>BUSINESS MADE **SIMPLE**

OFC/NFOEC-2007 Workshop
"40Gb/s networks and the PMD challenge

Cost impact of PMD on 40G deployment

Kim Roberts

krob@nortel.com

NORTEL

40 Gbps TDM, *a tough problem to solve*

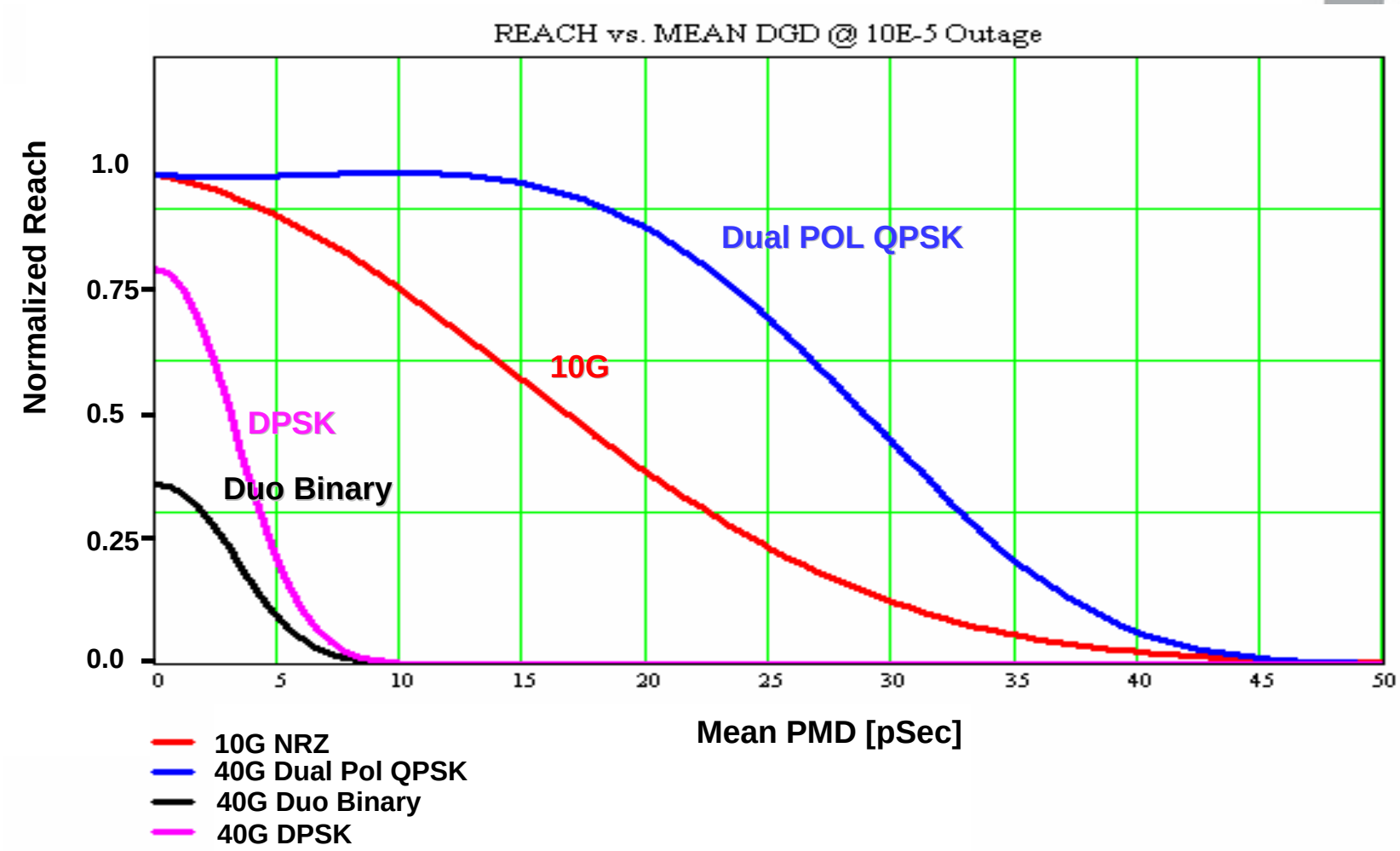
- > Bit interval reduced from 100ps to 25ps
  - Increase electrical bandwidth by a factor of 4
  - Increase optical spectrum occupied by a factor of 4 (to ~ 6 RZ)
    - Increased system impact of optical filters
    - **Constraints on Line ingress/egress**
- > 16 times less tolerance to chromatic dispersion
  - More stringent dispersion map
  - Increased installation difficulties
  - **Need to be engineered day one**
  - May need active CD compensators over fiber temperature
- **> 4 times less tolerance to PMD**
- > 6 dB drop in noise margin

40G Modulation Cases Considered

	Duo-Binary	DPSK	2-POL QPSK
Reach[1] [km]	500-800	1200- 1500	1600-2000
CD Tolerance. Assuming a tunable CD compensator[2] [pSec/nm]	+/- 400	+/- 400	+/- 50,000
PMD Tolerance[3] [pSec mean]	3.5	3	25
Filter/OADM Tolerance 100GHz Grid[4] [# of ADM Traversed]	8	8	>16

1 - at identical margin
2 - at 1dB of OSNR penalty
3 - at 2dB of OSNR penalty
4 - at 3dB of OSNR penalty

Reach Impact of PMD

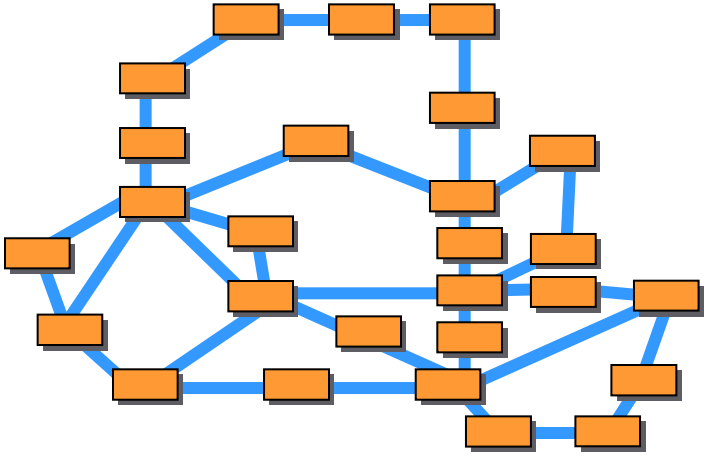


•Each system "under test" has been designed with equivalent Margin for practical in-the-field deployability and long term operation.

•PMD impact modeling includes 1st order PMD and higher order PMD impact

Network Design Assumptions

Fibre Characteristics



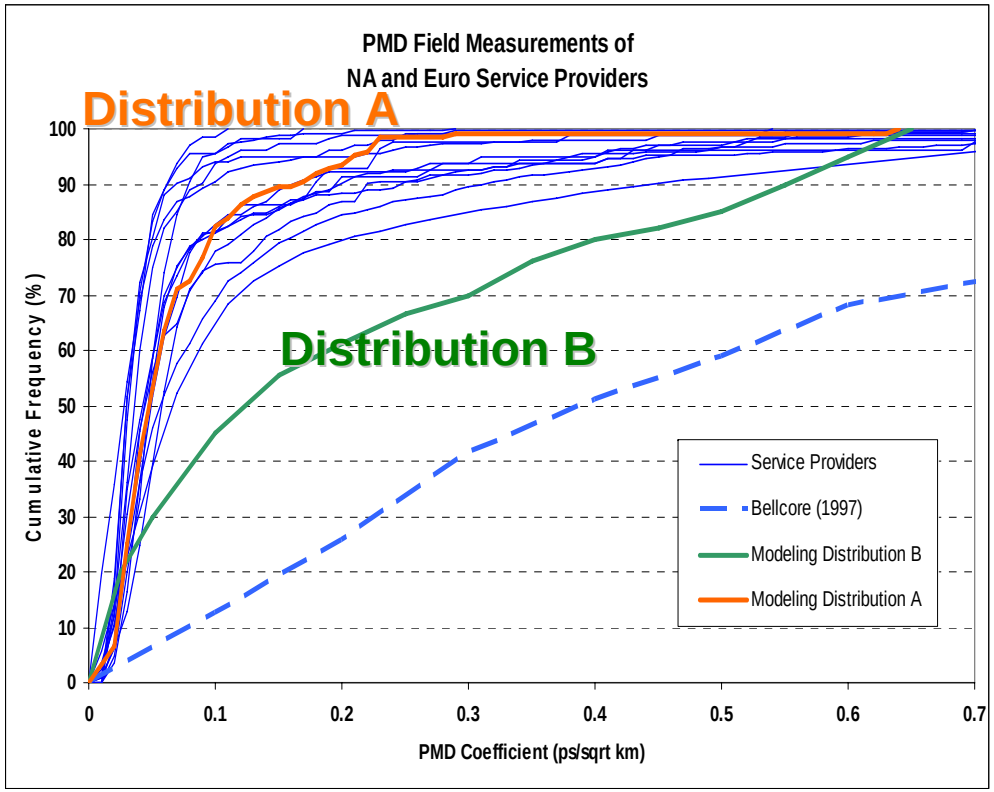
Nodal Connectivity: 2.7

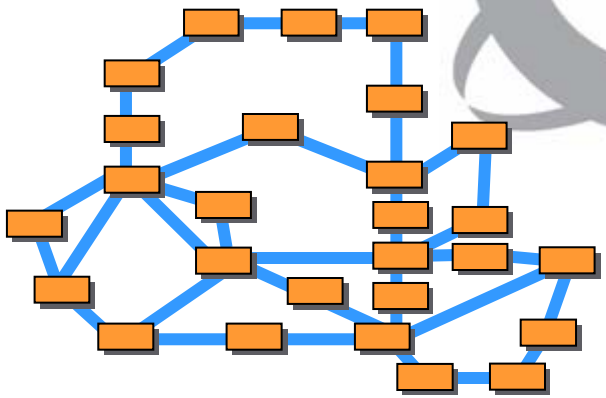
- **800 10G demands**
- **36% logical mesh**
- **4x10G mux aggregates 10G demands into 40G wavelengths**
- **ROADMs**

Same network and demand are scaled for two cases:

	<Node-Node> [Km]	<A-Z> [Km]
Regional Network	~250	~600
Long Haul Network	~600	~1500

PMD Distribution



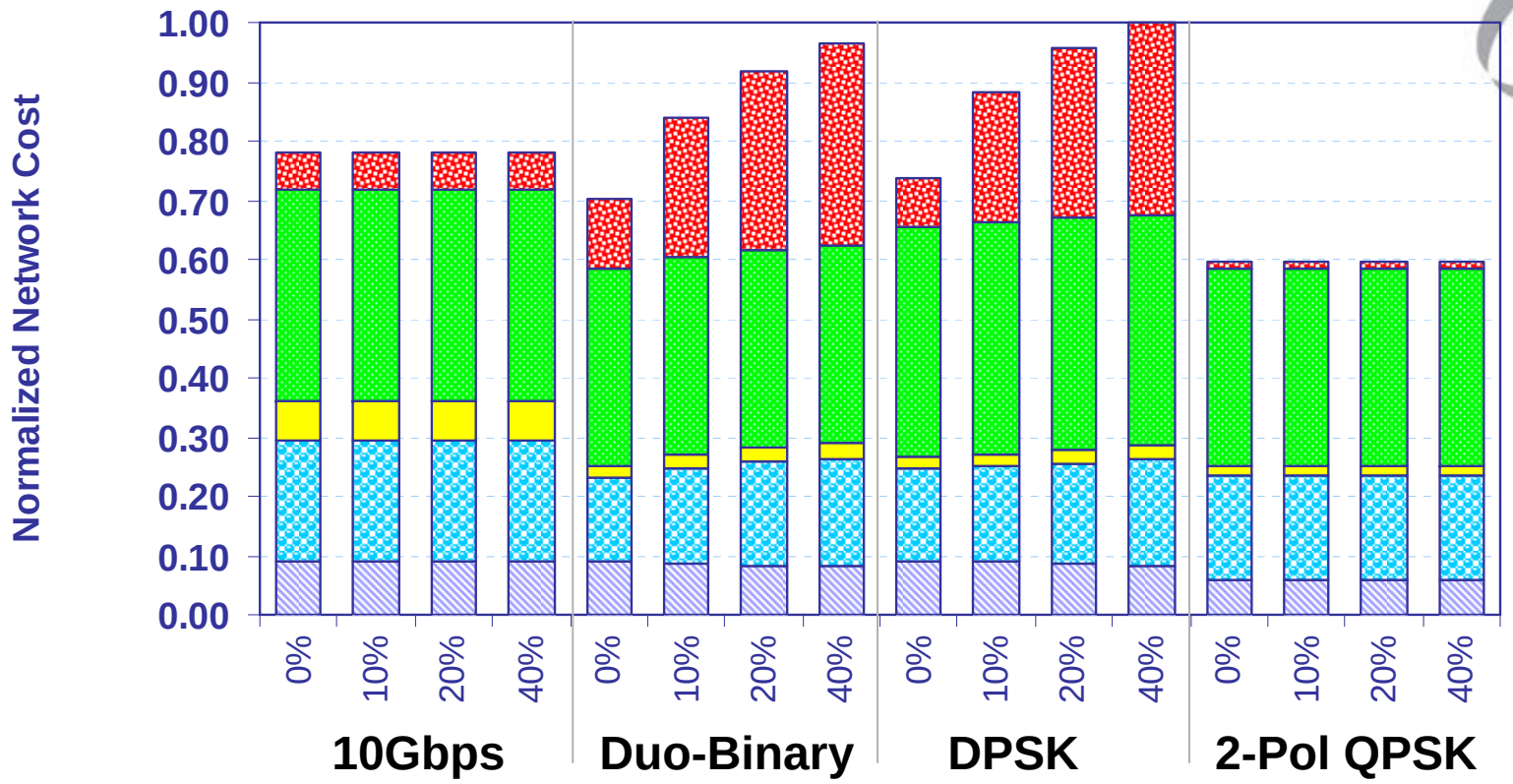


1. Node-Node segments were <u>randomly</u> selected and declared PMD candidate
   - 0 to 40% of the Node-Node
2. A PMD value was assigned to each of the fibre spans

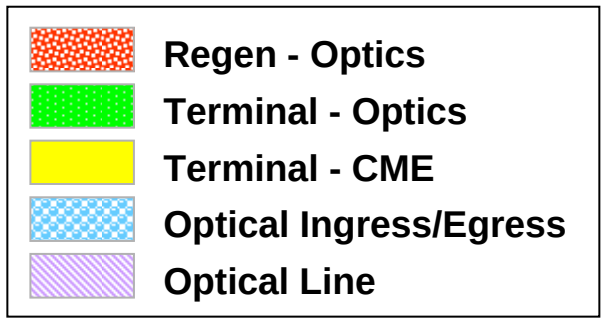
<u>Distribution A:</u> Large scale 10G deployment without significant PMD issue

<u>Distribution B:</u> Procedure to take into account PMD at 10G

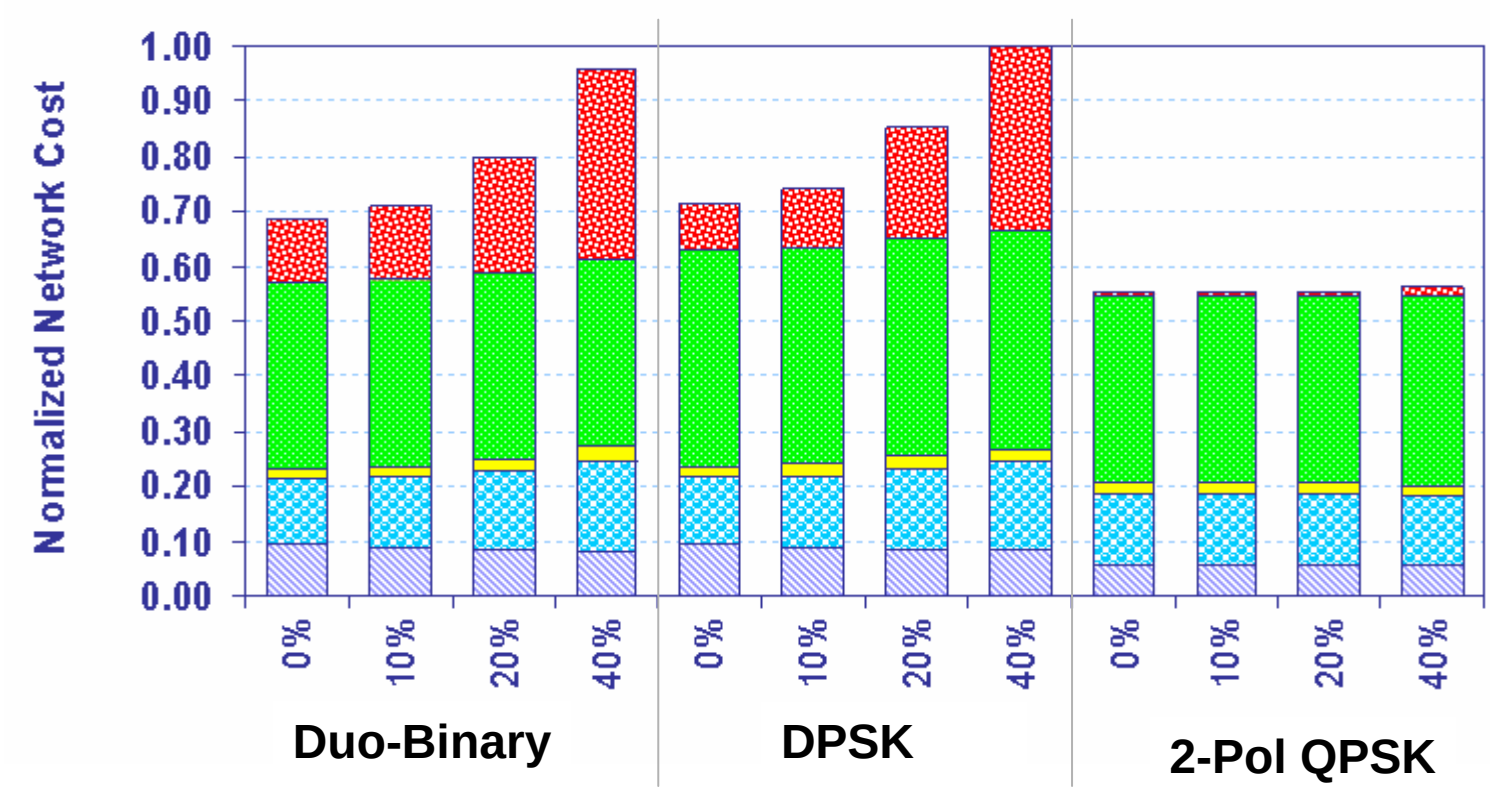
Regional Network with PMD Distribution A



- 10G not impacted by PMD
- 40G TDM solutions severely impacted by PMD
  - 15% to 25% of total network cost
- 2-POL QPSK 40G not impacted by PMD



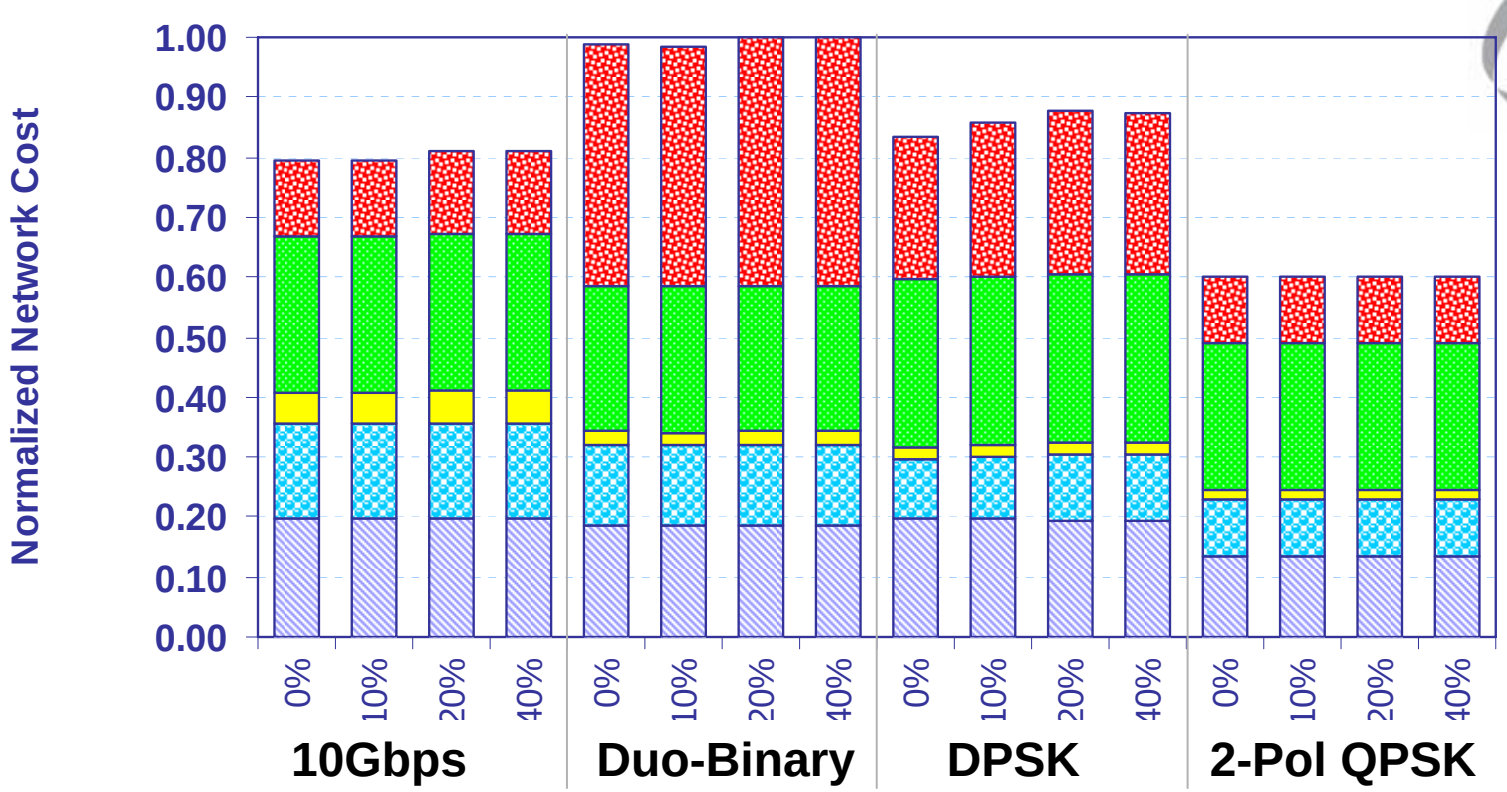
Regional Network with PMD Distribution B



- No significant difference from Regional A
- The 40G TDM solutions severely impacted by PMD
  - 15% to 25% of total network cost
- 2-POL QPSK 40G not impacted by PMD

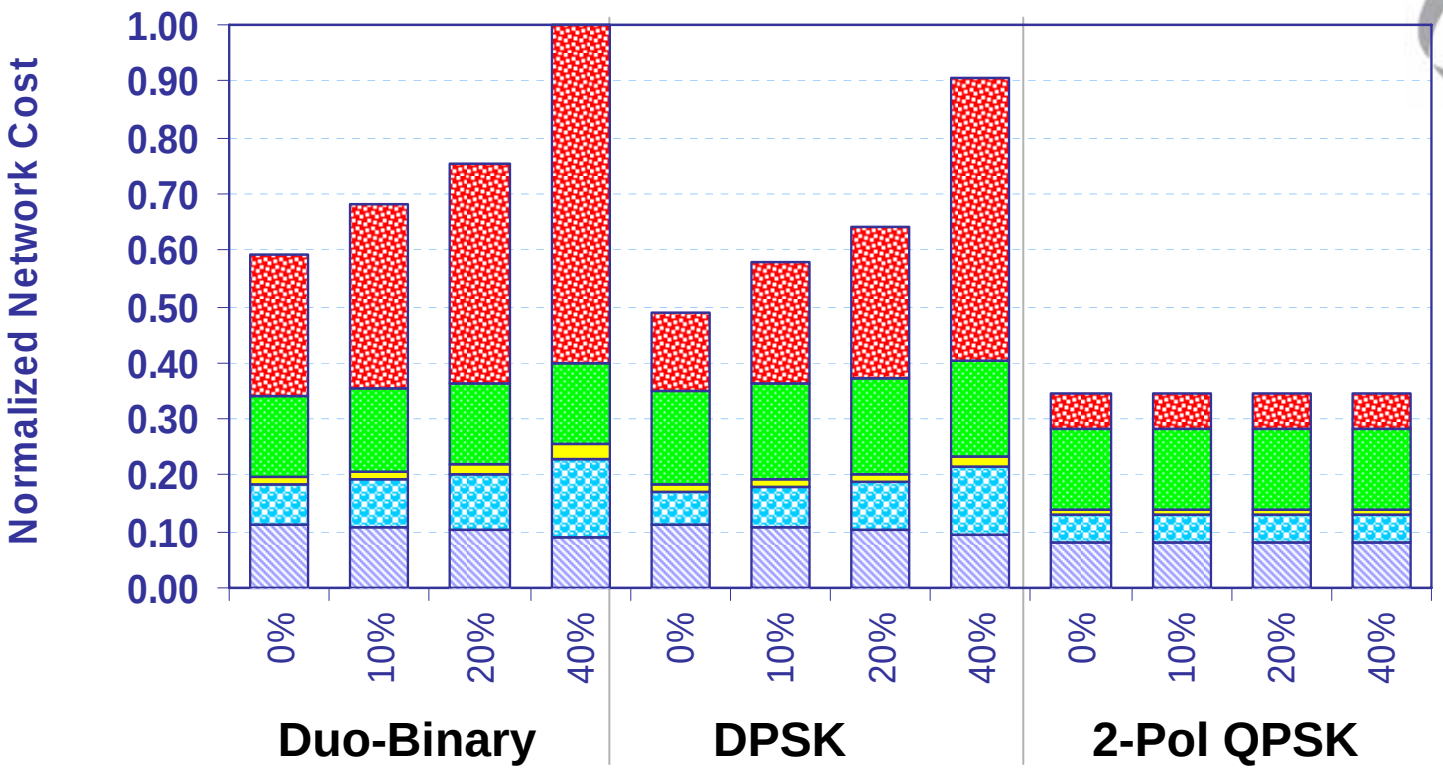
Regen - Optics
Terminal - Optics
Terminal - CME
Optical Ingress/Egress
Optical Line

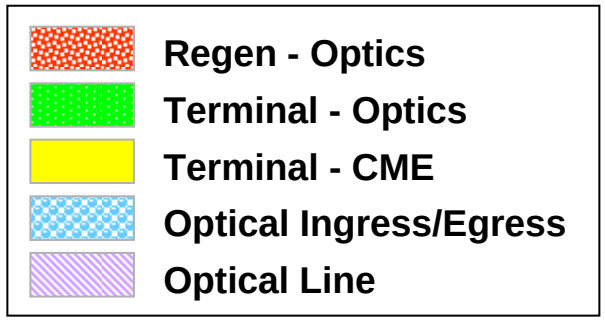
Long Haul and PMD Distribution A



- PMD impact slight
  - Regens already required for noise reset PMD

Long Haul and PMD Distribution B





- **40G TDM regens needed for PMD**
  - **10% to 40% of total network cost**
- **2-POL QPSK 40G tolerates the PMD**

Conclusions

> PMD can have a severe impact on total network cost
  - Additional regens and/or PMD mitigation devices

> Current regional networks have hidden PMD issues at 40G
  - 10G was deployed here without issues

> Long Haul costs very sensitive to PMD

> A deployable 40G solution needs to tolerate PMD

> Deployment of ROADMs increase optical distances, aggravating impact of PMD