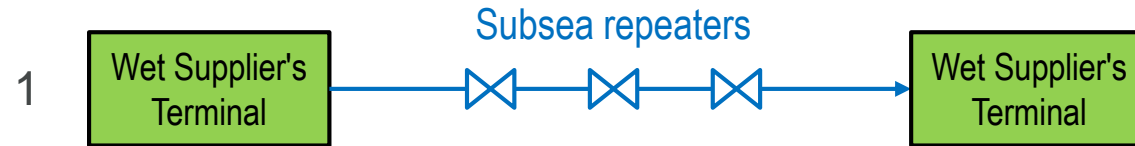
What the Terminal Supplier needs to know



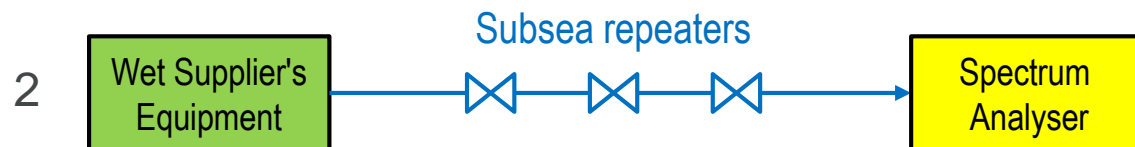
- Fibre: attenuation
 fibre core size └───┬───> determines non-linearity
 dispersion |
▪ Repeater: output power └───┬───> may vary with wavelength
 bandwidth |
 noise figure |
▪ Other: repeater spacing
 loss of in-line equalisers └───> may vary with wavelength
▪ Interface: line-amplifier noise figure └───> may vary with wavelength
 optical levels └───> may vary with wavelength
 connector types
- These *should* define the performance of the submerged portion
- **How can they be validated?**

How to validate the WET part

- After the first phase of the build

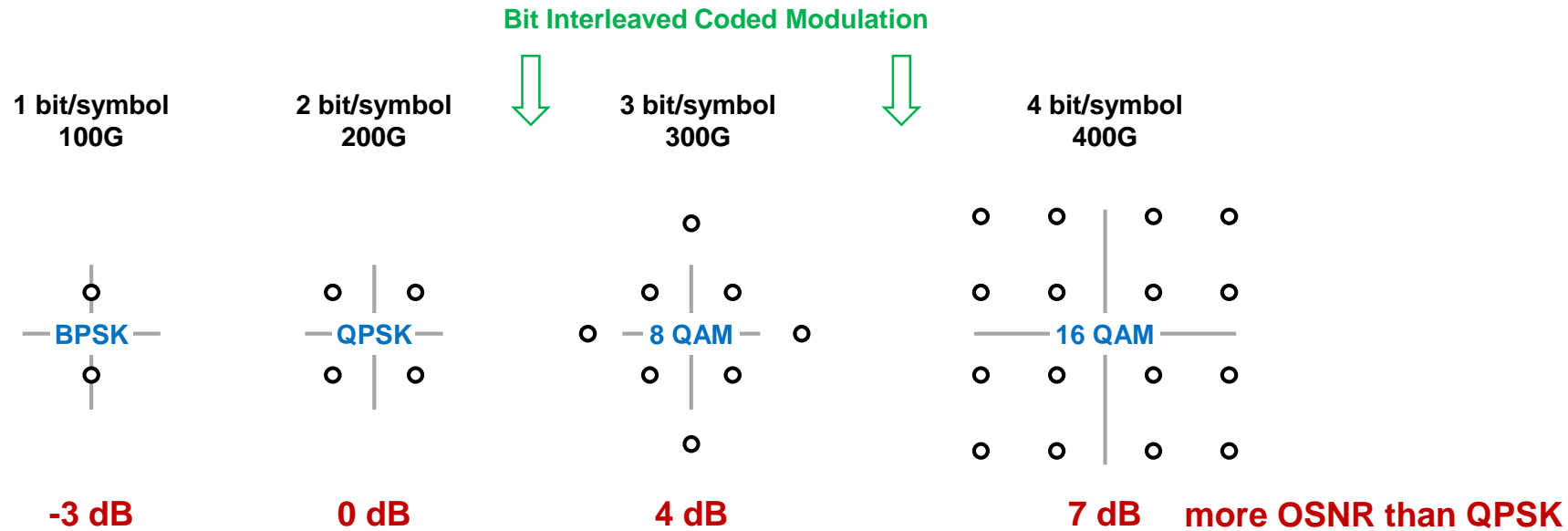


- Proves that the system works in for one supplier
- Is it representative? Dry supplier may use a different modulation or have different performance



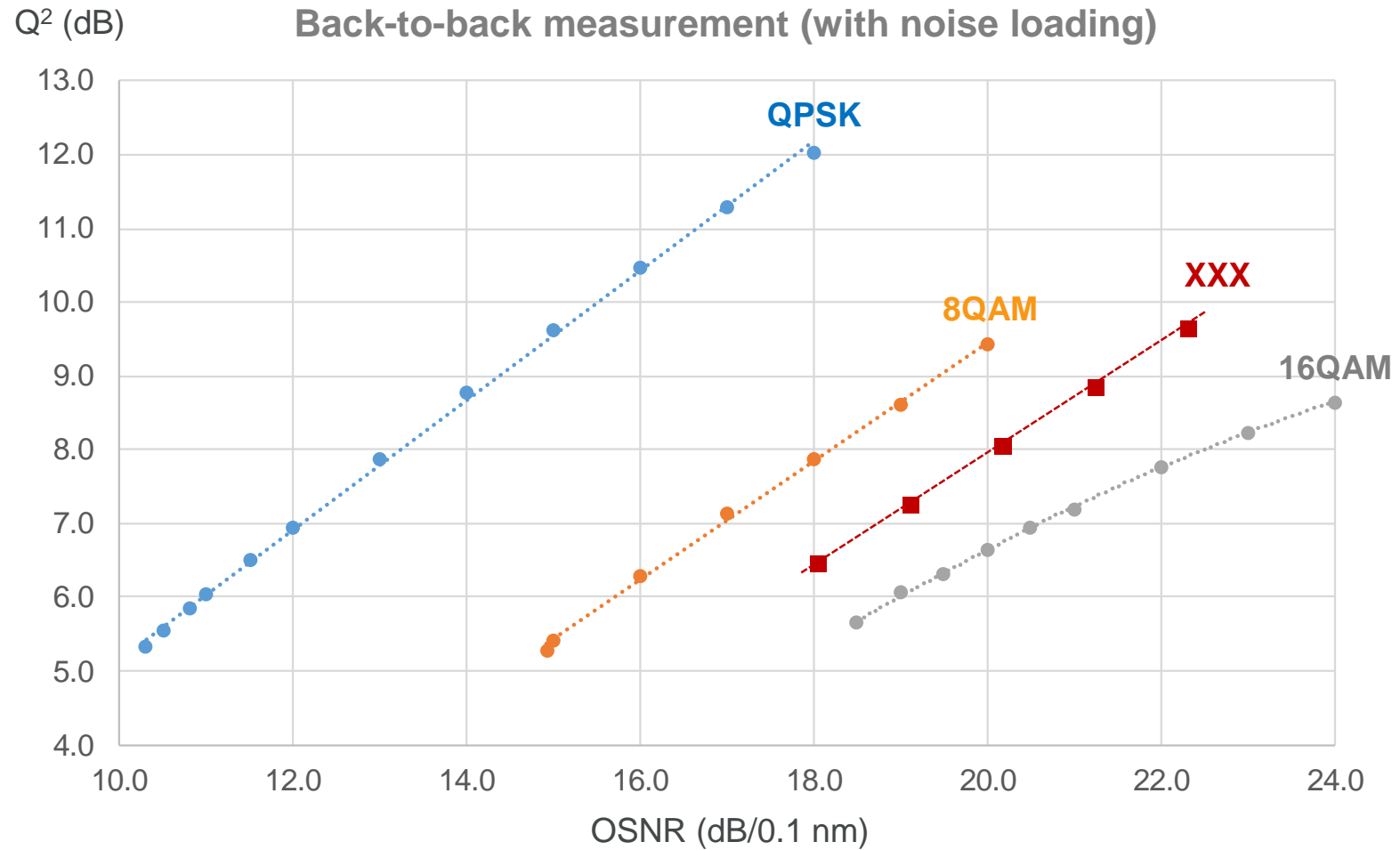
- Provides OSNR and Q is clearly related to OSNR
- Useful, but may not expose non-linear issues

Higher order modulation formats



- Higher order formats need more OSNR typically higher signal levels
risk of non-linear penalties

Q and OSNR – Example



Power budget (BOL – Beginning Of Life)

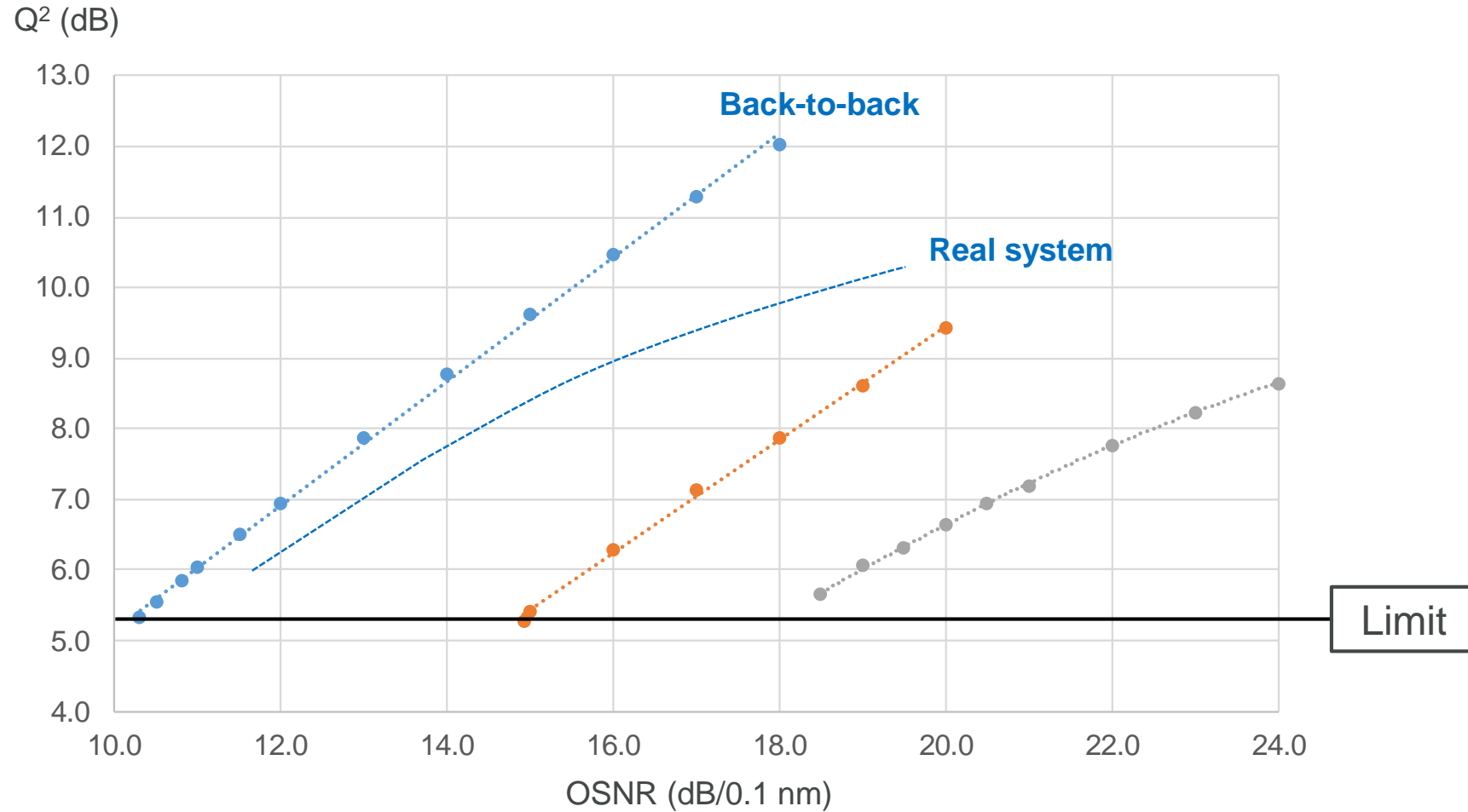


- A BOL OSNR at full loading
- 1 Back-to-back Q at BOL OSNR
- 2 Propagation impairments
- 3 Other impairments
- 4 Margin for Q variations (5 sigma)
- 5 BOL Segment Q ↔ Segment OSNR
- 6 Repair and ageing impairments
- 7 EOL Segment Q
- 8 FEC limit at BER = 1E-14

- 3.1 Non-optimal pre-emphasis
- 3.2 Wavelength tolerance
- 3.3 Polarisation effects
- 3.4 Supervisory impairment
- 3.5 Manufacturing etc.
- 3.6 Unspecified

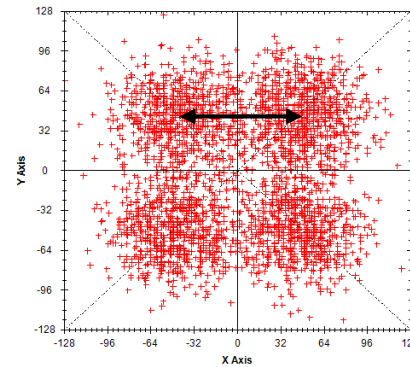
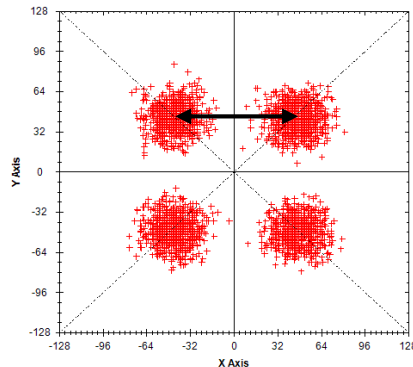
▪ Can one use Segment OSNR in this way?

Q and OSNR – Example



A possible solution – G-OSNR

- Generalised OSNR (also known as Electrical OSNR)
- Uses a coherent detector to measure the OSNR at the decision point
- Measure statistical spread and constellation spacing



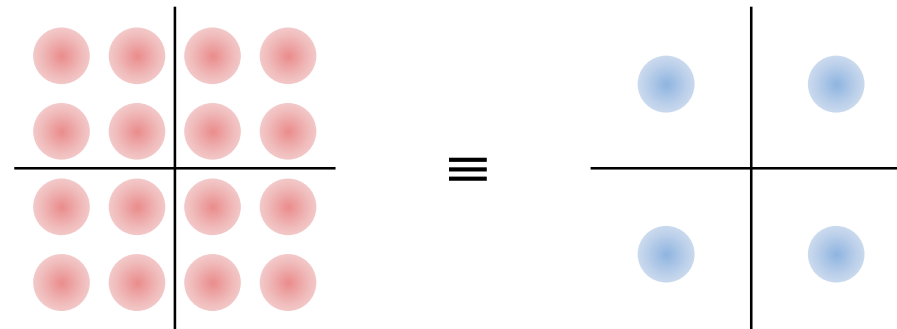
covers ALL impairments
includes non-linearity

- If the setup is representative, the resulting G-OSNR can be used

Example measure G-OSNR using QPSK, then apply result to 16QAM

Correct use of GOSNR

- Conditions need to be comparable
 - Same WL grid
 - Same power per wavelength
 - Correct pre-emphasis



- Ideally:
 1. Measure for a range of conditions
 2. Check by doing some inter-operation testing

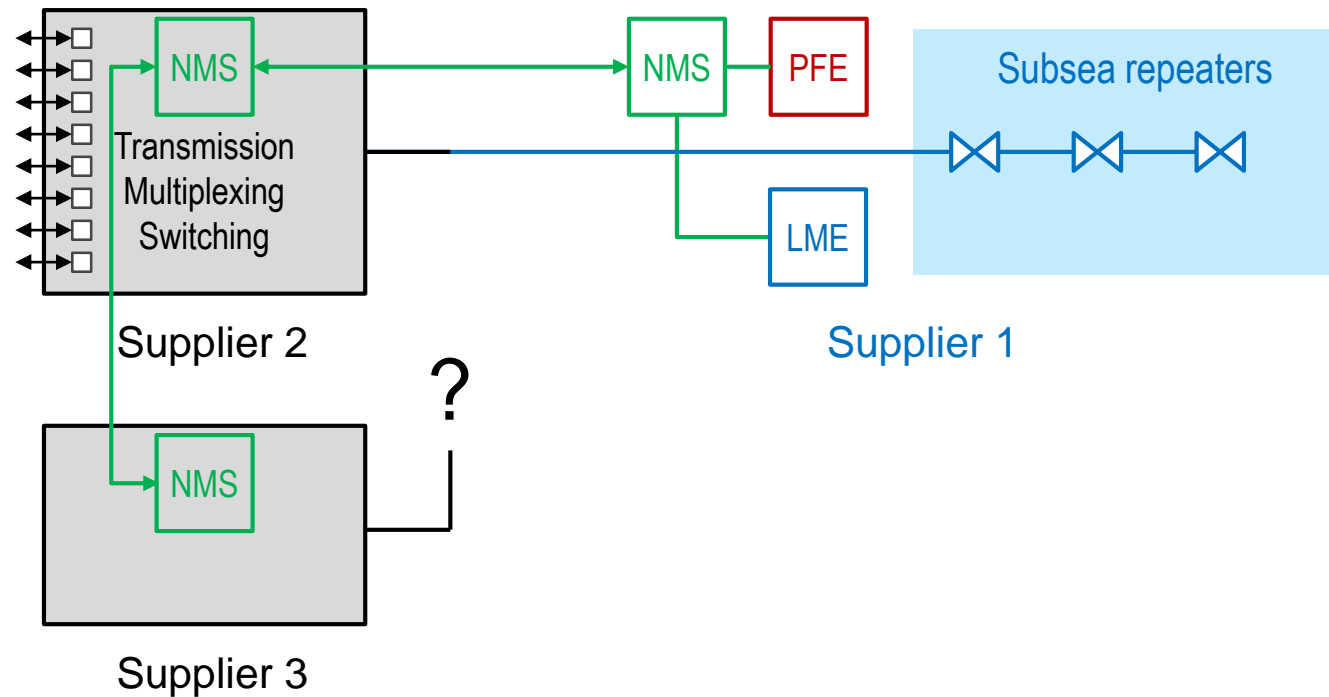


Improving the Open Interface

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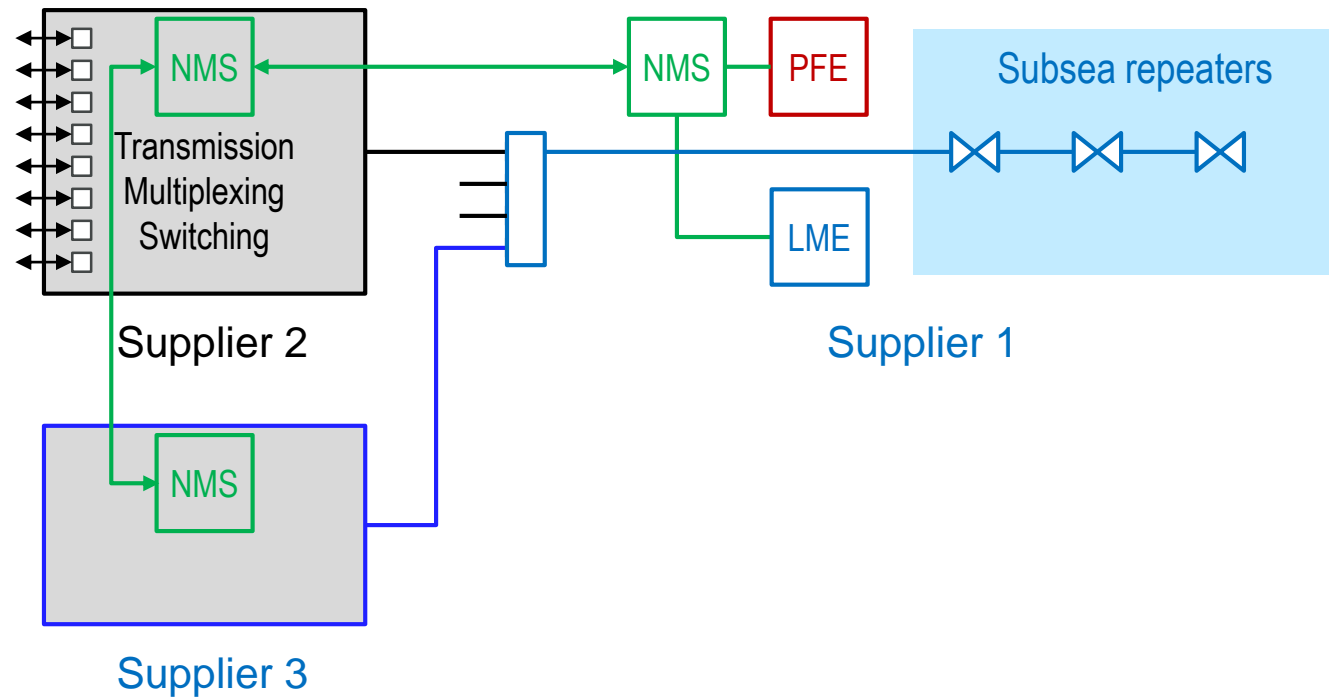
Adding capacity later

- Should be considered initially



Adding capacity later – simple solution

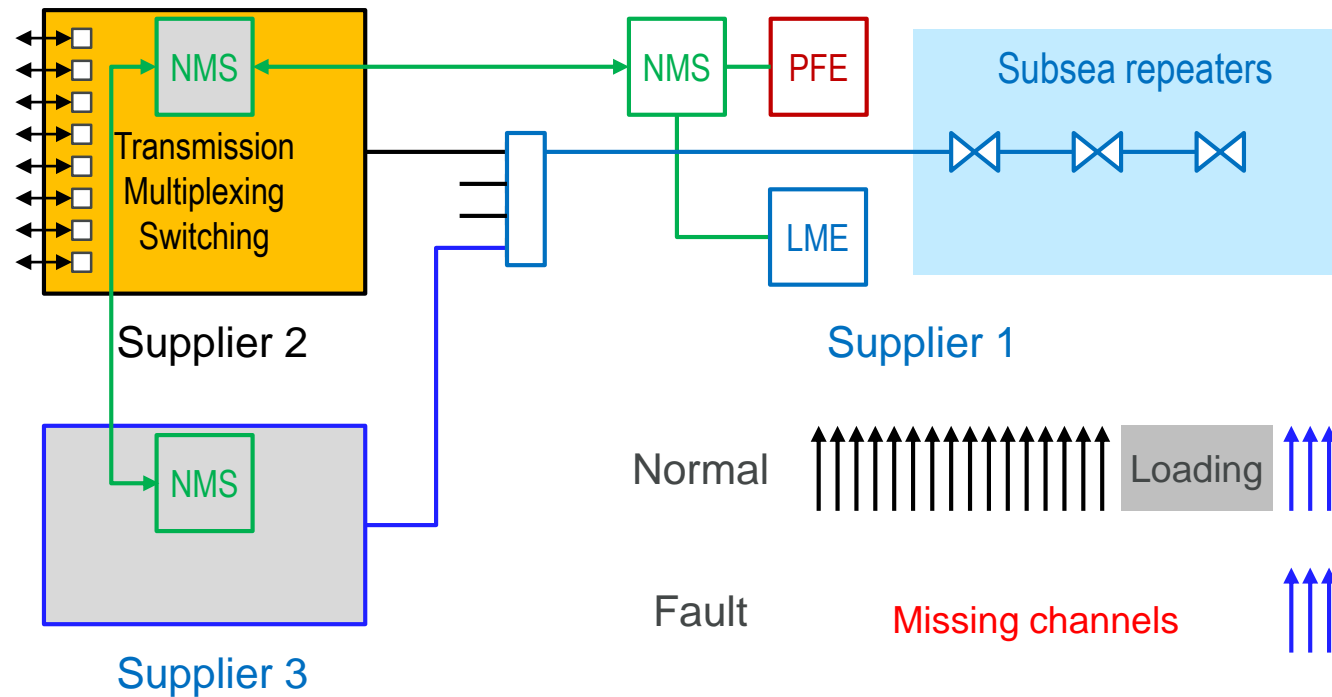
- Use a multi-port coupler



- Important to get wavelengths and levels correct

Adding capacity later – potential problems

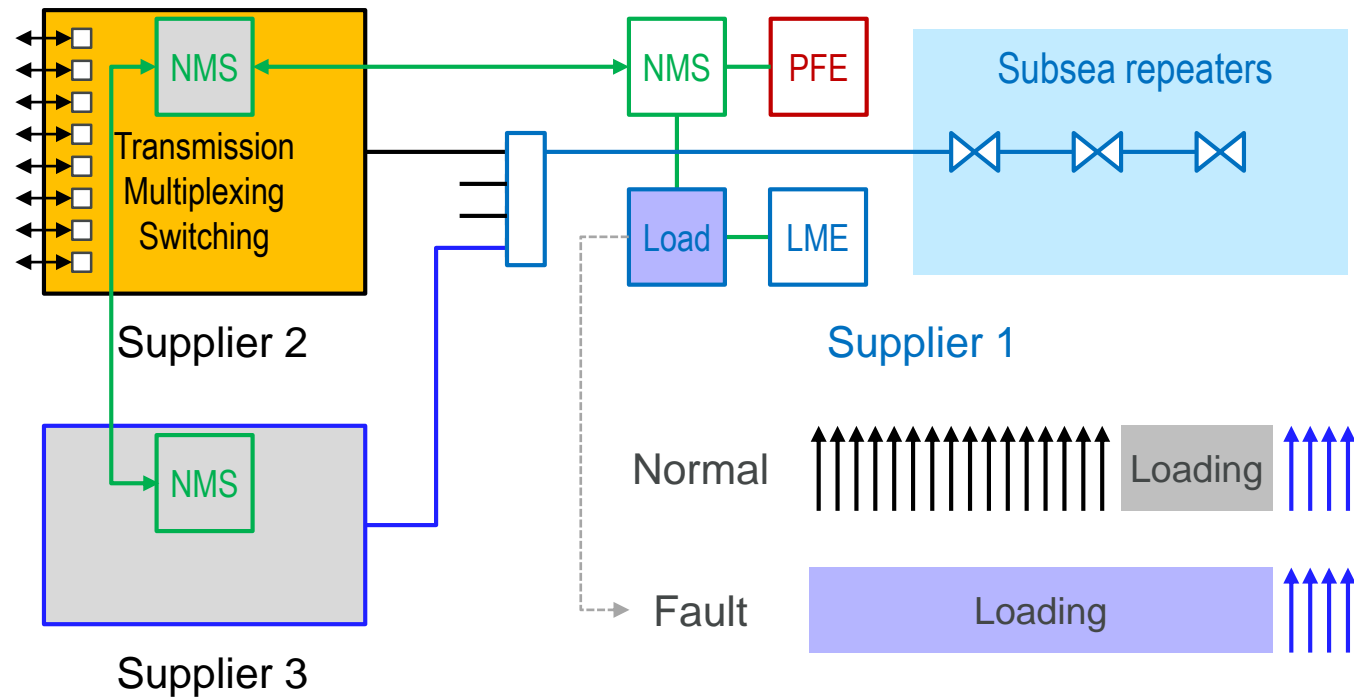
- Example: Terminal fails



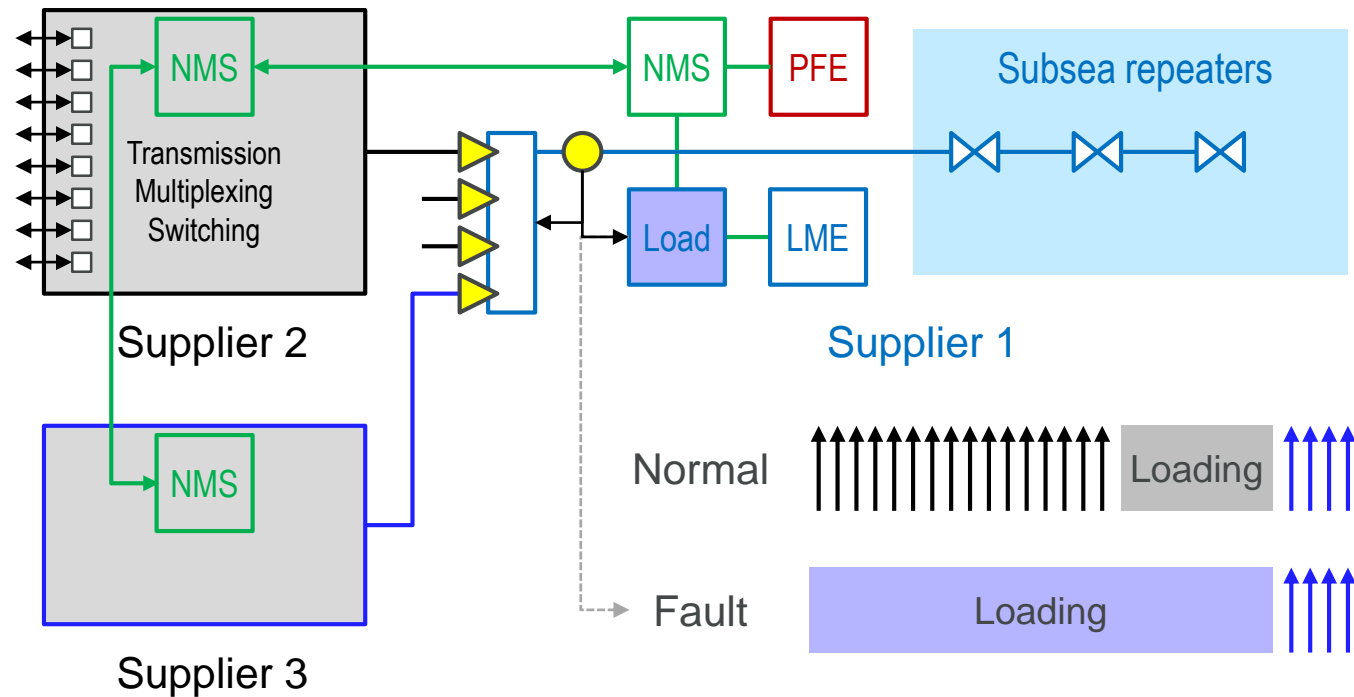
- Will affect Supplier 3 wavelengths

Make the wet interface handle the problem

- Wet Interface monitors input signals; adds loading when needed



- Control levels to avoid any interactions



- Provides complete isolation of different terminals

- Open systems offer several benefits, but may not be for everyone
- There are several flavours of Open
 - Configuration
 - Contractual arrangement

- Key technical challenge is Acceptance testing of the WET portion

- Other things to consider
 - Network Management – at least two solutions
 - Security
 - Isolation of different suppliers
 - Whatever I forgot ...

- If you have questions or comments please email them to Tony.Frisch@Xtera.com



Thank you for listening

Any questions?

Email them to Tony.Frisch@Xtera.com

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