PSM4:
Near-Term Optimal,
Long-Term Building Block

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IEEE P802.3bm “Next Gen 40G and 100G Optical Ethernet”

PSM4: Copiously Supported by Contributions

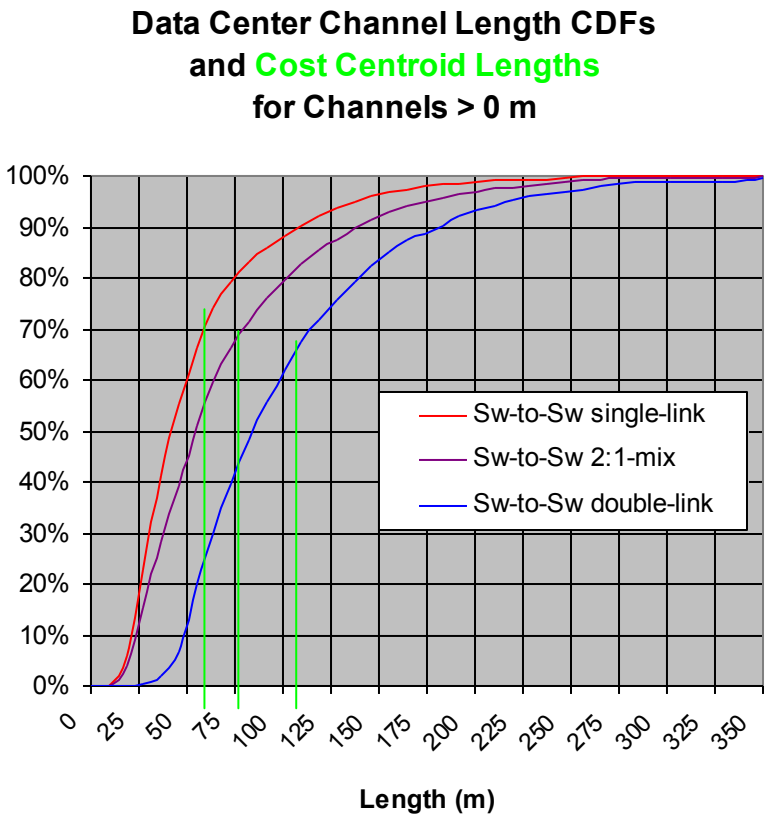
petrilla_01_0112_NG100GOPTX.pdf	100G Next Gen 2km SM PMD
anderson_01_0112_NG100GOPTX.pdf	Feasibility of 1300nm Parallel Optics for 100GbE Short Reach SMF Interconnects
anderson_02_0112_NG100GOPTX.pdf	Proposal for 100G PHY SMF Objective
kipp_01_0112_NG100GOPTX.pdf	Low Cost 100GBE Links
petrilla_02a_0112_NG100GOPTX.pdf	Mid Range (MR) definition, comparisons and reach objective
petrilla_01a_0312_NG100GOPTX.pdf	Intermediate SMF reach option for 100GE
paklert_01c_0312_NG100GOPTX.pdf	Proposed 100G PSM4 relative costs
paklert_02c_0312_NG100GOPTX.pdf	Why PSM4?
kolesar_01b_0512_optx.pdf	Cabling Cost-Centroid Lengths for Simplified Total Cost Comparisons
cole_01a_0512_optx.pdf	Cabled Fber Connectivity Relative Costs
paklert_01_0512_optx.pdf	PSM4 technical fesibility and relative cost updates
anderson_01a_0912_optx.pdf	100GBASE-PSM4 Optical Budget - Working Consensus View
petrilla_03a_0912_optx.pdf	100G PSM4 & RS(528, 514, 7, 10) FEC
petrilla_01_1112_optx.pdf	100G PSM4 Link Model and Results
anderson_01_1112_optx.pdf	100GBASE-PSM4 Optical Budget Baseline Consensus Proposal
petrillaExamplePSM_LinkModel_121105.x	Example PSM4 Link Model
palkert_01_1112_optx.pdf	Network architecture growth path using PSM4
welch_01_0113_optx.pdf	An Economic Comarison of PSM4, PAM, and LR4
petrilla_02_0113_optx.pdf	100G PSM4 Link Model Results Update
petrilla_03_0113_optx.pdf	100G PSM4 Power, Size & Cost Estimates & Comparisons
anderson_03_0113_optx.pdf	PSM4 Technology & Relative Cost Analysis Update
kolesar_01_0313_optx.pdf	Broad Market Potential and Economic Feasibility of PSM4
anderson_01_0313_optx.pdf	500 m SMF Objective Baseline Proposal
palkert_01_0313_optx.pdf	PSM4 Broad Market Potential update
kolesar_02_0313_optx.pdf	Loss Budgeting for Single-mode Channels
petrilla_02_0313_optx.pdf	100G PSM4 Link Model & Results Update
welch_01_0313_optx.pdf	PSM4 vs. WDM : A Silicon Photonics Perspective
palkert_02_0313_optx.pdf	System level cost comparisons of 100G variants for 100-500m data center installations

PSM4: Lowest Total Channel Cost

- Parallel cabling costs are reasonable
  - Cost-centroid lengths << 500 m
  - LR4 is 2-fiber alternative

Cost-Centroid Lengths [m]

Length Selection	Switch-to-Switch Channels		
Single-mode deployed for	Single Link	2:1 Mix Link	Double Link
All Lengths	59	75	106
> 100 m	148	157	163



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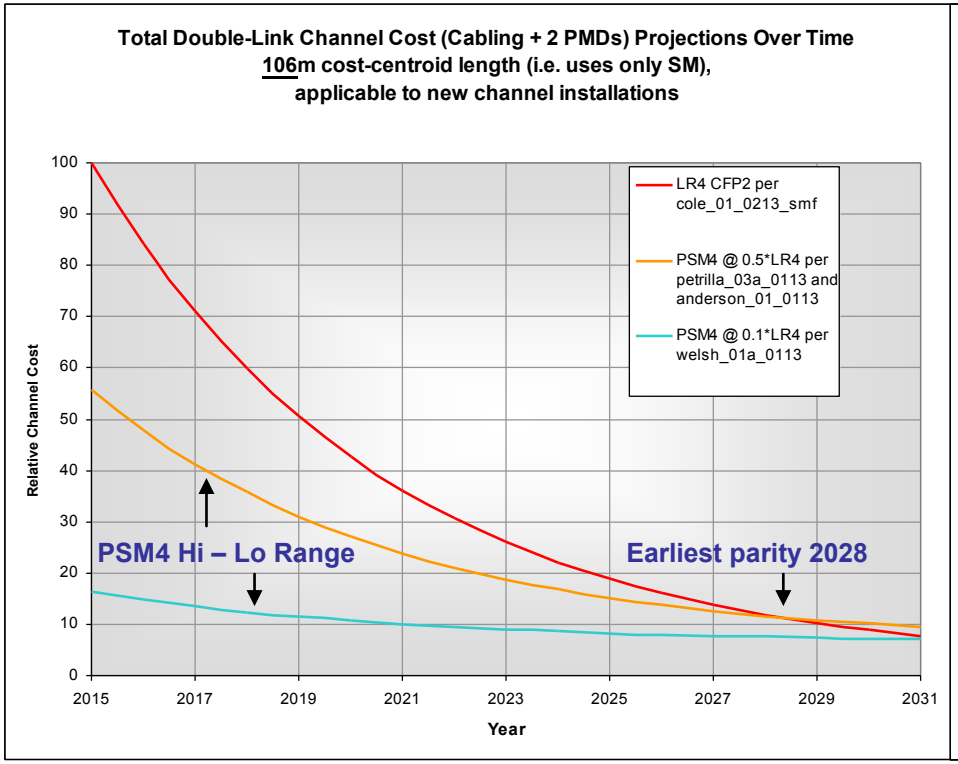
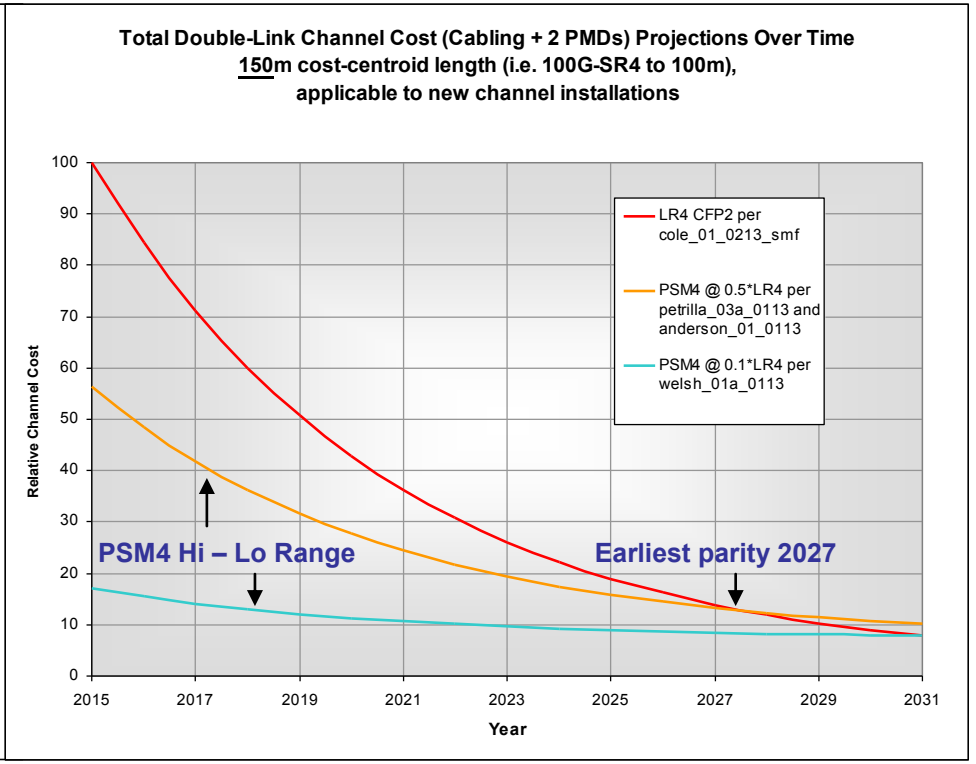
PSM4: Lowest Total Channel Cost

- Will maintain lowest cost well into the future

Total Double-link Channel Cost Over Time: New Cabling

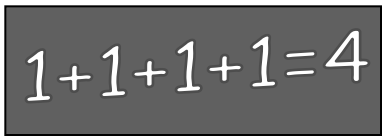




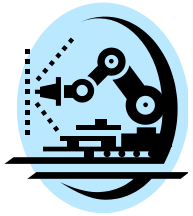
source: kolesar_01a_0313_optx

PSM4: Lowest Cost

- Simplicity ➡ technical feasibility ➡ devel. efficiency ➡



lower cost ➡ lower CapEx



- Power efficiency ➡ density ➡ lower OpEx & CapEx

PSM4: Foundational Technology

- Slide 38 of the 400GbE CFI Consensus:
  - **Technology for 400 Gigabit Ethernet**
    - **Leverage 100GbE building blocks**
    - **Plausible implementations for today and next generation**
    - **Fits with dense 100GbE system roadmap**

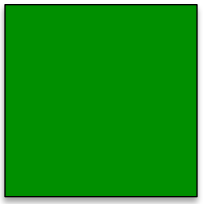
- 100GbE over 500m SMF is a “building block” for 400GbE (and beyond) in data centers

400G

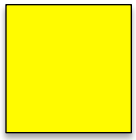
- Initial 400GbE near-certainties:
  - Data rate: 400Gb/s
  - Electrical interface: 16 channels × 25Gb/s
- 400 GbE Building Blocks considered for 100GbE, 500m SMF:
  - PSM4, CWDM, LR4, PAM, Others
- Building Block Approach:
  - Avoid “bleeding-edge” ➔ combine building blocks
  - Start with most-robust least-exotic
  - Then implement next-least-exotic
- Reach-Dependent: Shortest reach ➔ least-exotic, etc
  - SR favors parallel (24-fiber, 10ch X 10Gb/s/ch, 400m reach)
  - LR favors duplex-fiber LWDM
  - 500m solution should be less exotic than 10km

Stacking Building Blocks

- Build upon the most-mature least-exotic technology!

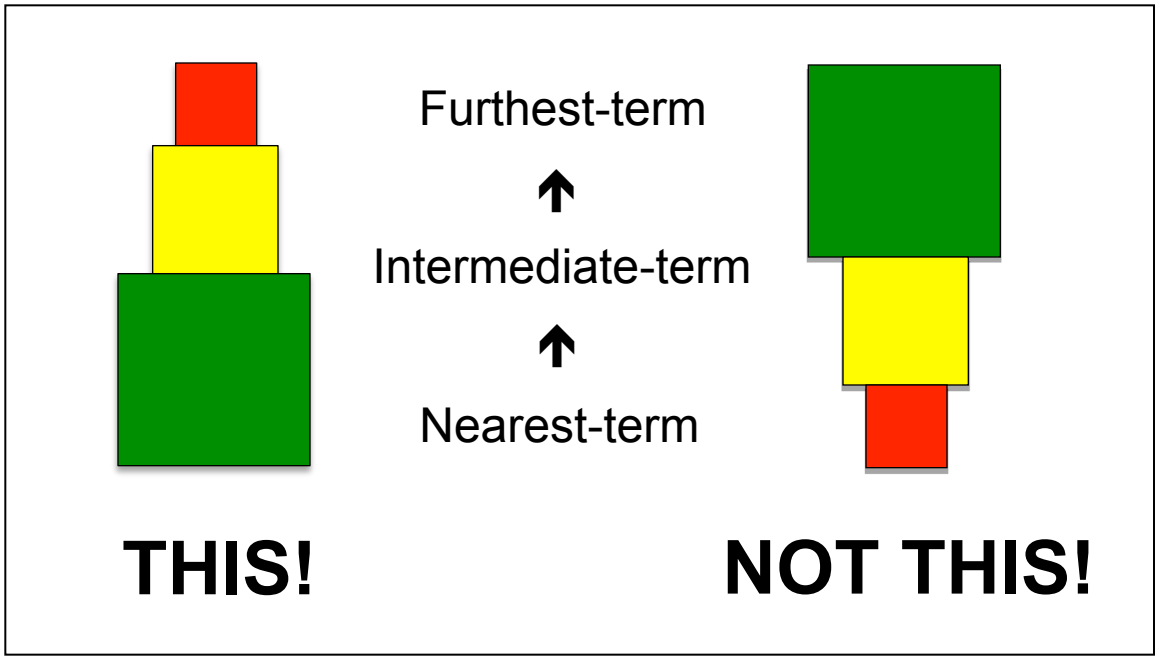


Mature



Developing

Bleeding-Edge



PSM4 Building Block for Higher Speeds

- Early adoption of PSM4:
  - multiple generations of higher speeds without “bleeding edges”
  - no electrical mux/demux
  - APC MPO connectors accommodate future PAM, etc
  - [1.6T, 6.4T are potential increments; 1.6T mentioned in ≥3 presentations in the HSE Consensus Ad Hoc]

Speed	100G	NG-100	400G	400G	400G	400G	1.6T	6.4T	6.4T
Cores/direction	1	4	4	4	4	4	4	4	4
Wavelengths/Core	4	1	4	1	2	1	4	8	4
Polarizations/Core	1	1	1	1	1	1	1	1	1
Amplitude levels	2	2	2	16	2	4	4	16	16
Phase shifts	1	1	1	1	1	1	1	1	1
P/Q-AM bits/symbol	1	1	1	4	1	2	2	4	4
Electrical (Gb/s)	10	25	25	25	50	50	50	50	100
Electrical Mux	2.5	1	1	1	1	1	1	1	1

APC Connectors

- Specifying APC end-faces for single-mode MPO has several benefits
  - Matches the default SM MPO/MTP end-face commonly deployed in pre-terminated structured cabling environments
  - 55 dB return loss performance greatly mitigates (virtually eliminates) reflection-related impairments
  - Opens the door to a greater variety of transmission technologies
    - Example: Enables advanced encoding technologies like PAM
    - We will likely require combinations of technologies to enable practical solutions at rates higher than 100G

Summary and Closing Perspectives

- The cost structure of 100G-PSM4 channels will be lower than 100G-LR4 channels for more than a decade
  - Supports long-term Economic Feasibility for PSM-4
- PSM4 in 802.3bm forms the most-solid building block for data-center 400GbE and beyond
  - Simple technology that emulates (lowest-cost) SR-4
  - Avoids “bleeding edge” optics for multiple speed generations
  - Paves the way for more advanced technologies, especially PAM
  - Sets stage for 500m solution to utilize optical technologies that are “one-generation-back” from 10km solutions ➔ cheaper!
  - Undisputed technical feasibility (January Interim 62 - 0)
  - Highest straw-poll support at March 2013 Plenary
- PSM4 standardization is straightforward (likely easiest)
  - How many plan significant activity in 802.3bm and 400GbE SG?