Society of Cable Telecommunications Engineers

www.SCTE.org

Next Generation HFC Networks

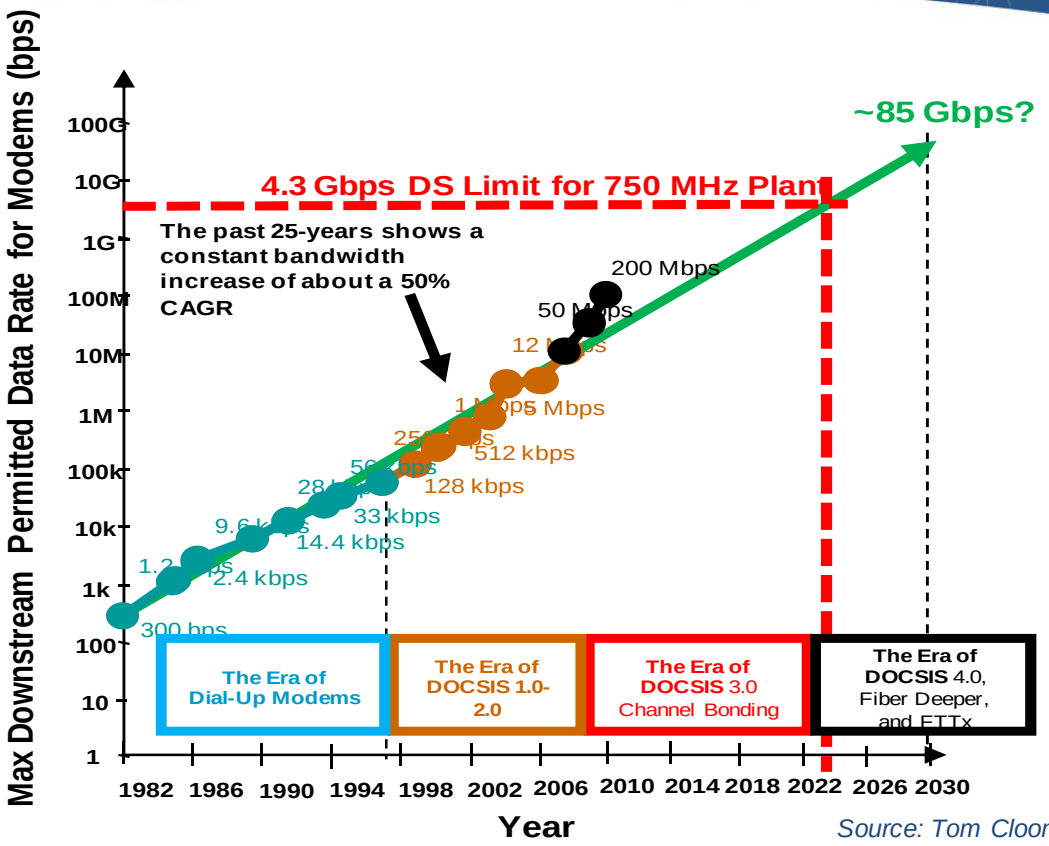
Daniel Howard
SVP of Engineering & CTO, SCTE

Including material from:
Mike Emmendorfer/Arris and Rob Howald/Motorola from presentations at the SCTE Canadian Summit, Toronto, Canada

Introduction

- Required HFC network capacity grows exponentially:
  - Rule | Metric | CAGR | 10 year growth
  - Nielsen's Law | Data rate | 50%/year | 57x
  - Moore's Law | CPU power | 60%/year | 100x
  - ***Network capacity is most limiting to user experience***
- Downstream growth also due to HD, 3D, UHDTV, etc.
- To remain competitive, ***cable networks must continue to expand the capacity*** (data rate) available to users
  - Downstream and upstream needs grow at different rates

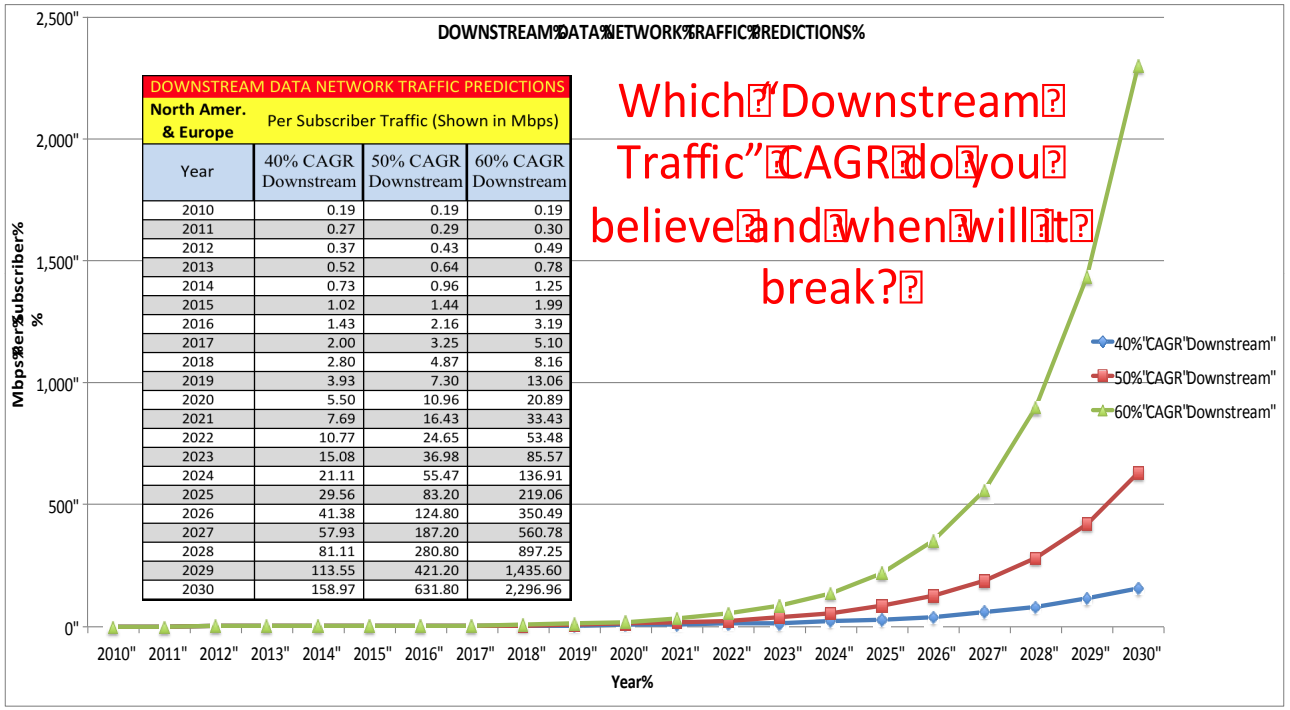
Problems Of Success: Nielsen's Law Validated



Source: Tom Cloonan/Arris

Downstream Predictions

- 40-75% CAGR reported by MSOs

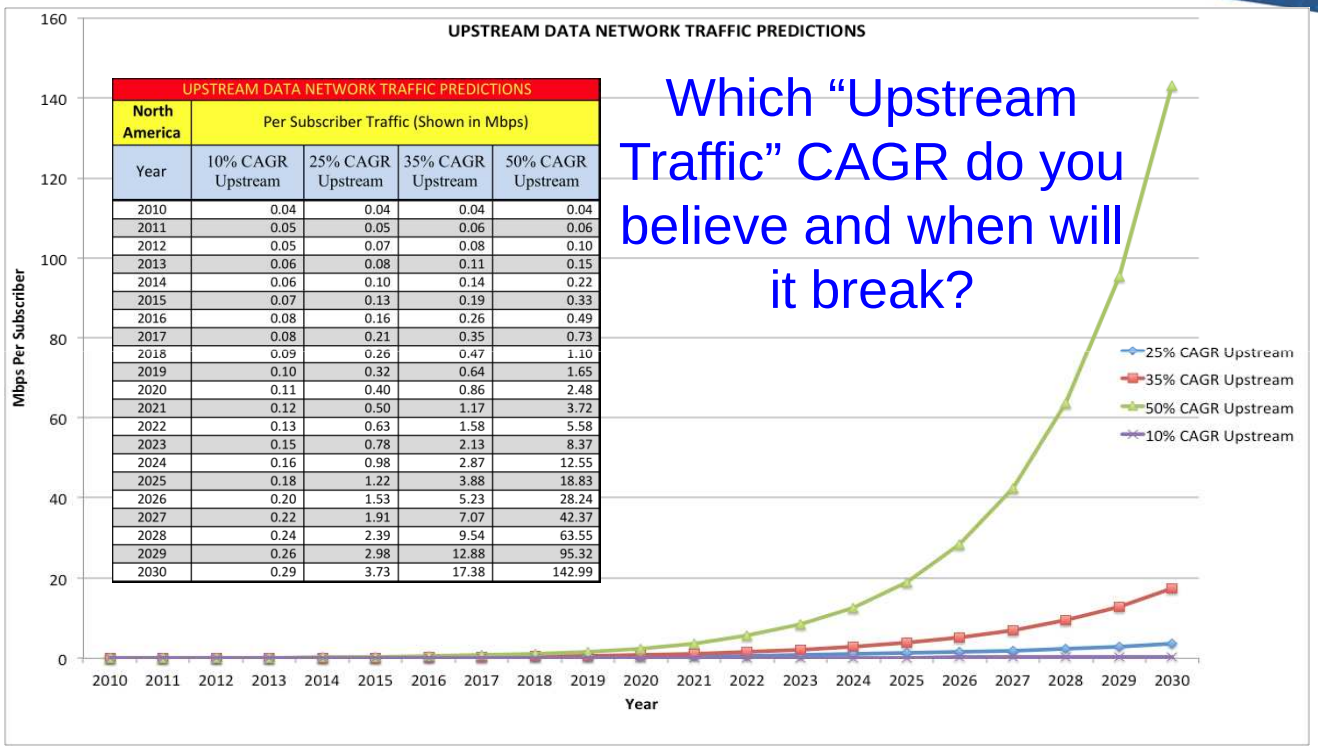


DOWNSTREAM DATA NETWORK TRAFFIC PREDICTIONS

North Amer. & Europe	Per Subscriber Traffic (Shown in Mbps)		
Year	40% CAGR Downstream	50% CAGR Downstream	60% CAGR Downstream
2010	0.19	0.19	0.19
2011	0.27	0.29	0.30
2012	0.37	0.43	0.49
2013	0.52	0.64	0.78
2014	0.73	0.96	1.25
2015	1.02	1.44	1.99
2016	1.43	2.16	3.19
2017	2.00	3.25	5.10
2018	2.80	4.87	8.16
2019	3.93	7.30	13.06
2020	5.50	10.96	20.89
2021	7.69	16.43	33.43
2022	10.77	24.65	53.48
2023	15.08	36.98	85.57
2024	21.11	55.47	136.91
2025	29.56	83.20	219.06
2026	41.38	124.80	350.49
2027	57.93	187.20	560.78
2028	81.11	280.80	897.25
2029	113.55	421.20	1,435.60
2030	158.97	631.80	2,296.96

Upstream Growth is Slower

Society of Cable Telecommunications Engineers



UPSTREAM DATA NETWORK TRAFFIC PREDICTIONS				
North America	Per Subscriber Traffic (Shown in Mbps)			
Year	10% CAGR Upstream	25% CAGR Upstream	35% CAGR Upstream	50% CAGR Upstream
2010	0.04	0.04	0.04	0.04
2011	0.05	0.05	0.06	0.06
2012	0.05	0.07	0.08	0.10
2013	0.06	0.08	0.11	0.15
2014	0.06	0.10	0.14	0.22
2015	0.07	0.13	0.19	0.33
2016	0.08	0.16	0.26	0.49
2017	0.08	0.21	0.35	0.73
2018	0.09	0.26	0.47	1.10
2019	0.10	0.32	0.64	1.65
2020	0.11	0.40	0.86	2.48
2021	0.12	0.50	1.17	3.72
2022	0.13	0.63	1.58	5.58
2023	0.15	0.78	2.13	8.37
2024	0.16	0.98	2.87	12.55
2025	0.18	1.22	3.88	18.83
2026	0.20	1.53	5.23	28.24
2027	0.22	1.91	7.07	42.37
2028	0.24	2.39	9.54	63.55
2029	0.26	2.98	12.88	95.32
2030	0.29	3.73	17.38	142.99

Which “Upstream Traffic” CAGR do you believe and when will it break?

HFC Architecture Options: Downstream

- Reduce the number of homes per node
  - Fiber deep architecture, doubles or quadruples capacity for every split
- Increase the order of modulation from 256 to 1024 QAM
  - 25% increase in capacity, more difficult to maintain
- Eliminate simulcast via unicast architecture
  - Must get node size to 250 HHP or less
- Reclaim analog channels, convert to digital
  - Converting 40 analogs to SD gives ~ 210 MHz RF BW
- Increase HFC RF range to 1 GHz with new amp technology
  - Adds 250 to 750 MHz HFC, 140 to 860 MHz HFC
- Surgical solutions for high need customers
  - RFoG, MEF, EPoC
  - Should couple with edge/node QAM solution for scalability

Challenges

- Migration planning while supporting legacy services and moving to next generation unicast services is challenging
  - Switched digital video (SDV) as key solution for legacy MPEG2 devices while moving to MPEG4/unicast/IP model
- Make ready-cost of fiber deep
- Cost of going to 1 GHz plant is 2x cost of DTAs
  - DTA also solves theft of service issue
  - Legacy STBs don’t go to 1 GHz
- Impact of WiFi hotspots on capacity planning…

Emerging Popular Downstream: Solution: Digital to Advanced Node

- Digital optical transport to node
  - 880 Gbps to node via DWDM w/ 88 wavelengths
- PHY or MAC/PHY processing in the node/MDU
- Everything from the node to the customer remains the same:
  - Coax cable
  - Amplifiers
  - Taps

Many More Options

Optical Transport Technologies to Node

(Ethernet Narrowcast)

- 1 GbE Optical Ethernet
- 10 GbE Optical Ethernet
- 1G EPON
- 10G EPON
- GPON
- XG-PON
- G.709
- Others

RF Coax MAC/PHY Technologies in Last Mile

- Analog Video
- Edge QAM
- DOCSIS
- Ethernet over Coax
  - HPNA 3.1, HomePlug, G.hn, MoCA
- Ethernet PON over Coax (EPOC)
- Other RF coax technologies

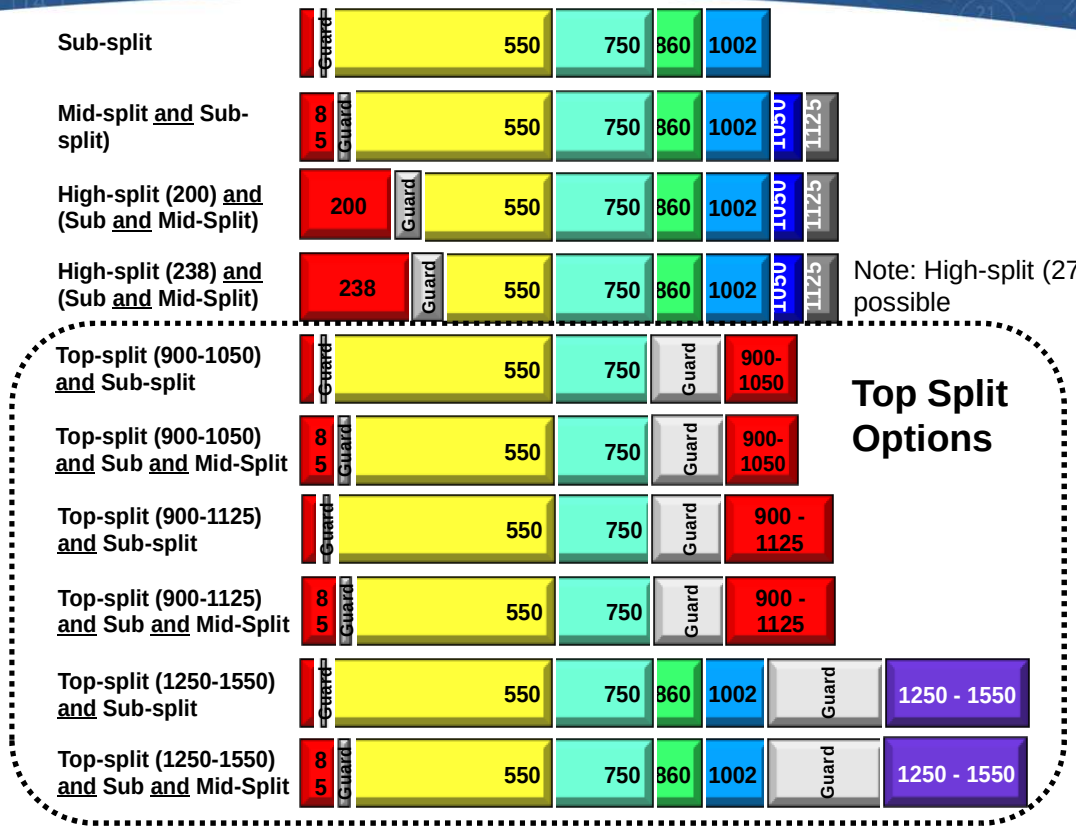
Optical Technologies in Last Mile

- GPON/EPON
- RFoG
- MEF

Upstream Options

- Use spectrum below 20 MHz
  - S-CDMA
    - Moto, Arris support but not yet Cisco
    - Keep as option when needed
  - More upstreams per RF port on CMTS
    - Use multiple bonded TDMA channels
    - Limited use against impulse noise but good against ingress only
- Increasing the split point (mid, high and top-split options)
- Higher order modulation
- The real question: When will we need more upstream, and what applications will drive the need?

RF Spectrum Expansion Options



Note: High-split (270) is possible

Top Split Options

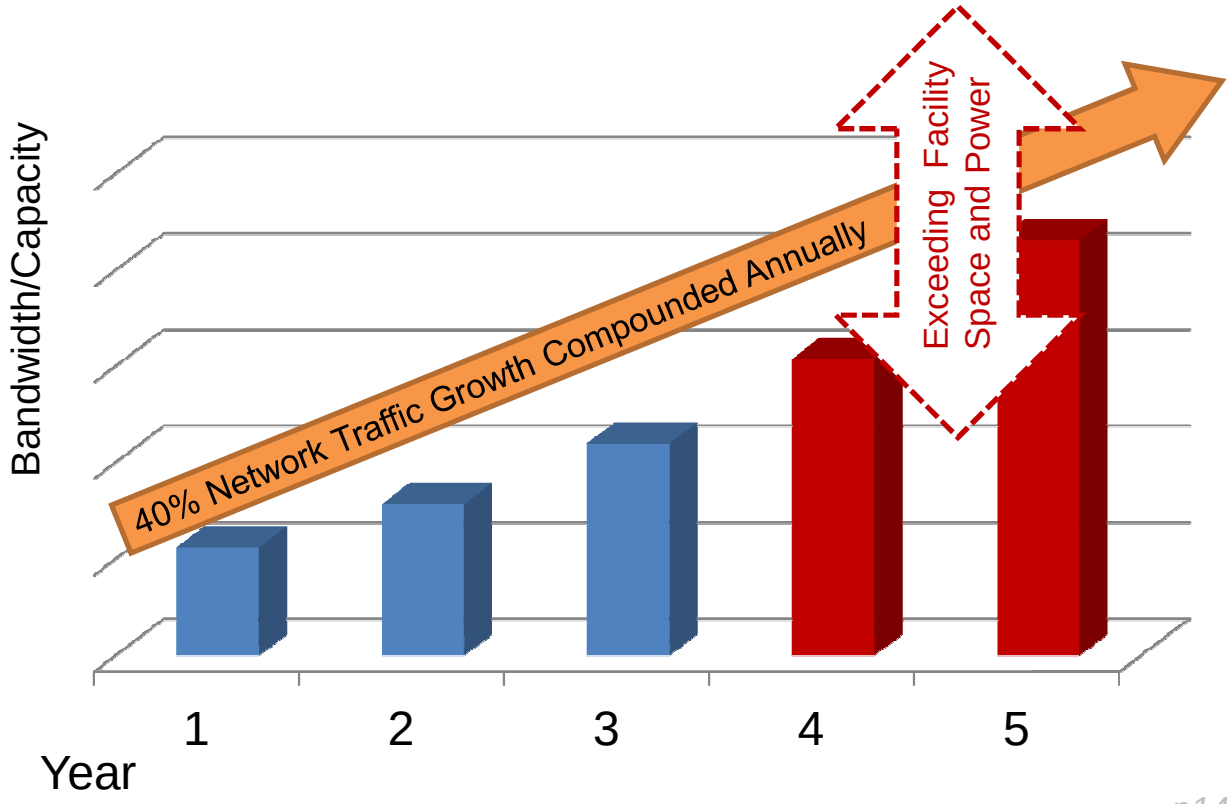
Upstream Capacity Summary

- Future upstream spectrum selection and desired data capacity impact the entire access layer architecture
- Mid-split & high-split preserves a 500 HHP node
- High-split reaches 1 Gbps DOCSIS upstream speeds
- Top-split spectrum is the worst performing and drives up costs for fiber builds and node splits/segmentation
  - Amazingly, all CMTS vendors agree on this one
  - Top-split does achieve 1 Gbps with Node + 0 or FTTLA

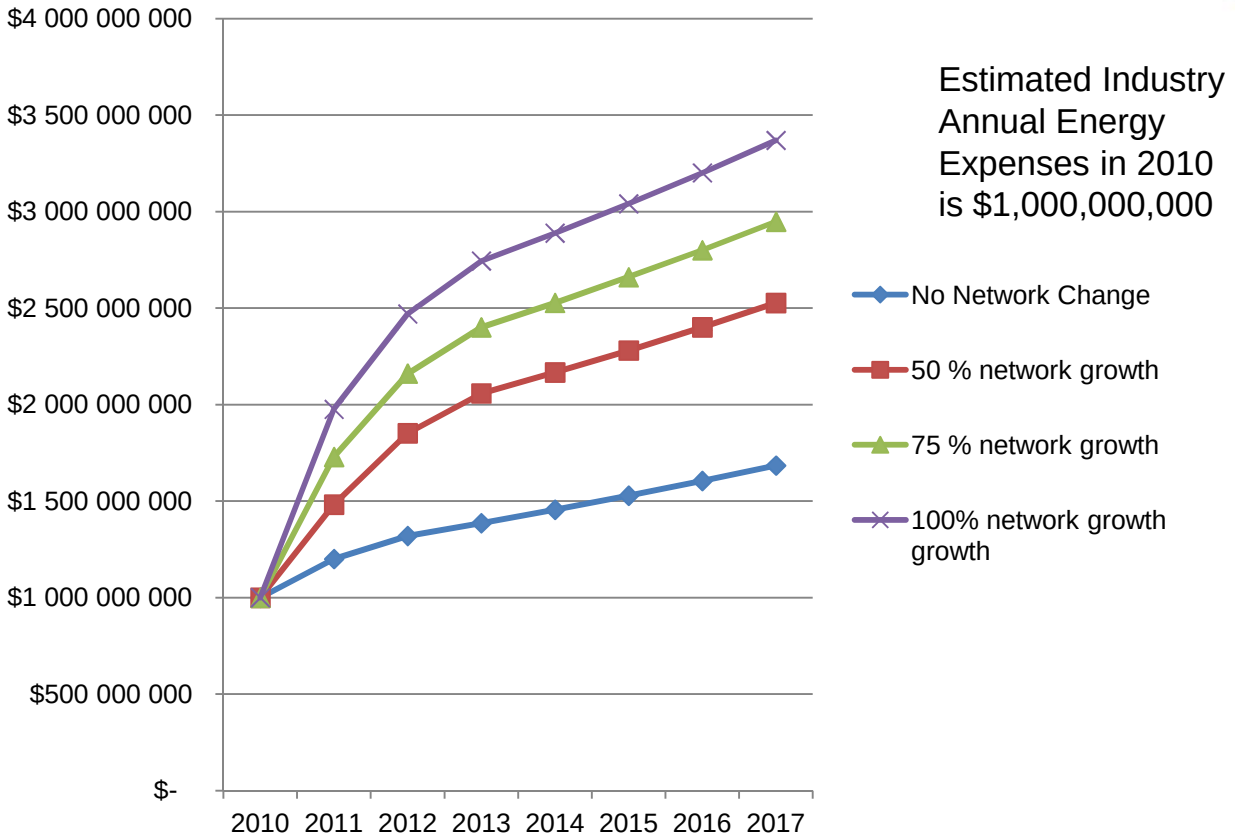
Conclusions for Next Generation HFC

- **Downstream service and traffic CAGR is major driver for network change** (e.g. from HSD and narrowcast video)
  - Node splits, analog reclamation, unicast/all IP, spectrum increases, ultimately all needed to keep up with Nielsen's law
  - Modern node technology (digital to node, QAM in node with upgradeable PHY) also required to keep up with capacity especially if fiber to node is limited
    - Permits surgical solutions for highest speed users like business, MDUs
- **DOCSIS modifications might include:**
  - Use of multi-carrier modulation (OFDM) and 1024QAM+
  - Use of modern error correction (ex: LDPC)
  - Support backwards compatibility with the DOCSIS MAC

The Energy and Form Factor Challenge



Energy Cost Considerations



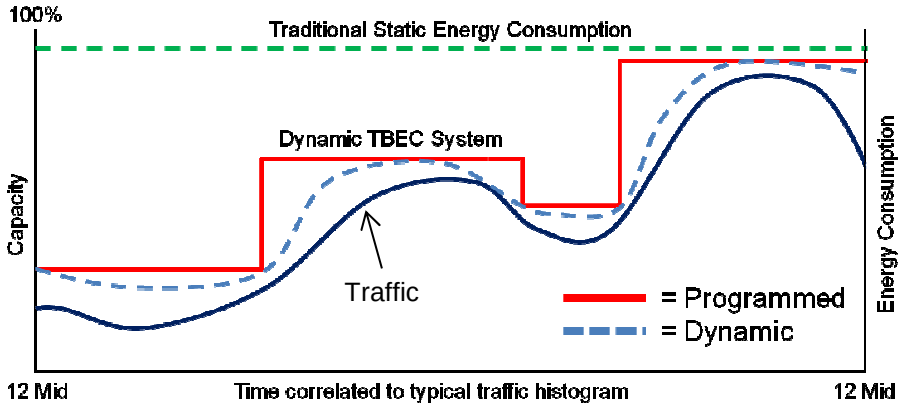
Estimated Industry Annual Energy Expenses in 2010 is $1,000,000,000

SCTE Standards Five-Year Plan

- SMS 001 – SCTE SMS Facilities Energy Management Recommended Practices
- SMS 002 – Product Environmental Specifications & Test Procedures
- SMS 003 – Adaptive Power System Interface Specification (APSIS™)
- SMS 004 – Energy and Density Benchmark Measurement (for hardware)
- SMS 005 – Predictive Alarming (EMS System/hardware)
- SMS 006 – Graphical Hardware Specification
- SMS 007 – 3D Facility Modeling of Energy
- SMS 008 – Virtual Monitoring & Control (telemetry)
- SMS 009 – Transaction Based Energy Consumption
- SMS 010 – High Availability Energy Measurements & Parameterization
- SMS 011 – Disaster Recovery (preparation and facilitation of DR practices)
- SMS 012 – Business Continuity (high reliability network planning)
- SMS 013 – Fleet (alternate fuel, GPS routing, telemetry, and procurement)
- SMS 014 – Recycling (end of life management)
- SMS 015 – Energy Financial Specifications
- SMS 016 – Network to Network Power System Interface Specification
- SMS 017 – Symbology of energy sources for network powering and fleet

Next Major SCTE Standard: APSIS

- SMS 003 – Adaptive Power System Interface Specification
  - Energy consumption management in networks using a common control protocol and system interface specification
  - Control of entire facilities or specific features on individual equipment in the network based on a variety of external and internal influences



Modes
- Default
- Traffic-based
- Programmed
  - Optimize runtime of backup power
  - Smart network peer-to-peer network management

Other SCTE Energy Standards Coming Soon

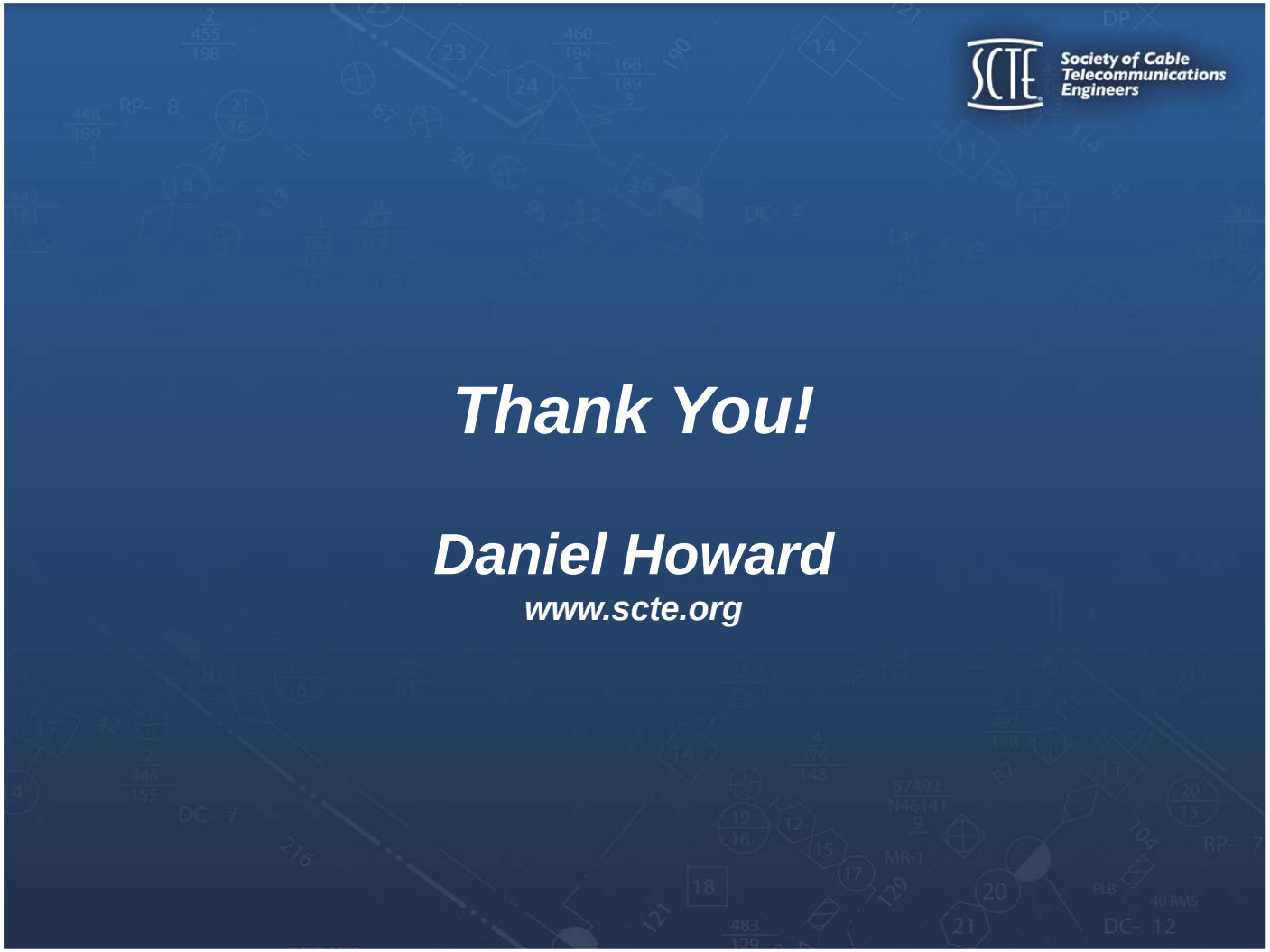
- SMS 004 – Density and Benchmarking
  - Metrics for measuring energy consumption and feature density in cable facilities
  - Example: Watts/QAM, throughput per cubic foot

- SMS 005 – Predictive Alarming
  - Critical parameters for predicting energy-related issues to maintain a high availability network
  - Optimization of MTBF via failure signatures

Bottom Line

- Next generation HFC networks must support growth in
  - Capacity
  - Energy consumption
- Must also support higher availability for business customers
  - Optical transport
  - Proactive network maintenance for coax last mile

Standing still = falling behind!


SCTE
Society of Cable Telecommunications Engineers
Thank You!
Daniel Howard
www.scte.org