![Telcordia logo] **Telcordia®**

"To Infinity and Beyond!": Why 40km+ links matter, and what HSSG might do about it

Prepared for March 2007 HSSG Meeting: Orlando FL
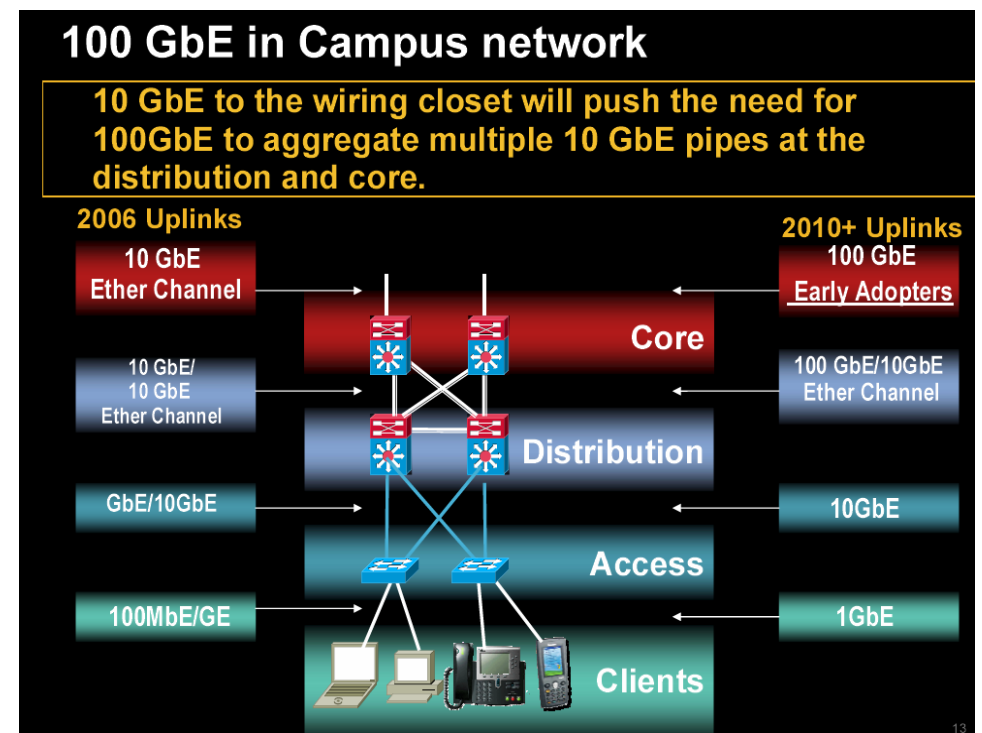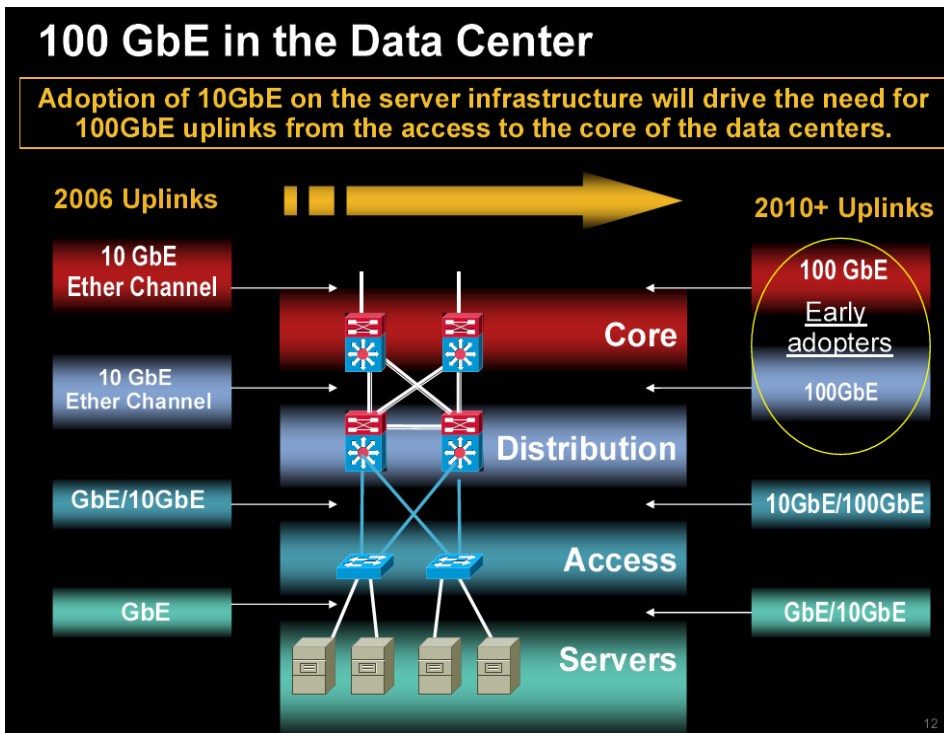
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7 Mar 2007

We have seen that 100 GbE will be a tiered market

100 GbE in the Data Center

Adoption of 10GbE on the server infrastructure will drive the need for 100GbE uplinks from the access to the core of the data centers.

2006 Uplinks

		2010+ Uplinks
10 GbE Ether Channel	Core	100 GbE Early adopters 100GbE
10 GbE Ether Channel		
GbE/10GbE	Distribution	10GbE/100GbE
GbE	Access	GbE/10GbE
	Servers	

100 GbE in Campus network

10 GbE to the wiring closet will push the need for 100GbE to aggregate multiple 10 GbE pipes at the distribution and core.

2006 Uplinks

|		2010+ Uplinks
10 GbE Ether Channel	Core	100 GbE Early Adopters
10 GbE/ 10 GbE Ether Channel		100 GbE/10GbE Ether Channel
GbE/10GbE	Distribution	10GbE
100MbE/GE	Access	1GbE
	Clients	

These graphics and much more from
: http://grouper.ieee.org/groups/802/3/hssg/public/jan07/barbieri_01_0107.pdf

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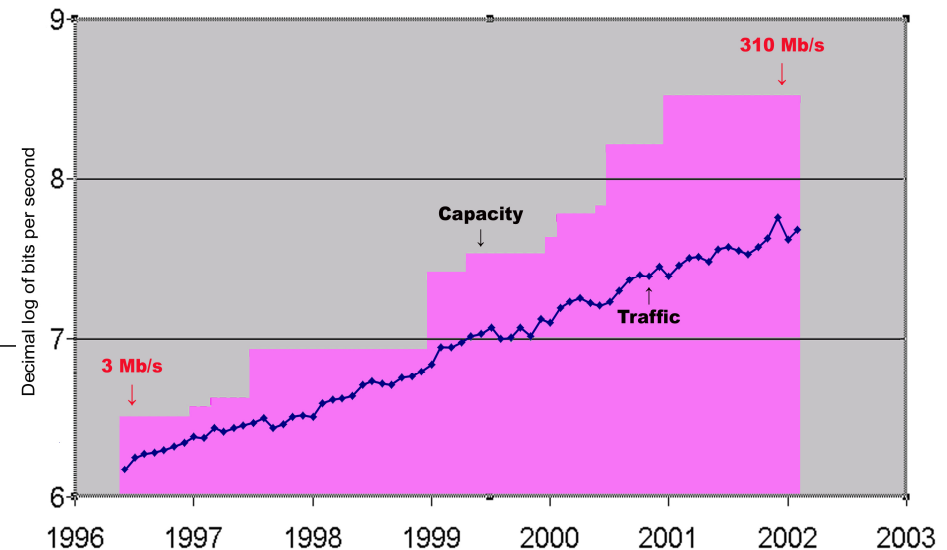# Tiering continues through Metro / Regional / Long Haul markets
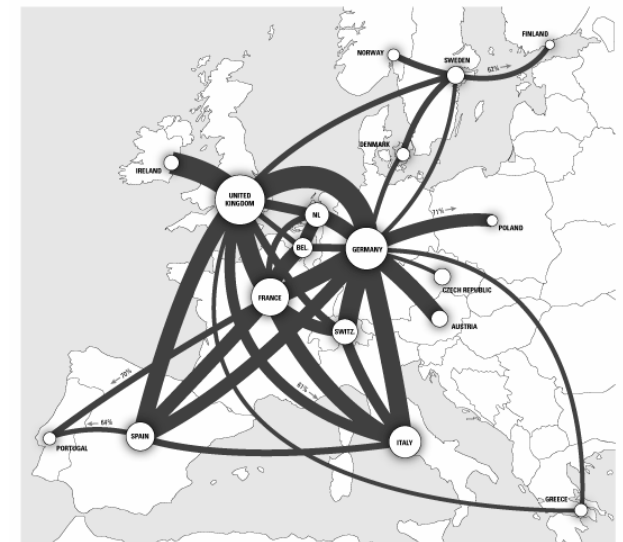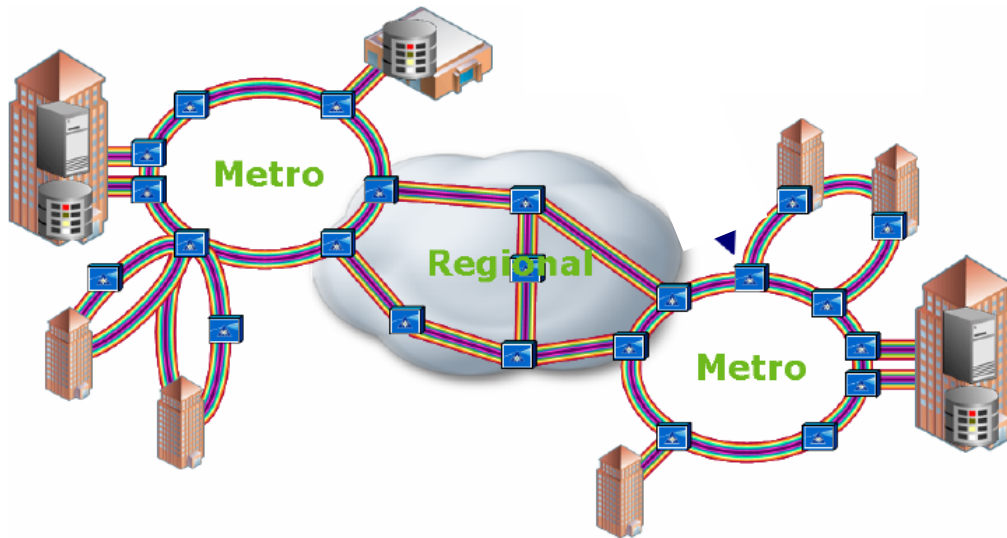
Metro / Regional Sketch from http://grouper.ieee.org/groups/802/3/hssg/public/nov06/young_01_1106.pdf

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Data growth continues at ~100% / yr

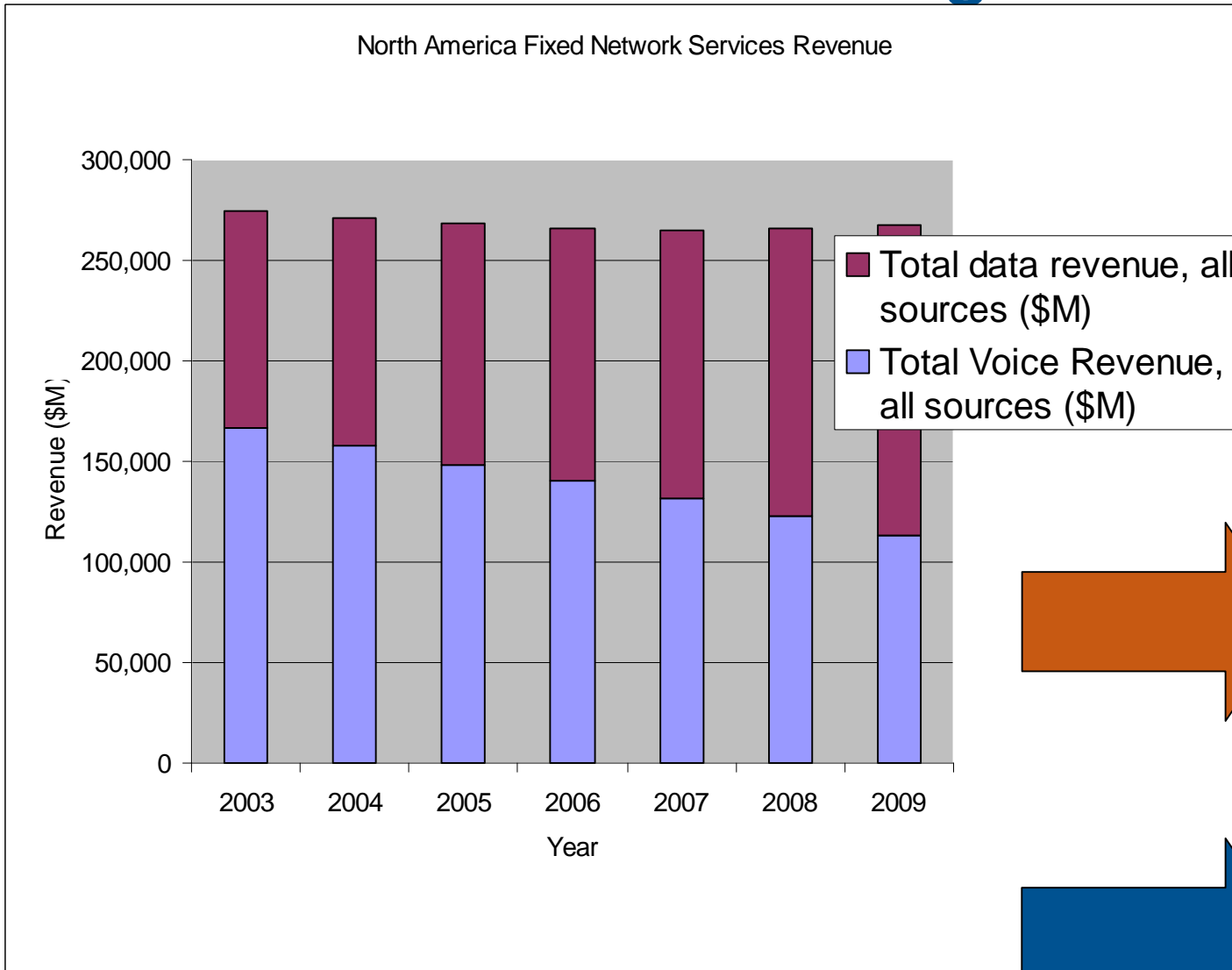**US Internet Backbone traffic (est)**
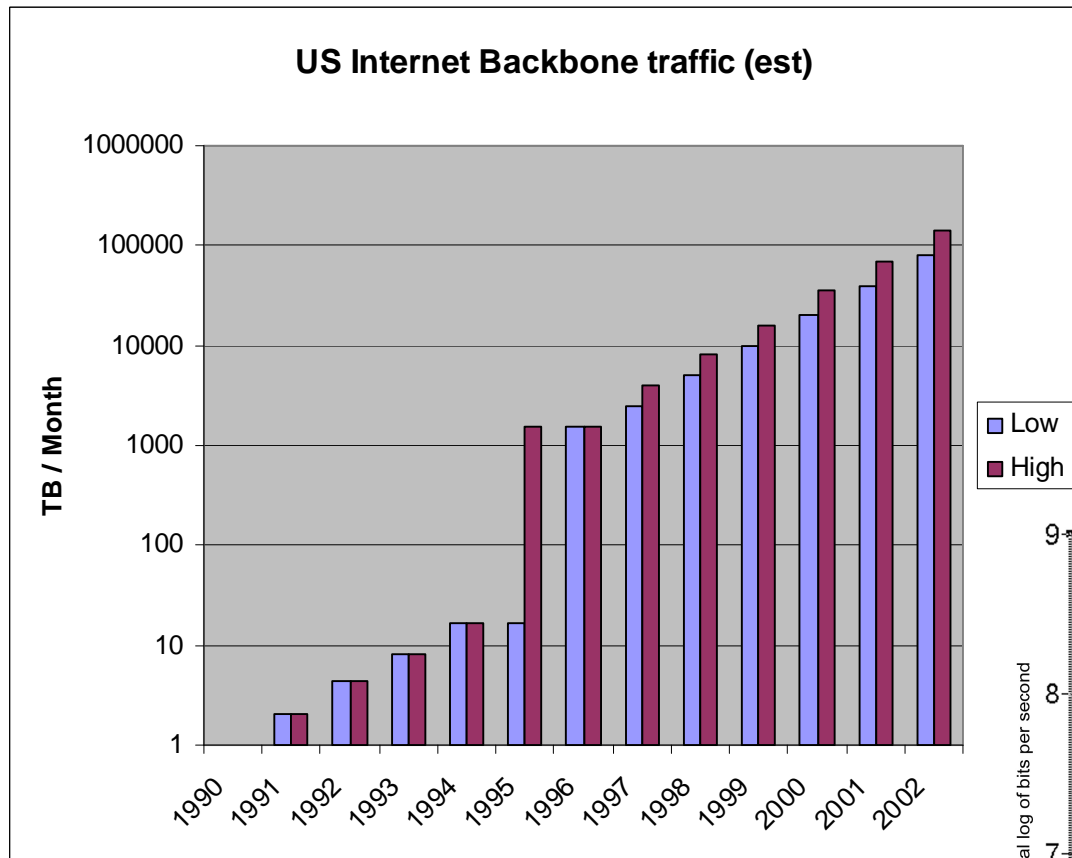
SWITCH traffic and capacity across the Atlantic

Internet traffic growth: Sources and implications, A. M. Odlyzko. *Optical Transmission Systems and Equipment for WDM Networking II*, B. B. Dingel, W. Weiershausen, A. K. Dutta, and K.-I. Sato, eds., Proc. SPIE, vol. 5247, 2003, pp. 1-15.

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Traffic Mix Has Changed

North America Fixed Network Services Revenue

Legend:
- Total data revenue, all sources ($M)
- Total Voice Revenue, all sources ($M)

X-axis: Year (2003, 2004, 2005, 2006, 2007, 2008, 2009)
Y-axis: Revenue ($M) — 0, 50,000, 100,000, 150,000, 200,000, 250,000, 300,000

Source: Gartner

Voice revenue much higher per bit than data

Data traffic dominates Voice.

Ethernet dominates Data

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The point is…

- Data indicates the dominant traffic format in N. A. Carrier networks is Ethernet.

- This trend is being replicated globally.

- Carriers cannot ignore Ethernet

- Can 802.3 HSSG ignore this market segment?
  - Metropolitan
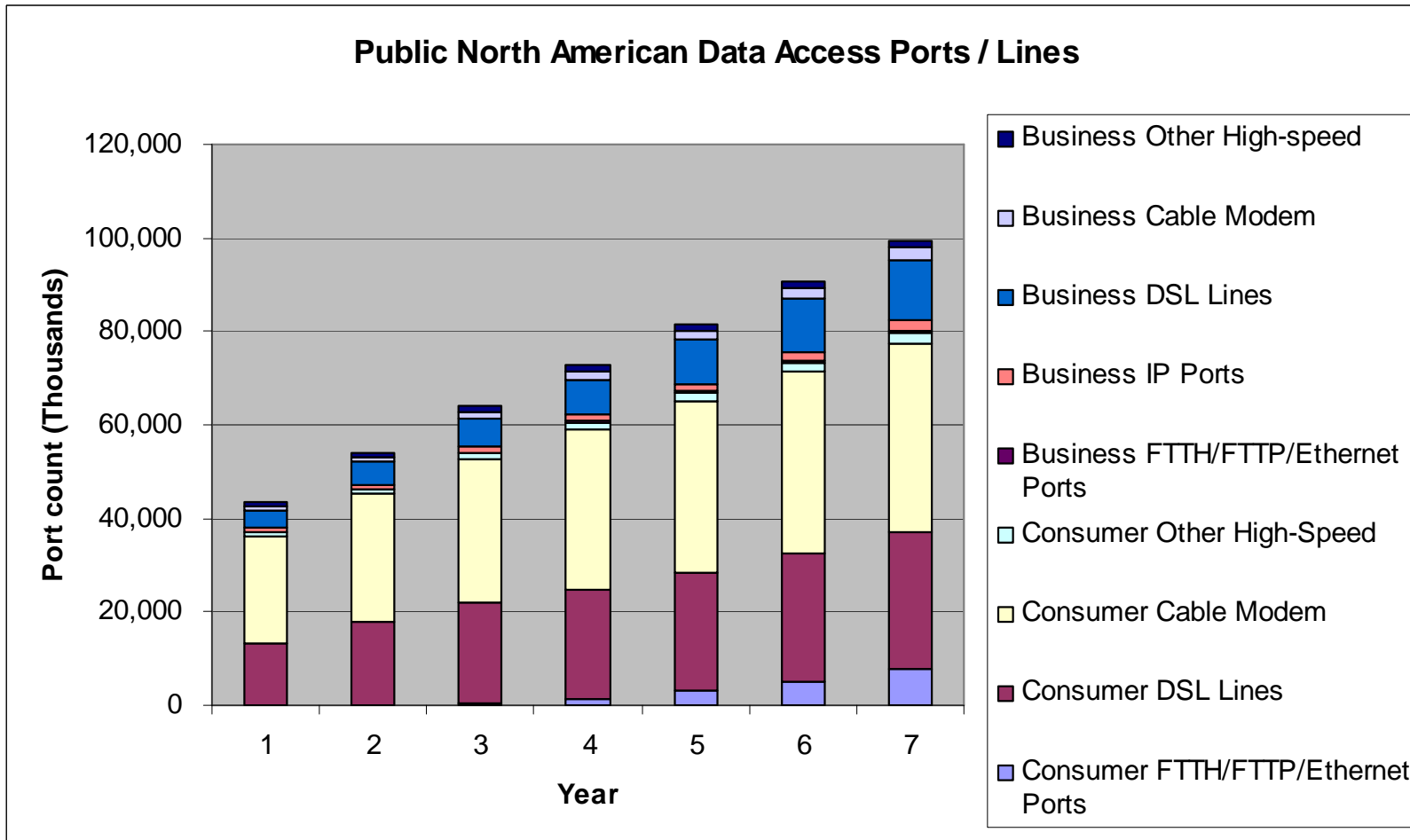 - Regional
  - Long Haul

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Global Telecom Infrastructure Market exceeds Global Server Market
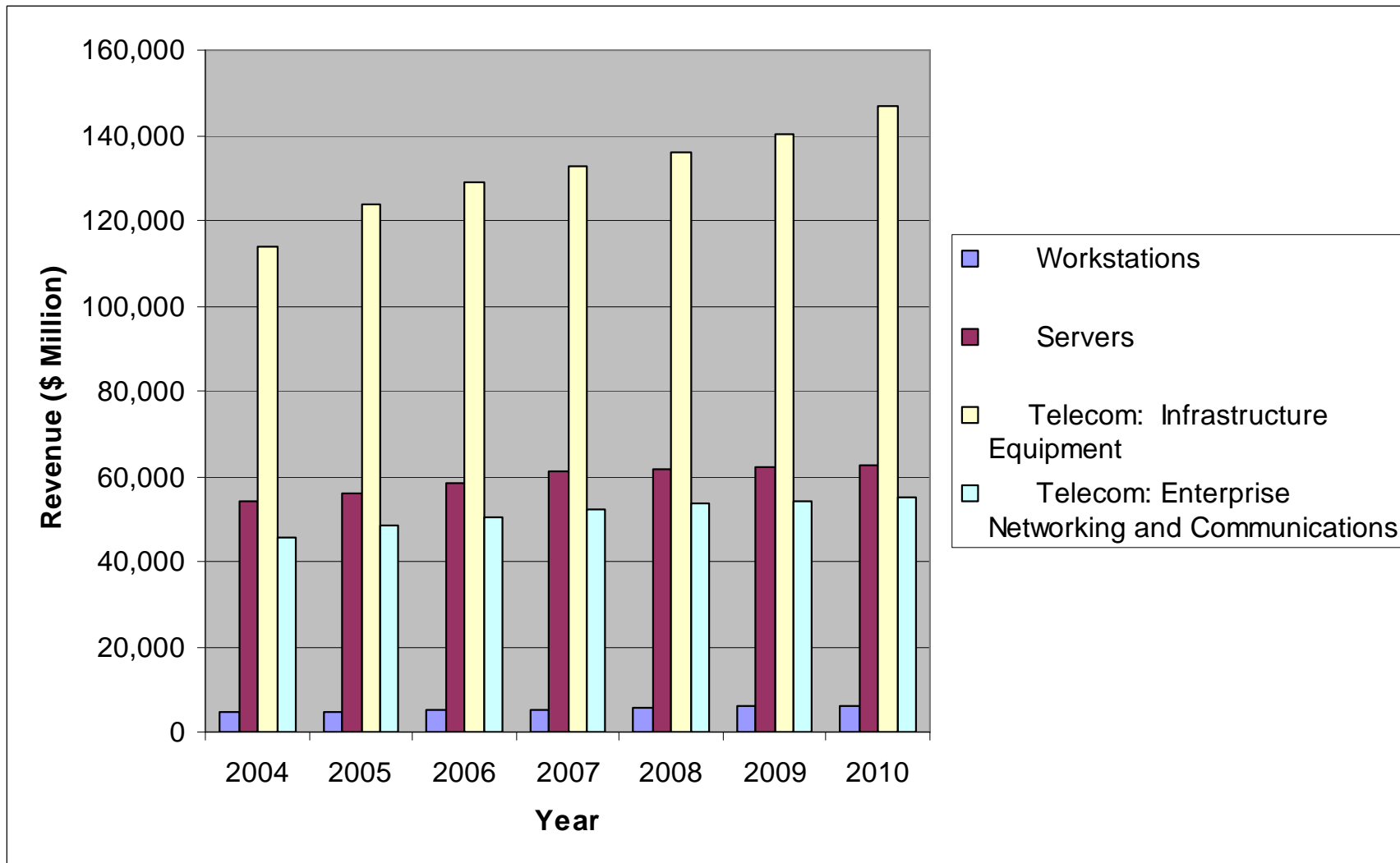
Source: Gartner, 2006

Consider also data from previous HSSG Presentations from AT&T and ComCast

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100 Million Fixed Network Ethernet Ports in North America by 2010

Public North American Data Access Ports / Lines

Port count (Thousands) vs Year (1-7), stacked bar chart with legend:
- Business Other High-speed
- Business Cable Modem
- Business DSL Lines
- Business IP Ports
- Business FTTH/FTTP/Ethernet Ports
- Consumer Other High-Speed
- Consumer Cable Modem
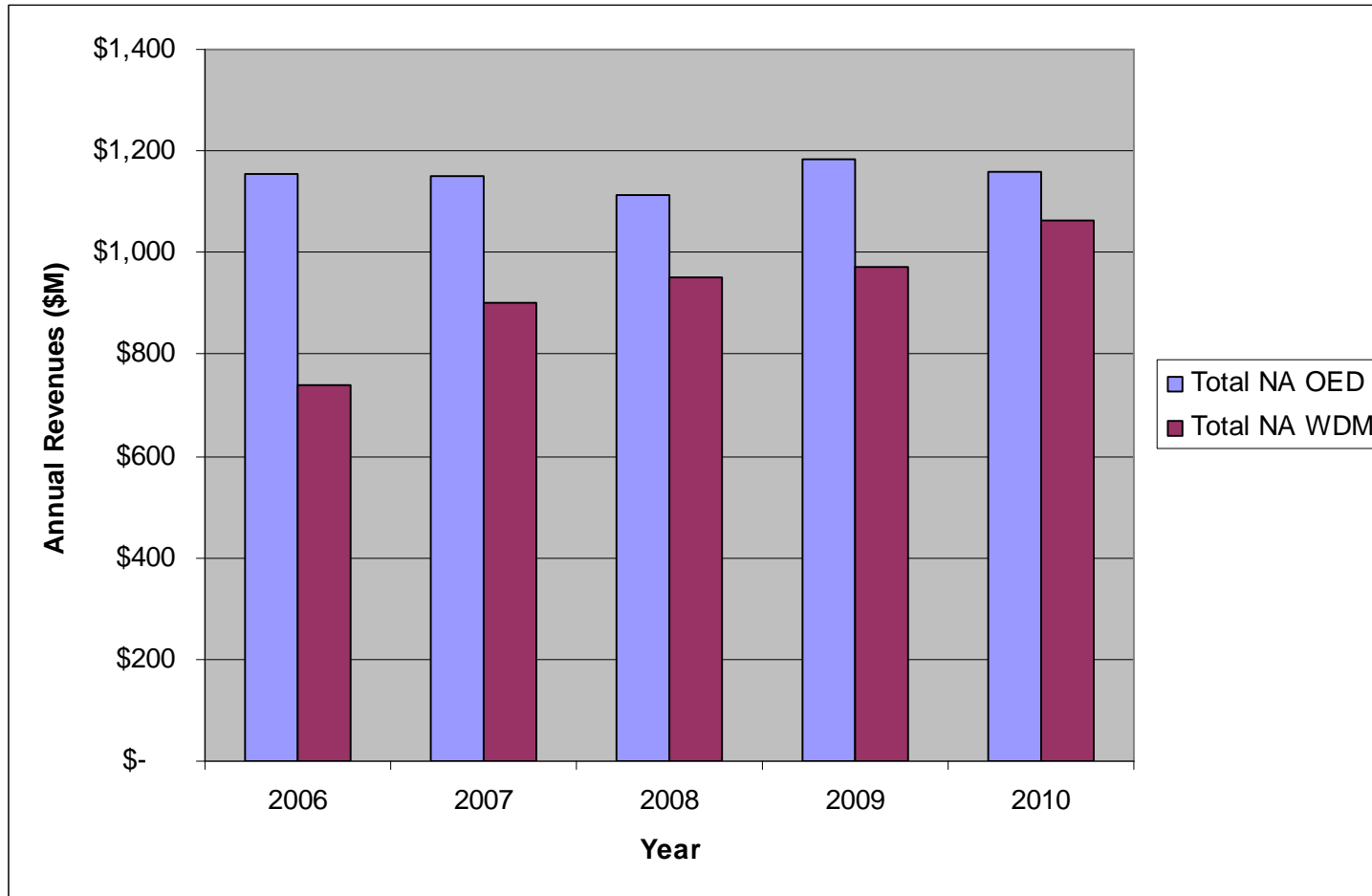- Consumer DSL Lines
- Consumer FTTH/FTTP/Ethernet Ports

Significant Opportunities for high rate aggregation in the network in the future

Does not include mobile ports
Does not include rest of the world
Does not include intermediate network ports

Source: Gartner, 2006

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North American DWDM and OED markets > $1 Billion.

Both have significant geographic extent.

Source: Ovum 2005   OED: optical edge device (MSPP)

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Issues of Importance for network operators

- LOWEST COST SERVICE DELIVERY
  - Low Cost Router Interfaces
  - Fast and easy provisioning
- Legacy carriers
  - Multi-protocol support
  - Management visibility
  - Compatibility with legacy infrastructure
- New generation carriers
  - Converged protocol
  - IP-centric
  - Ethernet-dominant
- High spectral efficiency and provisioning system transparency
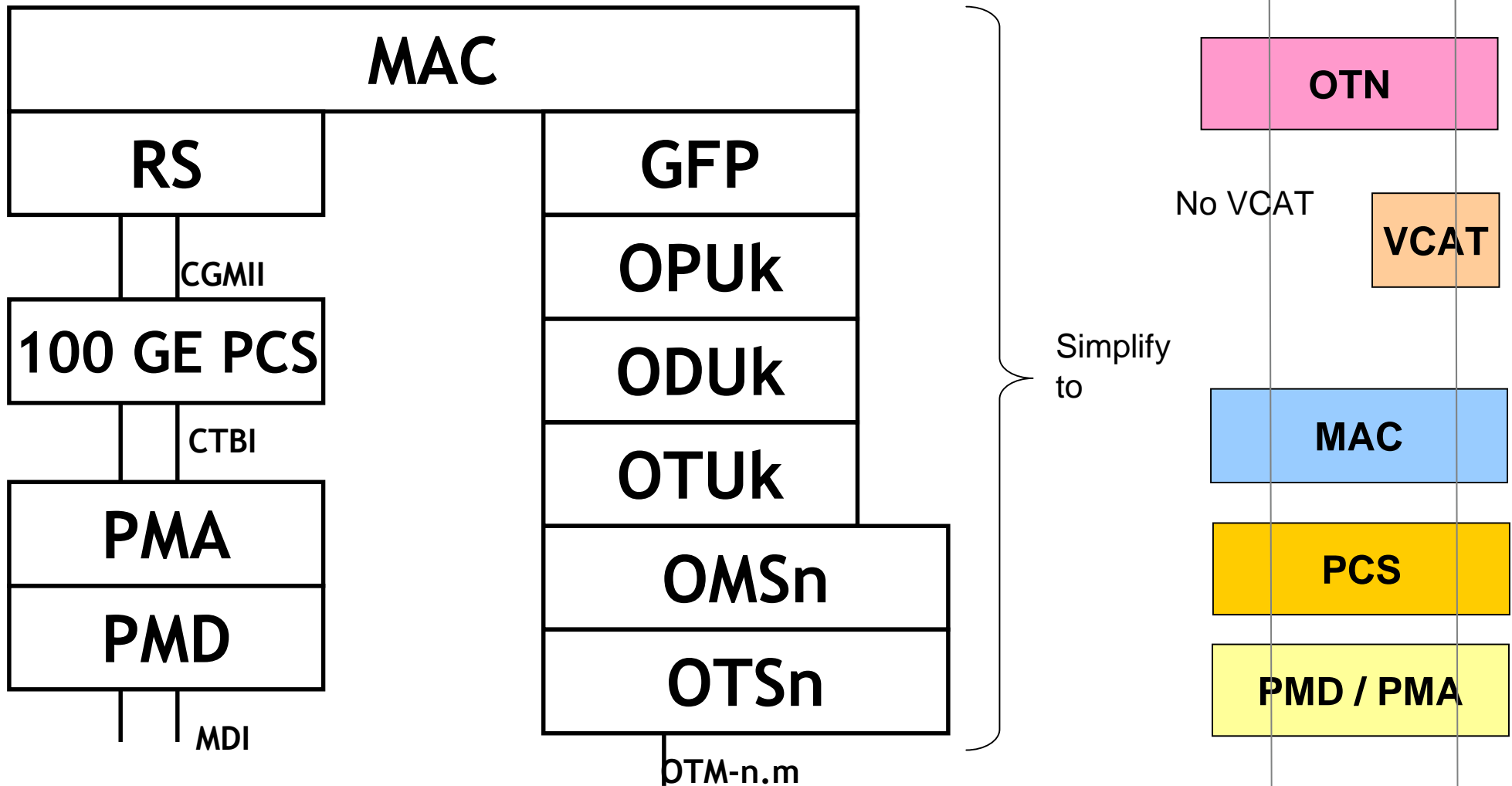- Resilience → Quality of Service and ability to support Service Level Agreements

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Why 40 km + matters

- Markets are significant
- Many applications need > 40 km reach and network footprint
  - Video distribution networks (e.g. MSO, FIOS, etc)
  - VOIP
  - Disaster recovery
  - Mobile network support
  - Large private networks (e.g. call centers, outsourcing)
- Local applications become more powerful when network extent is increased (the top of the pyramid influences the bottom)
- Public networks and networks with significant geographic extent have special needs
  - Manageability matters a great deal
  - Capacity and spectral efficiency matter a great deal
  - Resilience and fault recovery matter a great deal
  - Mantra's –
    - Don't require large numbers of highly skilled personnel
    - Deployment of transmission infrastructure dwarfs the cost of endpoint equipment
    - The cost of the PMD small relative to switching and services costs.
    - Quality of service matters.

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Scale-Insensitive Networking

- We have seamless global networks today. (G. Young, AT&T, Nov. 2006)

- Significant economic effects are driven by low-cost wide-area-networks.

  - Huge economic leverage for global businesses.

- Bottlenecks cannot be allowed to develop

  - The economy has adapted to ubiquitous communications to conquer distance in business

  - Attractiveness of local services is reduced when wide area reach is impacted.

  - Higher costs to communicate over significant distance would be very dislocating

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Protocol Route To the WAN (example)

MAC

RS — CGMII

100 GE PCS — CTBI

PMA

PMD — MDI

GFP

OPUk

ODUk

OTUk

OMSn

OTSn

OTM-n.m

Simplify to

OR

No VCAT
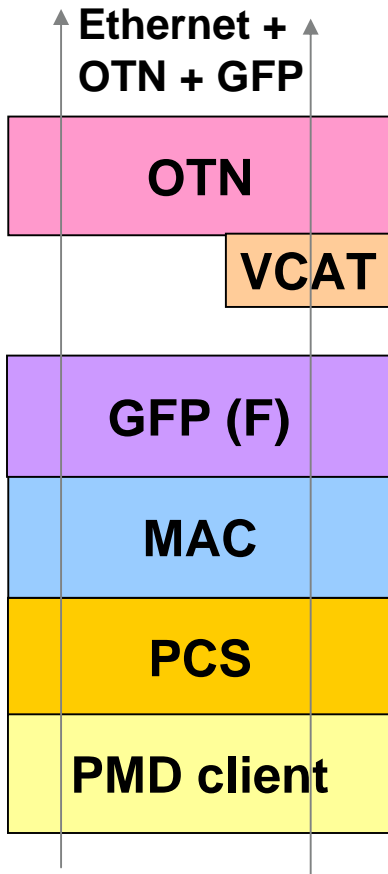
OTN

VCAT

MAC

PCS

PMD / PMA

From Trowbridge, March HSSG meeting

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Examples of maps to carrier networks

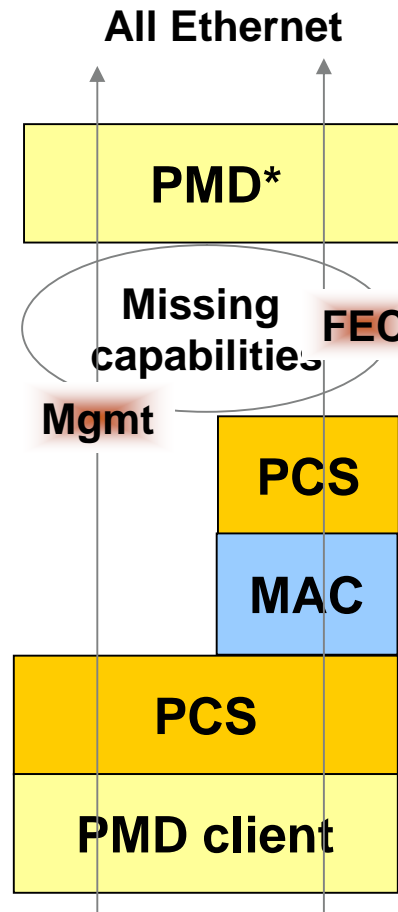**Being addressed at ITU. Attractive for multi-protocol networks.**

Not being addressed. Attractive to Ethernet Dominated Networks

Not being addressed. Should it?

Non-Transparent Packet Multiplexed

Transparent circuits for ultra-rate clients

Ethernet + GFP + SONET/SDH + VCAT + OTN

Ethernet + OTN + GFP

Ethernet + OTN + Mapping

All Ethernet

Column 1	Column 2	Column 3	Column 4
OTN	OTN	PMD*	OTN
VCAT	VCAT		SDH / SONET
GFP (F)	CBR mapping	Missing capabilities / FEC	VCAT
MAC	Mgmt?	Mgmt / PCS	GFP (F)
PCS	PCS	MAC	MAC
PMD client	PMD client	PCS	PCS
		PMD client	PMD client

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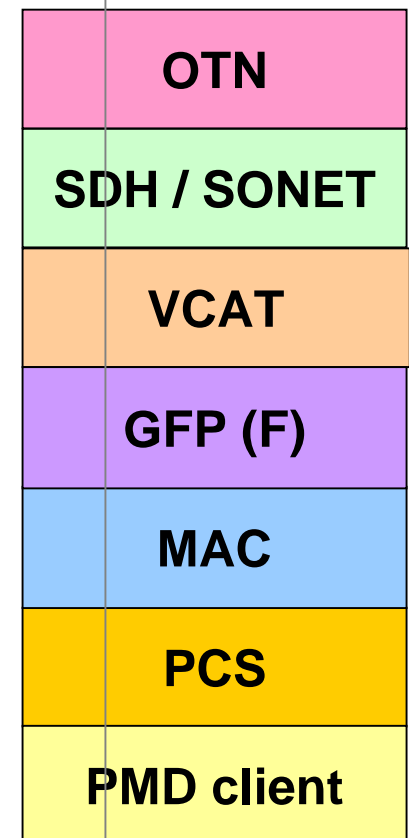
Options for Network Transport (1)

- OTN inter-working is being addressed at ITU
  - Options pursued in ITU Study Group 15. New Proposals regarding an OTU4 definition ~ 3 x ODU3. See Trowbridge March 2007 HSSG talks. Methods
    - Terminate PMD, transport 100 GbE PCS layer transparently with a new mapping TBD
    - Terminate PMD, terminate PCS, Use GFP-F mapping of MAC frames – client rate is independent of network rates.
    - PCS management capability ?
  - HSSG Coordination required

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Options for Network Transport (2)

- **All-Ethernet solutions not being addressed in a standardized way.**
  - PMD will be required – is proprietary acceptable?
  - PCS extensions will be required – is proprietary acceptable?
    - PCS based management capability may be attractive.
    - FEC will be required for most networks of even modest extent (This is ubiquitous for 40 Gb/s and even 10 Gb/s network links).
  - Standardization can drive cost out of the solutions.
  - A single protocol stack option
- **HSSG is not about picking solutions – should enable different options**

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Topics of importance

- For OTN networking
  - To support PCS-transparency – a new serial rate OTN
  - Consider enhanced management capabilities
  - FEC is already there
  - PCS-layer management messaging may be desirable
  - Feasibility of ~130 Gb/s transmission
  - Importance of bandwidth efficiency
  - Importance of different mapping types
- For Ethernet-only transport solutions
  - FEC requirements and precedence in other Ethernet projects.
  - management at PCS layer may be desirable
- For SONET / SDH compatibility
  - Is it needed?
  - Is any additional work required?
- VCAT buffering
- Commercialization of higher spectral efficiency transmission

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Proposal

- Consider a new 'ad hoc' for HSSG
  - "Carrier Ad Hoc" to address issues of importance to this segment. Including
    - Needs of the ITU
    - Issues relevant to direct support of Ethernet transport for networks of significant geographic extent
    - MEF / OIF / IETF / 802.1 interface
  - Examples of possible objectives and topics the community could address
    - PCS additions / modifications / trade-offs
    - MAC management / PCS management
    - FEC provisions (consider prior 802.3 precedents)
    - OTN support / ITU liaison

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Supporters

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THANK YOU!

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