Issues in DWDM Testing

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Agenda

- What your Equipment Measurement system limitations
- Challenges with 100G
- Other impairments in optical systems

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Rise of EMS

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Situation

- **What is EMS?**
- Uses Optical Channel Performance Monitoring using embedded device in EDFA's, ROADM's etc to monitor channels.
  - Provide Power, Wavelength & OSNR

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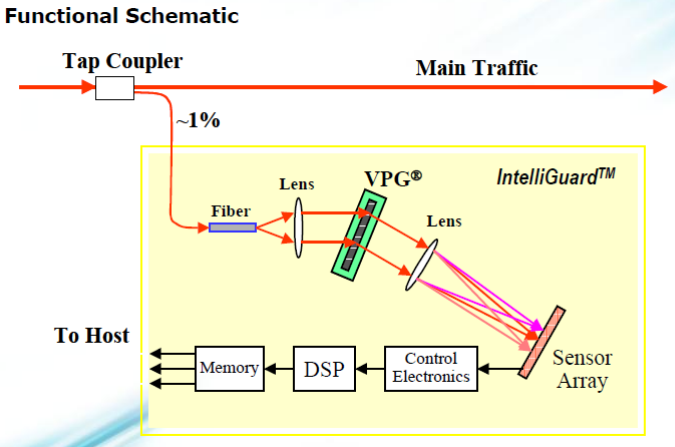
Optical Channel Performance Monitoring - example



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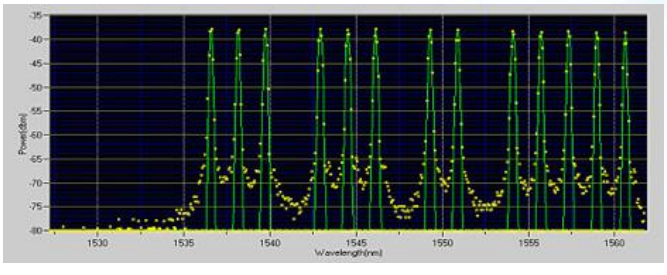
Optical Channel Performance Monitoring



› Example output from OCPM for 10G, 100GHz Channel Spacing

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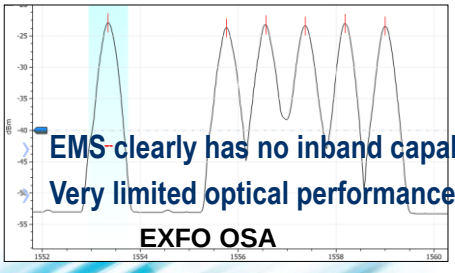
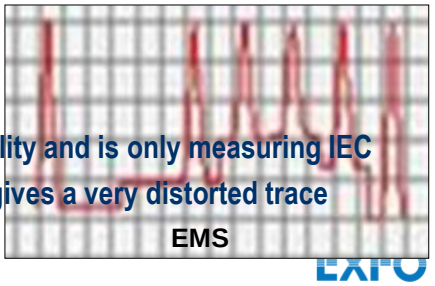
An example of a major European operator

Ch. #	OSNR (dB)		
	EMS	EXFO	Δ
1	35.3	23.4	11.9
2	30.1	24.2	5.9
3	22.0	24.9	2.9
4	21.2	24.0	2.8
5	27.4	28.0	0.6
6	36.9	27.9	9.0





EMS clearly has no inband capability and is only measuring IEC

Very limited optical performance gives a very distorted trace

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EMS Conclusion

EMS are very limited in accuracy (even where IEC valid)

Limited to 2.5 & 10G systems at 100GHz channel spacing

Not valid where we have ROADMs

Large errors at 50GHz channel spacing

An In-Band capable OSA is required to get an accurate picture of the network.

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100G OSNR story

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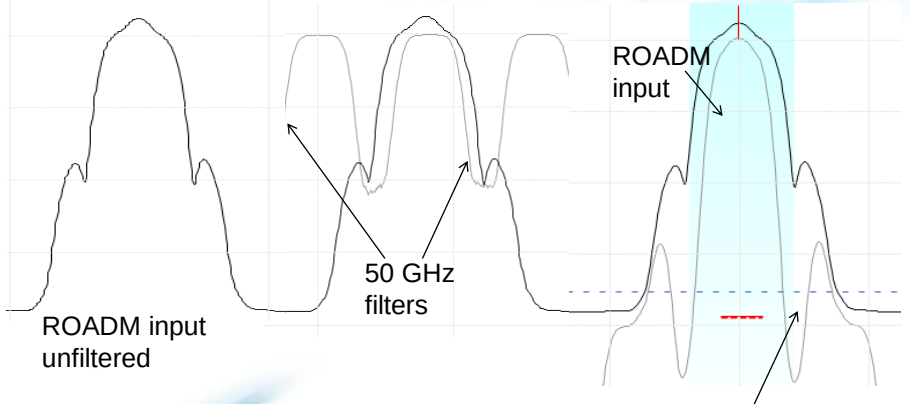
100G signals filtering in ROADMs

100G signal



For 100G signals:
- ROADMs still cause noise shaping
- Filtered 100G signals larger than 50 GHz grid.

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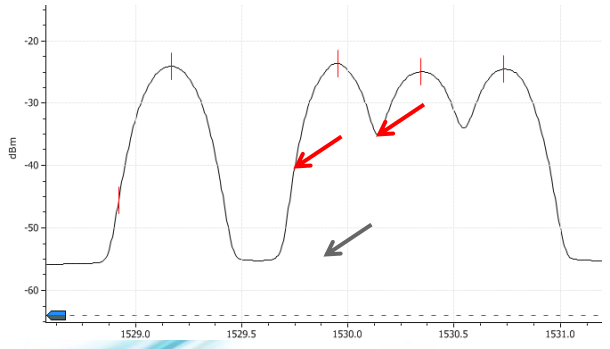
Why IEC fails in coherent networks

Case 1: Network operates at 40 Gb/s or 100 Gb/s

- Coherent 40G and 100G signals are closely spaced and overlap.
-The IEC interpolation method leads to an over-estimation of the noise level.
- It creates a false sense of problem.



Real noise level

IEC Noise level

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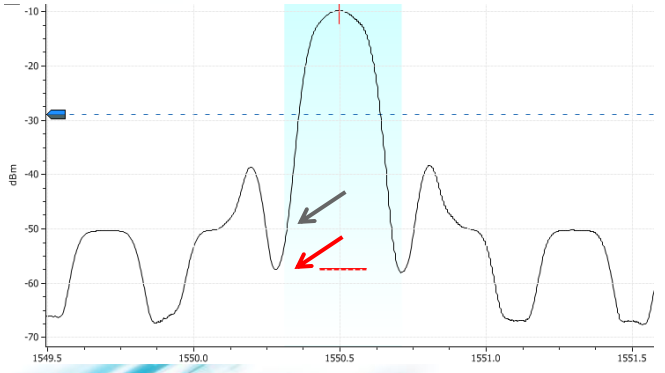
Why IEC fails in coherent networks

Case 2: ROADM present in network

- A ROADM contains filters that reduce inter-channel noise.
-The traditional interpolation method leads to an underestimation of the noise.
- It creates a false sense of security.



Real noise level

IEC Noise level

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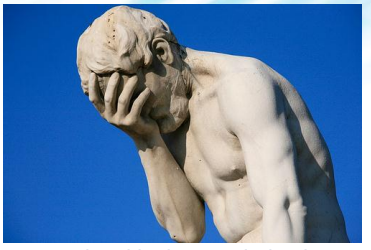
Why OSA's fail in coherent networks



- Same limitations apply for 100G
  - ROADM's
  - Spectrally wide
  - Filtering
- Polarization-based in-band OSNR does not work because signal looks unpolarized (two orthogonal pol's).
  - WDM-aware does not work
  - pol. nulling does not work

Need coherent OSNR (reference-based!)

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EXFO's approach – Reference-Based

Tap 1 Tap 2 Tap 3

- Can measure via Taps -> No service interruption
- Rely on same Maths as WDM-aware
- Use reference-acquired shape (Tap 1)
- Find noise contribution

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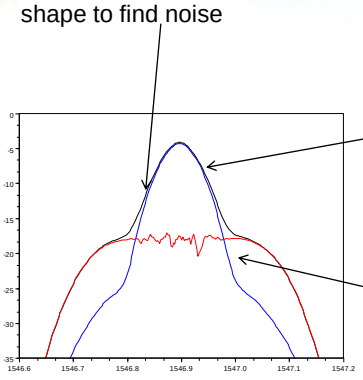
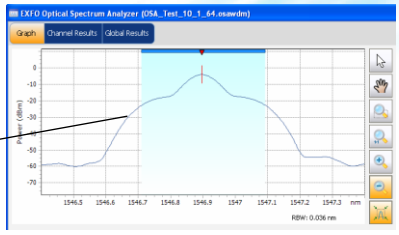
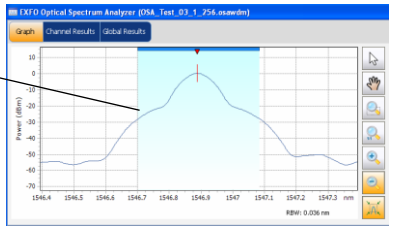
EXFO's approach – Reference-Based

- Use Reference Measurement as signal shape to find noise



Tap 2





Tap 3

- Showing with Tap 2 to demonstrate reference with residual OSNR but works well of course with Tap 1

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So is coherent OSNR available?

› EXFO now offers reference-based method as analysis service:

› The customer acquires traces at the transmitter and at the location of interest with EXFO OSA.

› **The ONLY solution available now in the market!!**

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Impairments in Next Gen Optical Systems

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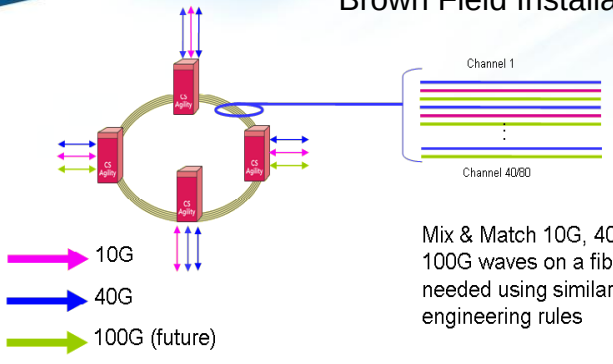
Next Generation Optical System

Brown Field Installation



Mix & Match 10G, 40G & 100G waves on a fiber as needed using similar engineering rules

- Increased network complexity
- New impairments to consider

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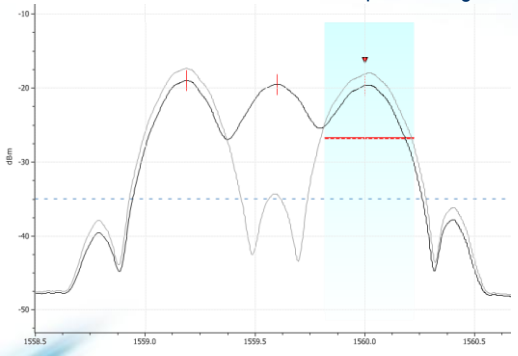
Interchannel crosstalk:

› In dense channel plans, when neighbor channels have a non negligible portion of their spectrum that extends within the channel bandpass of a given signal.



› **OSNR based on ASE noise will give an OSNR that doesn't equate to the BER the system.**

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Nonlinear Impairments:

- When signals interact with one another.
  - Have amplitude & phase modulation signals next to one another.
  - Gives rise to **cross-phase modulation**
- Lead to partial depolarization of neighbouring channels signals

- **Behaves like additional noise on top of the ASE – can degrade BER**

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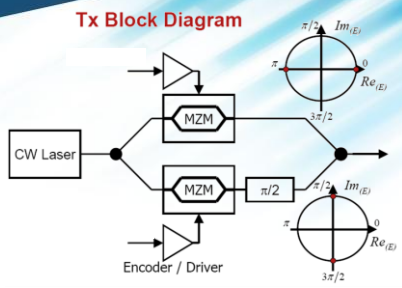
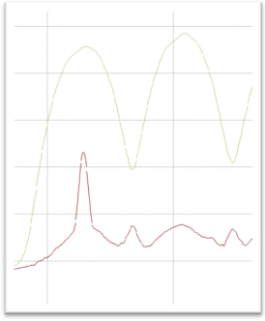
Carrier leakage

- In Phase modulated transmission, a CW source is modulated and is polarisation dependant.
- If poorly aligned – portion of signal transmitted though system un-modulated.
- **Wasted power & extra noise**





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Conclusion

› Challenges in measuring OSNR in ROADM based networks
› Challenges to overcome in measuring 100G OSNR

› Other contributors include, non-linear impairments, X-talk, misaligned modulators.

These will add to the noise and will effect BER.

Network operators want more visibility of their network

EXFO adding ability to measure;

PMD, X-Talk, Nonlinear impairments & much more to its OSA portfolio

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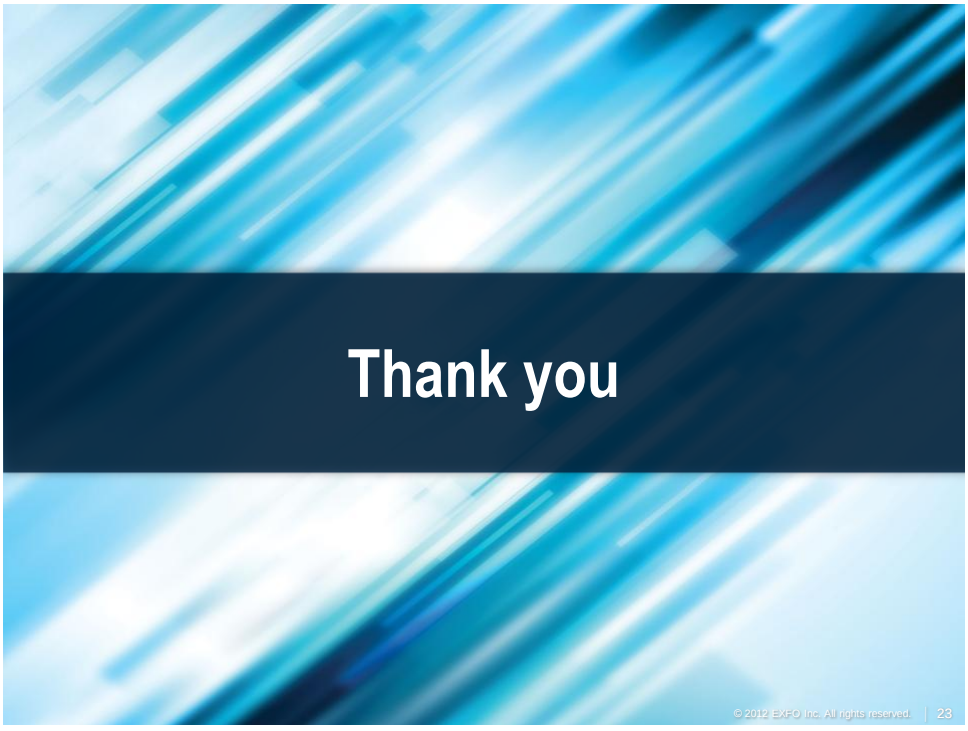
Thank you
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