



Economic Feasibility for NG 100G SMF Objective

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Introduction

- This contribution builds upon nowell_01_1111, and provides a relative cost analysis for different next generation 100G SMF solutions
- nowell_01_1111 concluded that a “*step function reduction*” in system cost is needed to justify a new SMF PMD
- A straw ballot held in Atlanta provided some insight into the Study Group’s definition of ‘step function reduction’
 - 25% cost of 100GBASE-LR4

Strawpoll 3 (Chicago rules)

A: I would be interested in a PMD supporting a 500m reach at 75% the cost of 100GBASE-LR4

B: I would be interested in a PMD supporting a 500m reach at 50% the cost of 100GBASE-LR4

C: I would be interested in a PMD supporting a 500m reach at 25% the cost of 100GBASE-LR4

A:1 B:10 C:40

Solutions Analyzed

Type	# Fibers	λ 's / Fiber	Mux	Length/ Ch Loss	Comments
CFP LR4	1	4	LWDM	10km / 6.3 dB	100GBASE-LR4 in CFP, 802.3ba
CFP2 LR4	1	4	LWDM	10km / 6.3 dB	100GBASE-LR4 in CFP2, 802.3ba
CWDM-nR4 (*)	1	4	CWDM	2km / ? dB	4x25G λ , uncooled, CWDM.
Ribbon-nR4 (*)	4	1	N/A	500m / ? dB	4x25G ribbon fiber, MPO connector.
PAM-n	1	1	N/A	2km / 4dB	Single wavelength, mutli-level PAM. Both PAM-8 and PAM-16 analyzed

(*) Based on anderson_01_1111

Cost Model Methodology

- Complete optical module cost was analyzed for each solution, factoring in:
 - Component BOM (number / cost of components)
 - Assessment of manufacturing / assembly complexity
 - Test
- In some cases there are implementation options or uncertainties on assumptions (yield) in which case we provide a range
- Data and assumptions are based on publicly available information, component cost data and syndicated research

Module Cost Analysis - Example

Transceiver Building Blocks	CFP LR4 (circa 2012)		CFP2 LR4		CFP2 PAM	
	Description	Cost	Description	Cost	Description	Cost
Tx (TOSA)	4x discrete EML	1	4xDML, integrated w/MUX in TOSA	0.32	Multiple Implementations	0.18 - 0.02
Rx (ROSA)	Integrated ROSA	1	Integrated ROSA	1	PIN/TIA	0.35
Opt Mux	Thin film	1	Integrated in TOSA	N/A	None Required	N/A
Opt Dmux	Thin film, Integrated in ROSA.	N/A	Integrated in ROSA	N/A	None Required	N/A
Serdes	10x10→4x25 Gb gearbox (CMOS)	1	4x25 Gb CDR (CMOS)		PAM Serdes	
Laser driver IC	4x25 Gb EML driver	1	4x25 Gb DML driver			N/A (*)
Misc	PCBA, housing, connector, IC, etc	1	PCBA, housing, connector, IC,etc		PCBA, housing, connector, IC,etc	
Assembly /Test	Assembly/test time and yield	1	Assembly/test time and yield		Assembly/test time and yield	
Module Cost		1		0.46		0.23-0.13

- Detailed cost analysis was performed on all aspects driving module cost
- Only Tx/Rx optics details shown above as tend to be dominate cost driver
- (*) Some implementations may include an external modulator driver

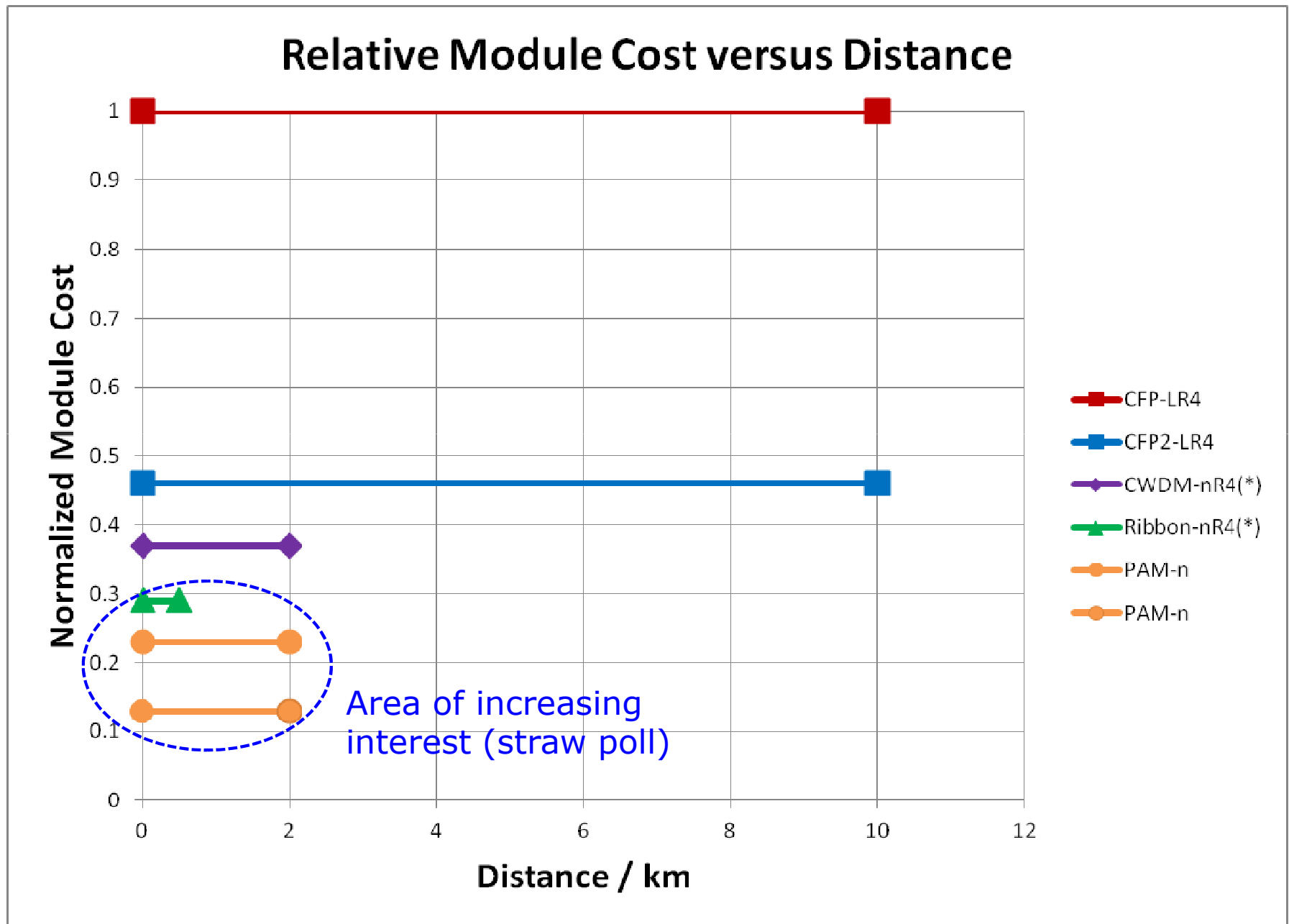
Module Cost Summary

	CFP-LR4 (10km)	CFP2-LR4 (10km)	CWDM-nR4 (2km)	Ribbon-nR4 (500m)	PAM-n (2km)
Relative Cost of Module	1	0.46	0.37 ¹	0.29 ¹	0.23-0.13 ²

Notes:

- (1) Based on Tx optics data from anderson_01_1111 (extended to include complete module cost)
- (2) Analysis included both PAM-8 and PAM-16, and a range of implementation options
- All, except CFP LR4, assume a 4x25G retimed electrical interface
- Module cost only. Does not include cost of fiber.

Module Cost versus Distance



(*) Based on Tx optics data from anderson_01_1111 (extended to include complete module cost)

Cost Trend Expectations

- Expect all of the solutions to follow a similar cost trend to 10GE optics over the past decade
- Once a PMD reaches the 'optimum' form factor, the cost really starts to drop due to high volume and mfg maturity...
 - e.g. SFP+ for 10G
- All solutions presented offer a better roadmap to optimum form factor than 802.3ba 100GBASE-LR4
 - Roadmap to CFP4 or better, with high port density

General Observations on Analysis

- **CFP/CFP2** - following known and expected cost reduction (with volume and time). Consistent with data already presented.
- **CWDM** - incremental cost reductions - leveraging wider wavelength grid and packaging optimization
- **4x25G Ribbon** - attractive cost reduction - Cisco has concern over new cable type in data center application - adoption potential unclear.
- **PAM8/16** - attractive cost reduction - primarily due to reduction on optics component count/mfg complexity – also compatible with existing DC cabling

Summary

- All solutions presented offer cost savings over 100GBASE-LR4
- Our analysis shows that a single wavelength (PAM) solution provides very attractive cost savings
- PAM cost savings primarily due to reduction on optics component count / mfg complexity

“Reduction of number of components is key to achieve the lowest cost solution for data center application”

Source: anderson_01_1111

- Recommend the SG consider adding a SMF objective that allows a PAM based implementation

Thoughts on 5 Criteria ...

- We believe 5 Criteria can be satisfied for a PAM based SMF objective:
 - TF - presentations this week
 - EF - this presentation
 - DI - different SMF reach and application from 100GBASE-LR4
 - Compatibility - consistent with 802.3ba architecture - also compatible with current DC cabling
 - BMP - at projected cost factors, believe significant DC adoption will happen