ALMA MATER STUDIORUM
UNIVERSITÀ DI BOLOGNA

Broadband Satellite Communications the DVB-RCS-NG Standard

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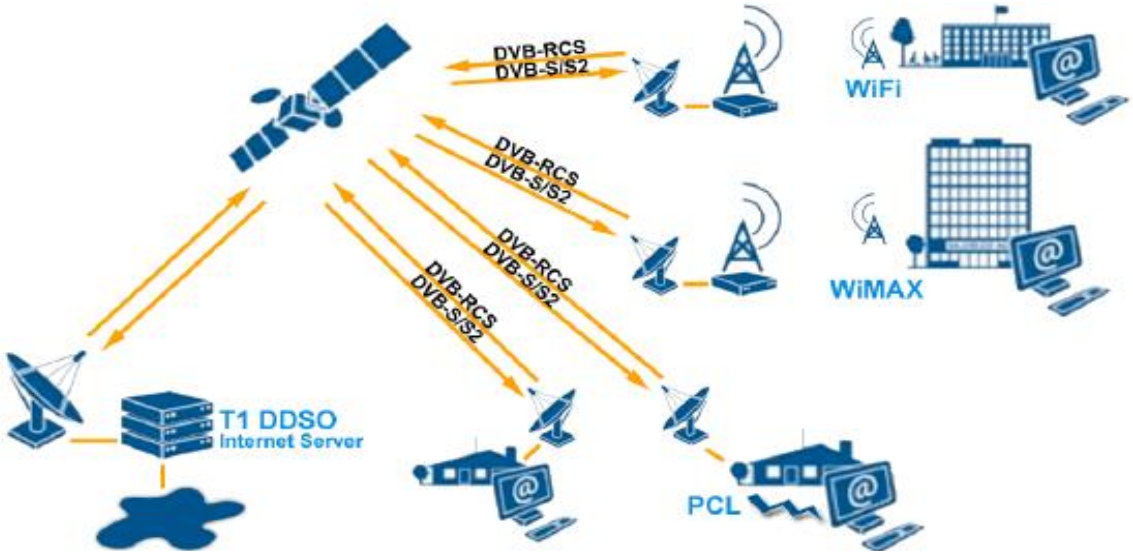
DVB-RCS Next Generation

- **What is it?**
  - A broaband access system via satellite for fixed and mobile applications
- **Market segments**
  - Fixed networks
    - Consumer, Multi-dwelling, Corporate, SCADA
  - Mobile networks
    - Aeronautical, Railway, Vehicular, Nomadic, Maritime
- **Objectives**
  - Low cost for consumer terminal
  - Robustness
  - Capabilities competitive with ADSL2+ and cable
  - Ability to support star and mesh networks
  - Interoperability at all layers
  - Fast definition of the standard



Broadband Access:
a key element for economic recovery

The International approach to Broadband Access

- **Development of "Broadband Access" is considered worlwide as a key element for Economic Recovery:**

- **The European Commission, as part of its "Economic Recovery Plan", aims at achieving 100 % high-speed internet coverage for all citizens by 2010**
  - 30% of the European Rural Areas are not reached by broadband access
  - constant rate investment until 2015 in "broadband access" can produce 1million jobs and 850 billion economy growth
  - 1 billion euro has been earmarked in January 2009 to extend broadband access to rural areas
- **On November 5, 2007, the European Parliament and the Council of Ministers agreed a new telecom package that foresees 12 reforms among which**
  - "Accelerating broadband access for all Europeans"
  - "Encouraging competition and investment in next generation access networks"

- **The US Government issued "the American Recovery and Reinvestment Act" on February 2009**
  - The extension fo broadband deployment in unserved, underserved, and rural areas and to strategic institutions is identified as a way to create jobs, spur investments in technology and infrastructure, and provide long-term economic benefits
  - 7.2 billion dollars have been reserved as "Broadband Stimulus"

BROADBAND ACCESS OUTLOOK IN OECD COUNTRIES

Source:

OECD

Organization for Economic Co-operation and Development

www.oecd.org

OECD countries

- Austria
- Belgium
- Czech Republic
- Denmark
- Finland
- France
- Germany
- Greece
- Hungary
- Ireland
- Italy
- Luxembourg
- Netherlands
- Poland
- Portugal
- Slovak Republic
- Spain
- Sweden
- United Kingdom

- Norway
- Switzerland
- Turkey

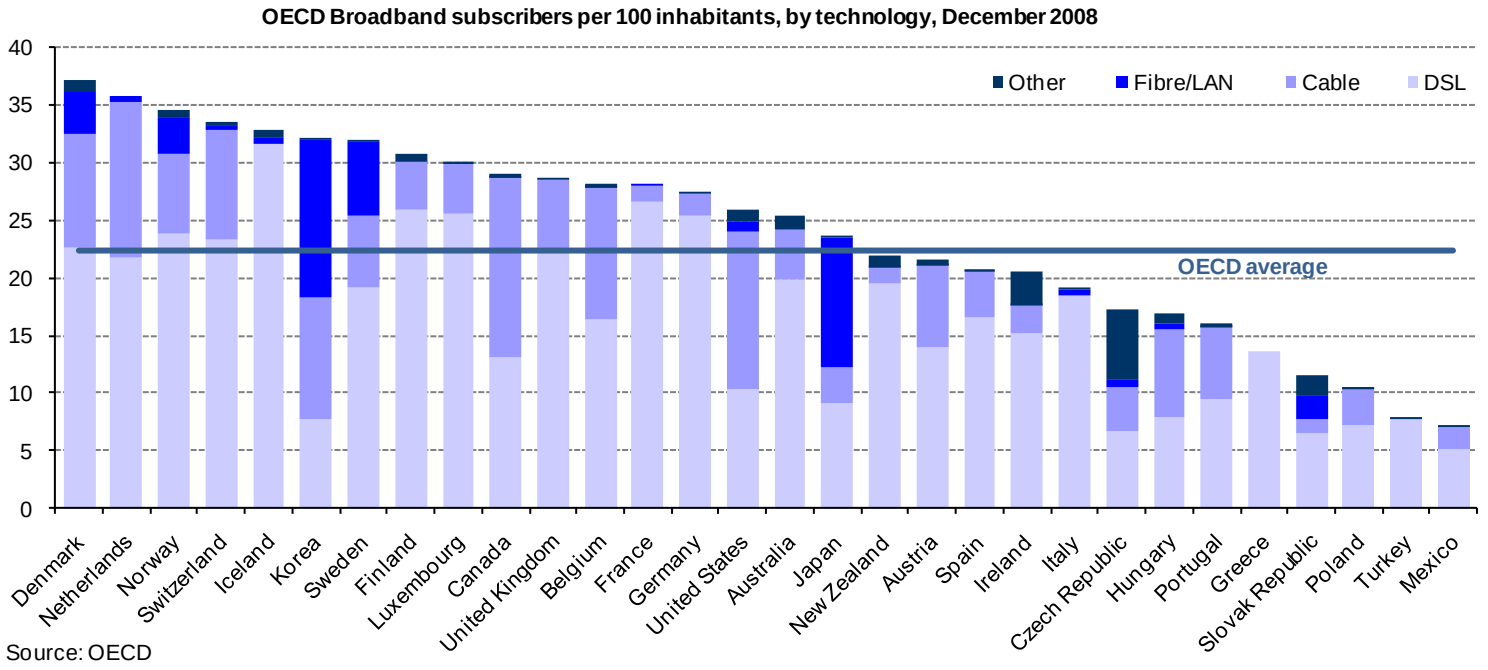
- United States
- Canada
- Mexico

- Japan
- Korea

- Australia
- New Zealand

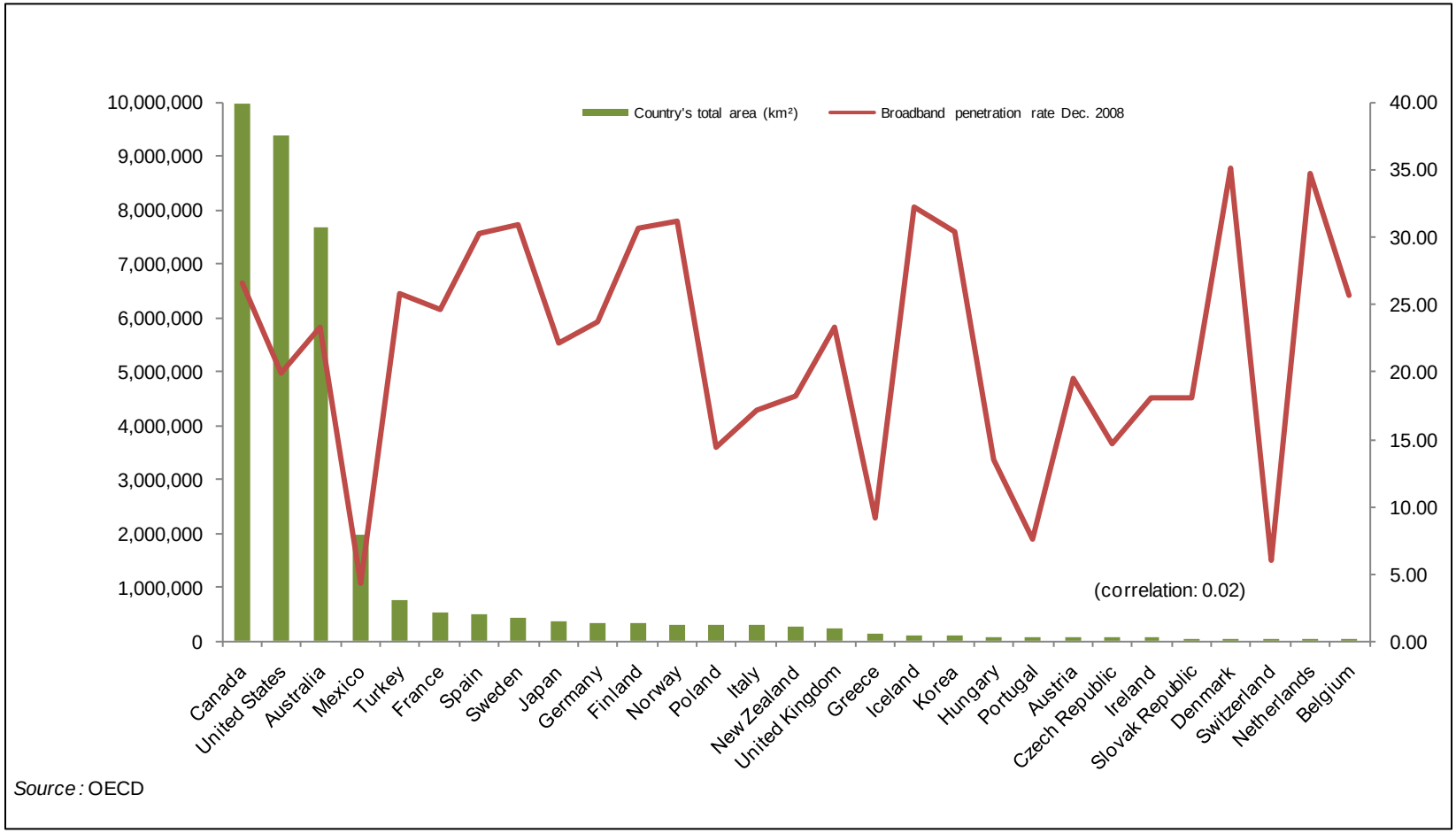
- Iceland

Broadband penetration

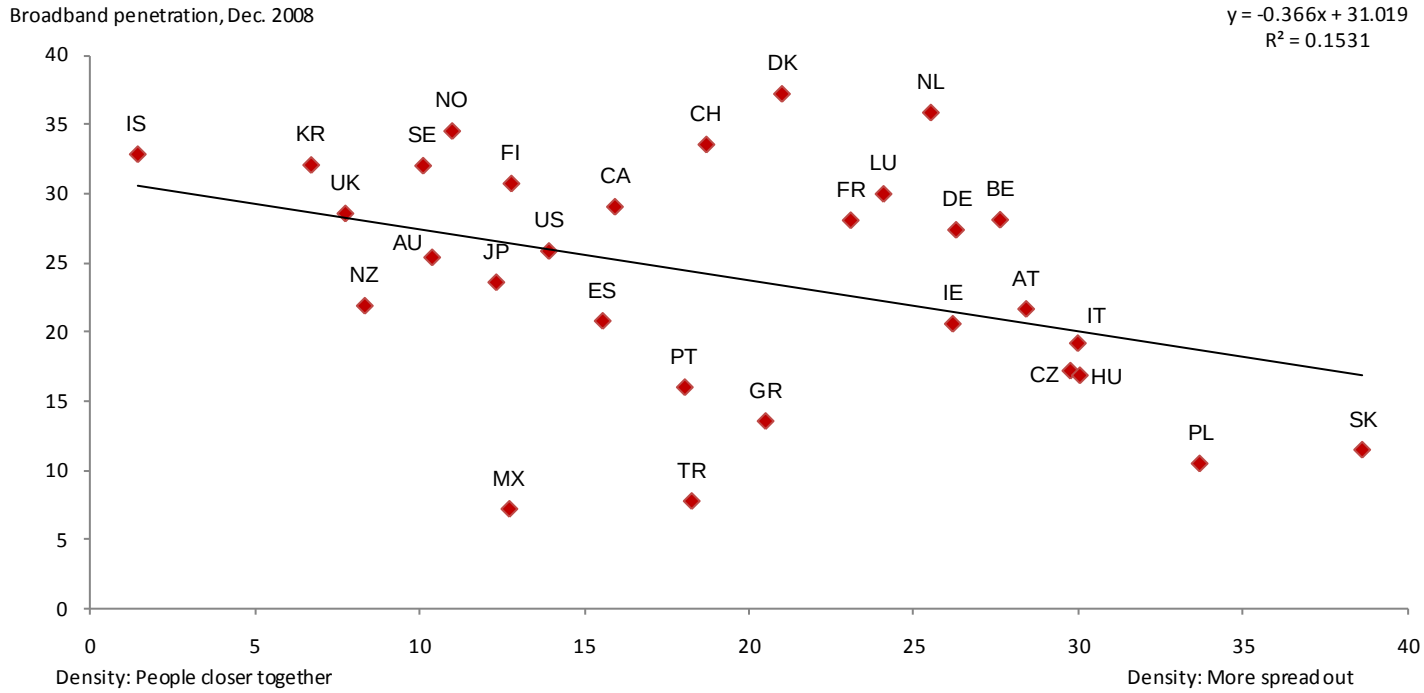


Source: OECD

Broadband Penetration and Country Landmass

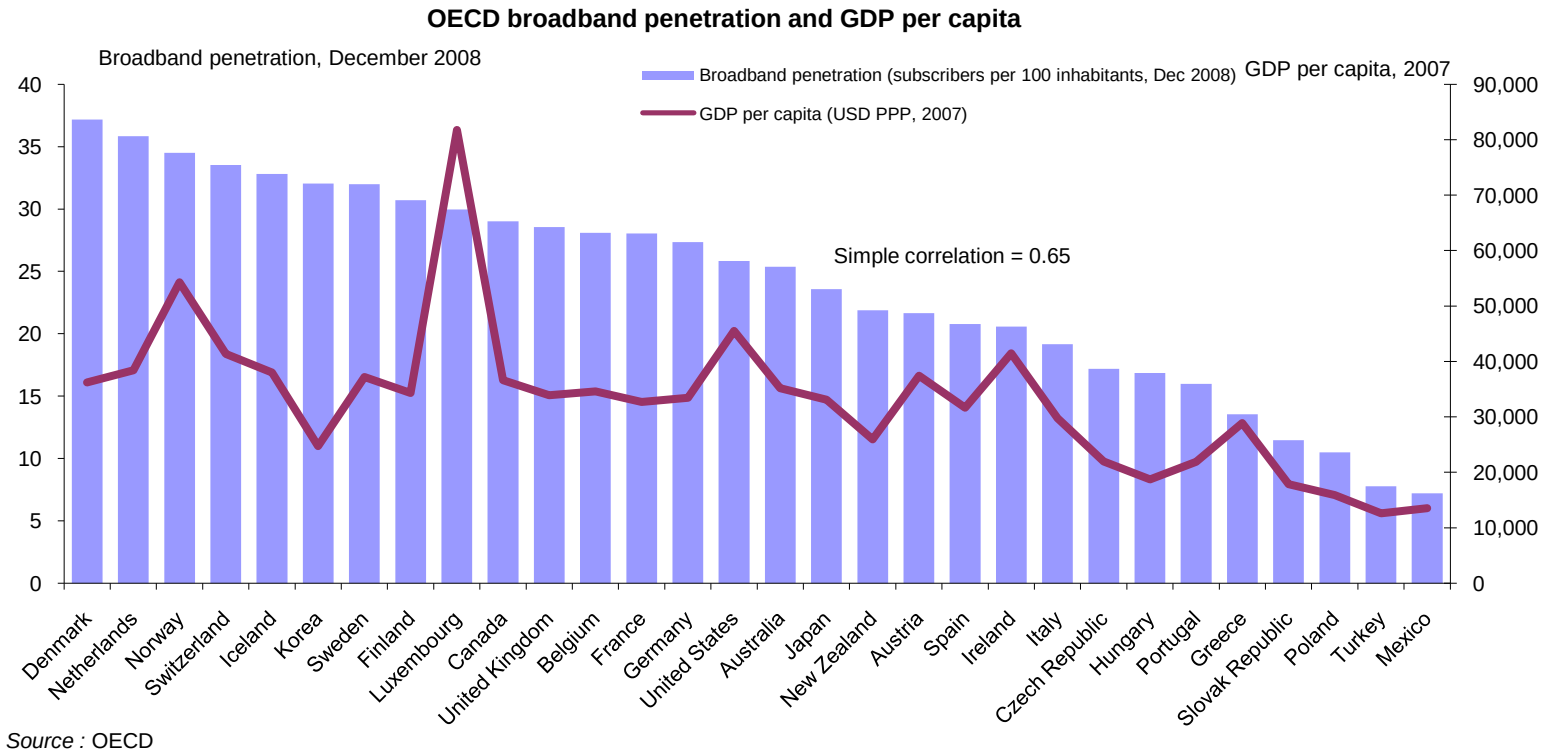


Broadband penetration vs. Population dispertion



Source : OECD

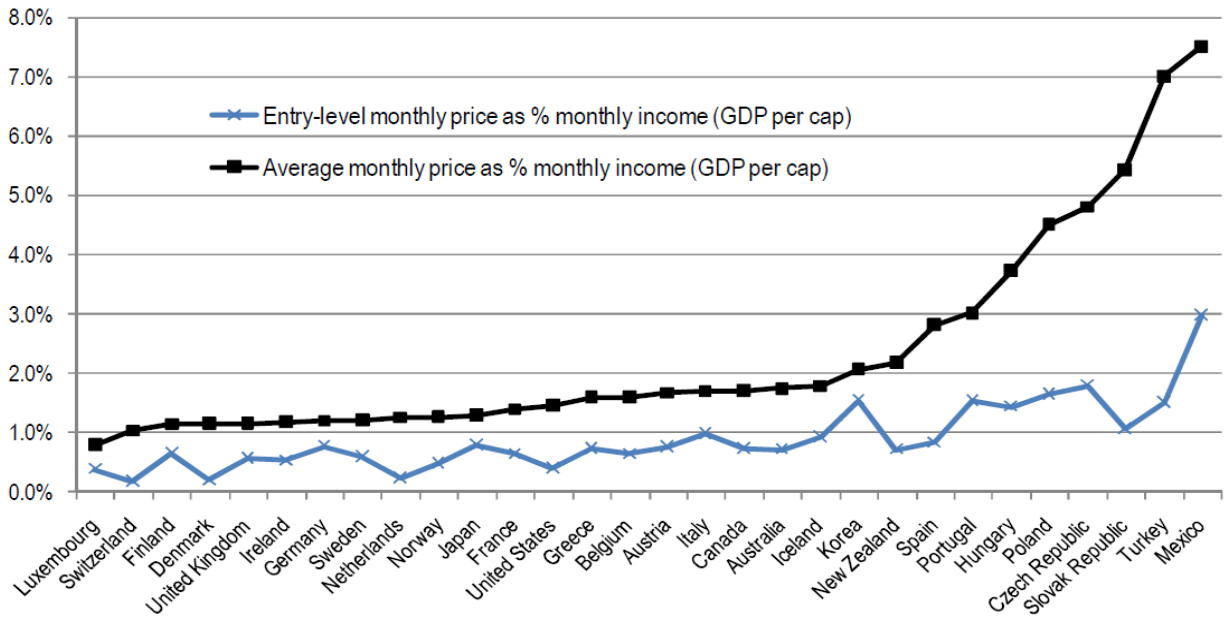
Broadband penetration vs. GDP per capita

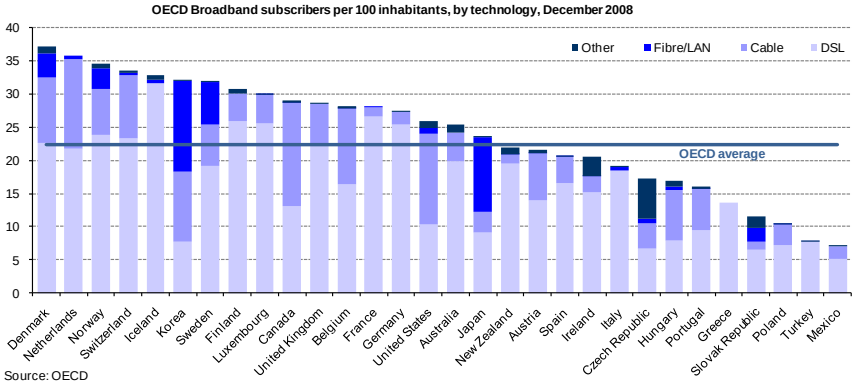


Source : OECD

Broadband Service Cost

Entry and average monthly broadband price as a percentage of monthly GDP per capita

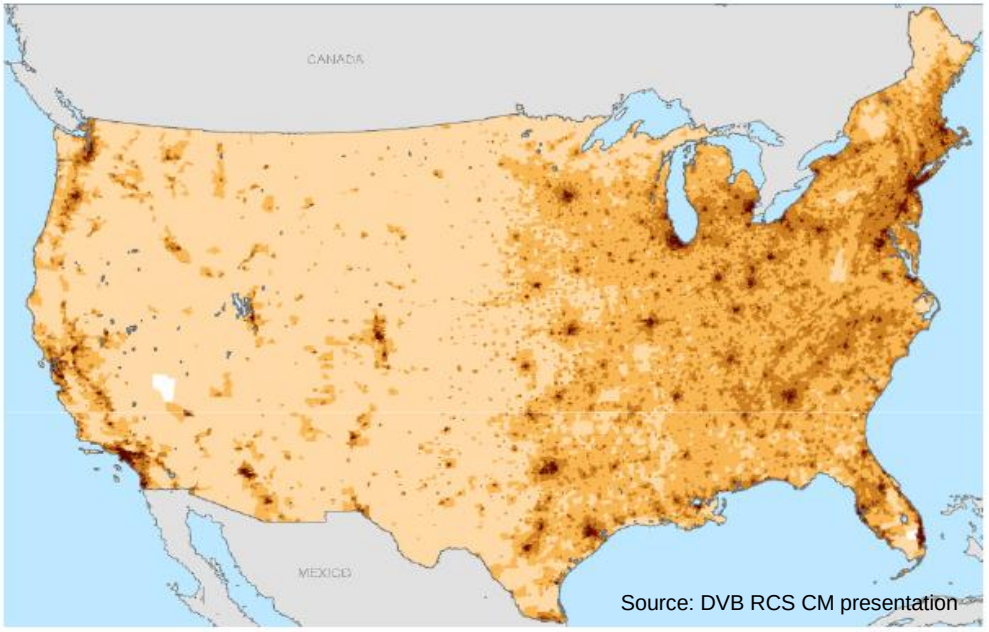




Source: OECD

Considerations

- **Broadband penetration is limited by the service cost and service quality , e.g.**
  - **Wildblue customers' location closely follows the population density map**
  - **There almost no perceived bias towards rural area**
  - **Customers are typically suburban with poor DSL services**



Source: DVB RCS CM presentation

- **Recent studies hve shown that the coverage costs through a fiber infrastructure increase exponential with the coverage (the last 7% coverage would cost as much as the entire network!)**
- **Unlikely that the total coverage objective can be reached thorugh a fiber-based approach (too expensive)**
  - **Wireless solutions among, which Satellite Networks ,represent a viable and competitive alternative provided that service cost and quality are comparable**

Examples of Service offering on 2-way satellite Broadband Access

Offer Service Provider X

Equipment Cost: €299-399

Down-link (kbps)	Up-link (kbps)	Volume (GB)	€/m
2048	384	1.8 (Down +Up)	29.90
2048	384	3.0 (Down +Up)	37.90
2048	384	5.0 (Down +Up)	54.90
2048	384	9.0 (Down +Up)	94.90

Offer Service Provider Y

Equipment Cost: €399

Down-link (kbps)	Up-link (kbps)	Volume (GB)	€/m
512	96	Progressive bit-rate decrease starting from 0.8 GB Down, 0.15 GB Up	29.90
1024	128	from 1.4 GB Down, 0.25 GB Up	39.90
2048	128	from 2.24 GB Down, 0.4 GB Up	69.90

Offer Service Provider Z

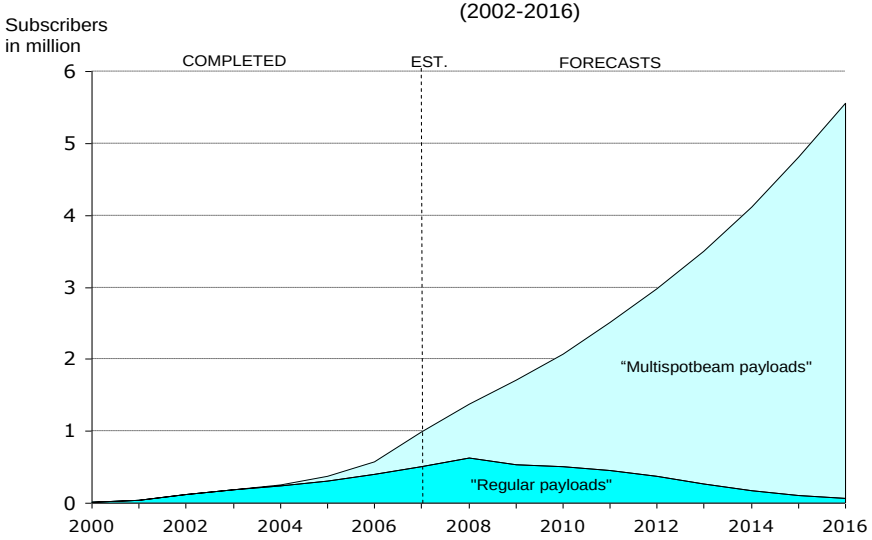
Equipment Cost: €615

Down-link (kbps)	Up-link (kbps)	Volume (GB)	€/m
512	256	5.0 (Down + Up)	22.00
1024	256	10.0 (Down + Up)	33.00
2048	512	15.0 (Down + Up)	44.00
3072	768	20.0 (Down + Up)	55.00

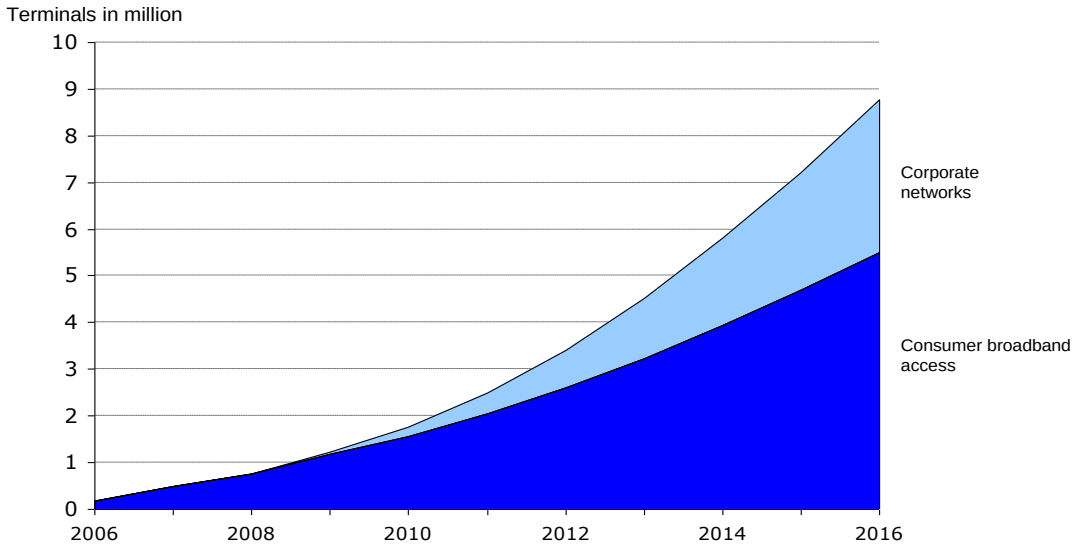
Source: ESOA "Satellite broadband: a sustainable solution"

Broadband Satellite Communications: market perspective (1/2)

Growth of Subscriptions to Consumer Satellite Broadband Access
Breakdown between Regular and Multispotbeam Payloads
(2002-2016)



Forecasts of terminals served by multispotbeam satellite systems
(consumer broadband & corporate networks, 2006-2016)



Source: Euroconsult 2007

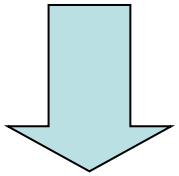
- **Total broadband market size available > 20 Million in Europe and North America**
- **The cost of the service will significantly drop due to a more efficient exploitation of the spectrum thus making the consumer market more appealing**
- **Satellite broadband access market booming thanks to multi-spot satellite systems**

Broadband Satellite Communications: market perspective (2/2)

- **Large multi-spot beam satellite networks, most in Ka band have recently been deployed or are being developed and will be operational over the coming years:**
  - **US:**
    - **WildBlue (2006, 30 Gbps, 41 beams),**
    - **Spaceway-3 (2007, 10 Gbps, 100 beams),**
    - **ViaSat-1 (2011, 100 Gbps)**
  - **Europe:**
    - **HylasOne (2009, 8 beams),**
    - **KaSat (2010, 70 Gbps, 80 beams)**
  - **Asia/Pacific:**
    - **IPStar-1 (2005, 84 Ku beams)**
- **Terminals market:**
  - **125,000 consumer VSATs have been shipped in the US in 2006 (source: COMSYS)**
  - **WildBlue ordered 500,000 terminals in 2007**
  - **By mid-2007, Hughes and WildBlue had already around 450,000 subscribers (source: COMSYS)**
- **Large population in Europe, but also in Latin America, still not reached by terrestrial access technologies**

Broadband Satellite Access: open standard approach

- **Need for an open standard to ensure**
  - **Low cost device: economy of scale in chip development and manufacturing**
  - **Terminal Interoperability**



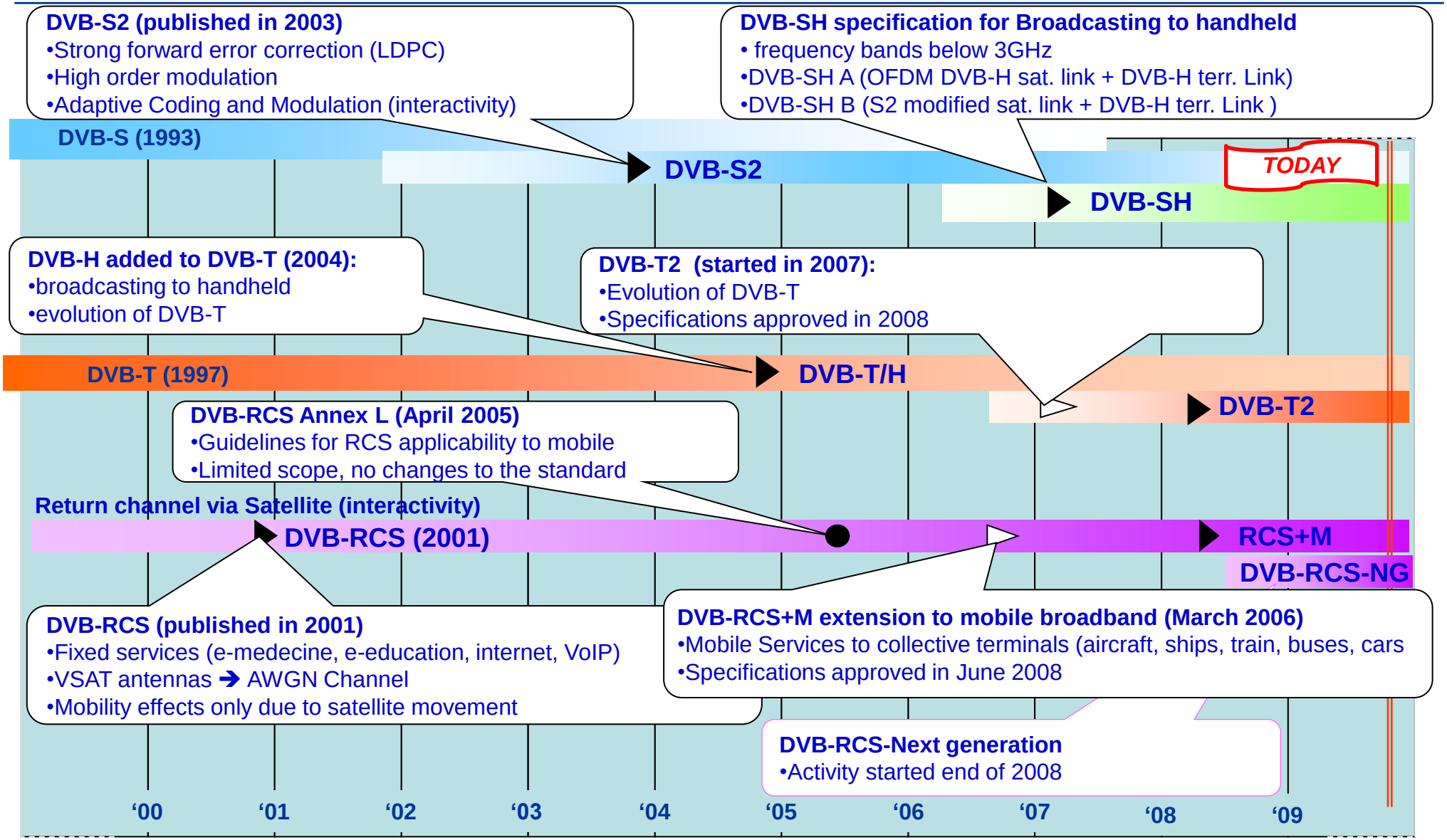
DVB

- **Next generation of Digital Video Broadcasting Return Channel via Satellite**

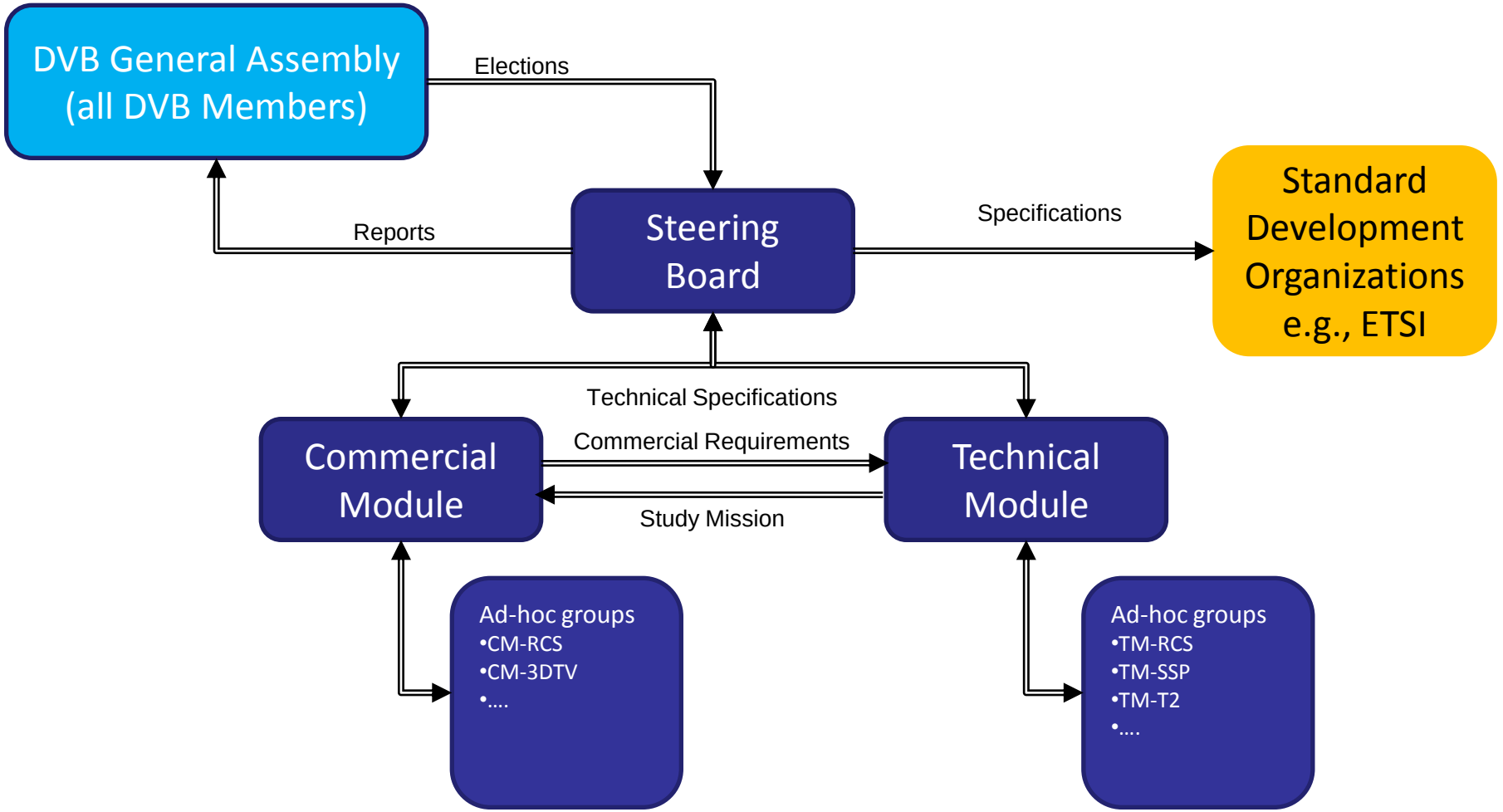
The Digital Video Brodcasting (DVB) Project

- Point to multipoint transmission standards for large volume of information at high data rate
- Information is mainly audio and video (MPEG2 format) but can also be other data
- Transmission (FL)
  - DVB-S and S2 → Satellite channel
  - DVB-T/H → Terrestrial channel (fixed and mobile)
  - DVB-SSP → Satellite Services to Portables (aka DVB-SH)
  - DVB-T2 → Terrestrial 2° generation
  - DVB-NGH → New Generation Handheld (still in study mission phase)
  - DVB-C → Cable channel
  - DVB-MS → Multipoint transmission system @ 10 GHz and above
  - DVB-MC → Multichannel Distribution System below 10 GHz
  - DVB-MT → Microwave terrestrial transmission
- Interactivity (RL)
  - DVB-RCC → cable TV distribution systems
  - DVB-RCP → ISDN, PSTN
  - DVB-RCD → DECT
  - DVB-RCL → Local Multipoint Distribution Systems (LMDS)
  - DVB-RCG → GSM
  - DVB-RCCS → Satellite Master Antenna TV (SMATV)
  - DVB-RCS → Satellite (now with Mobile Extension DVB-RCS+M)
  - DVB-RCT → Digital TV including multiple access OFDM
  - DVB-RCGPRS → GPRS
- Ad-hoc groups
  - DVB-CBMS → Convergence of Broadcast and Mobile Services

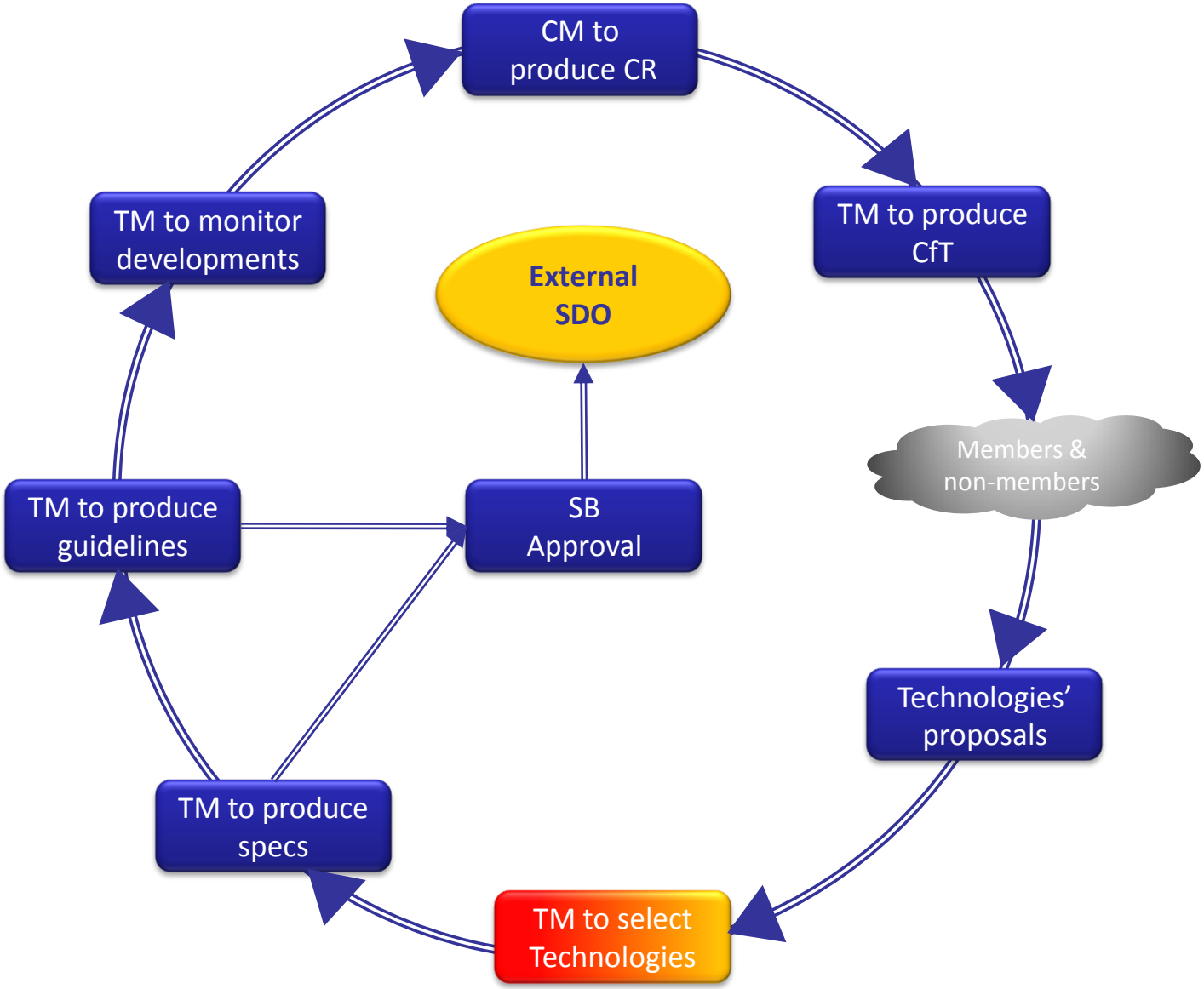
DVB Broadcasting and Broadband Standards



Digital Video Broadcasting Project

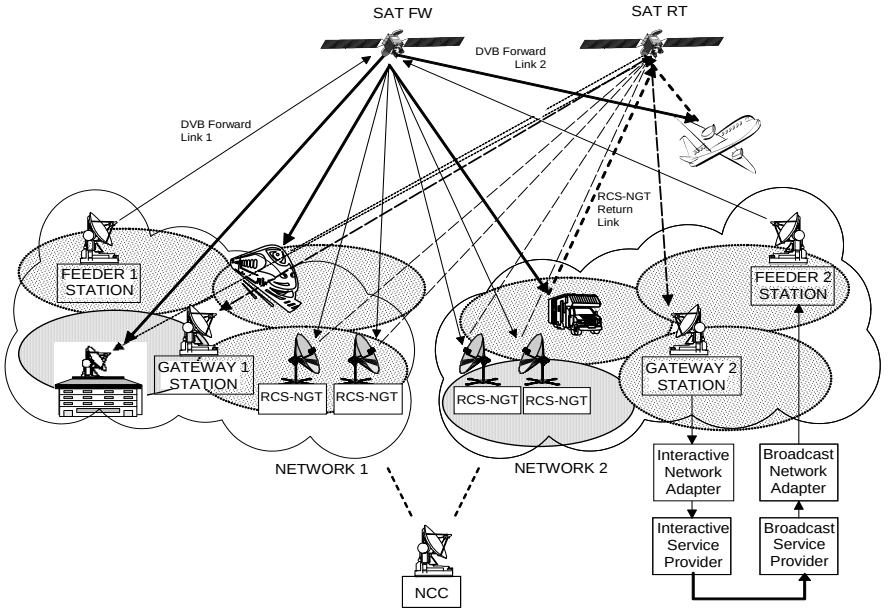


Standard production

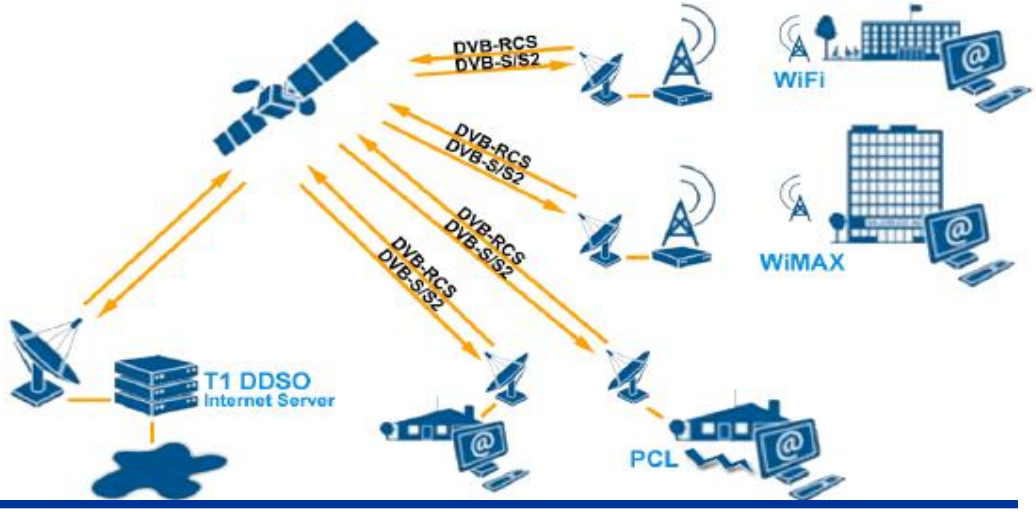


DVB-RCS Next Generation: a new standard

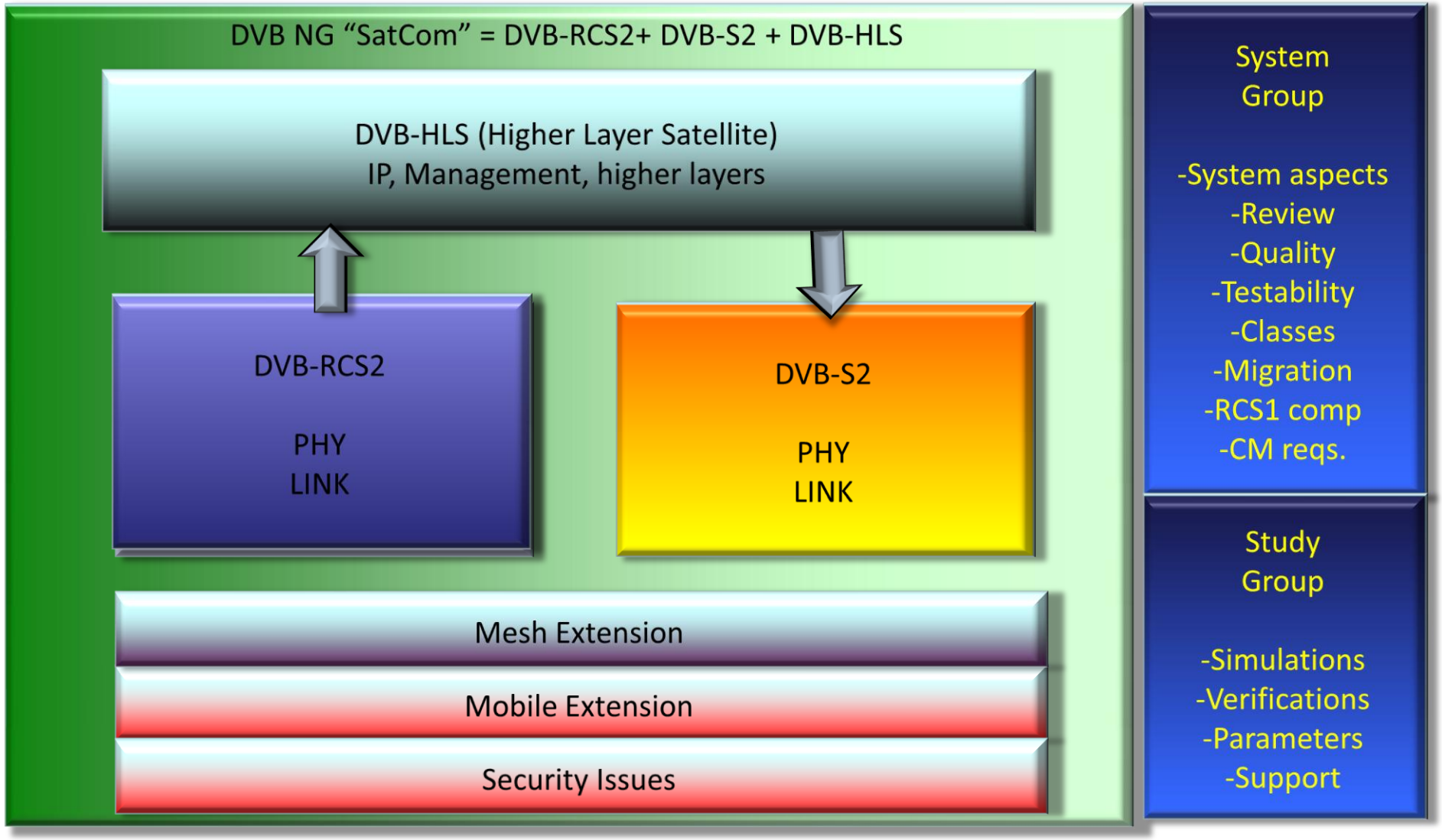
- **Objectives (from CM-RCS)**
  - Low cost for consumer terminal
  - Robustness
  - Capabilities competitive with ADSL2+ and cable
  - Ability to support star and mesh networks
  - Interoperability at all layers
  - Fast definition of the standard



- **Market segments (from CM-RCS)**
  - Fixed networks
    - Consumer, Multi-dwelling, Corporate, SCADA
  - Mobile networks
    - Aeronautical, Railway, Vehicular, Nomadic, Maritime



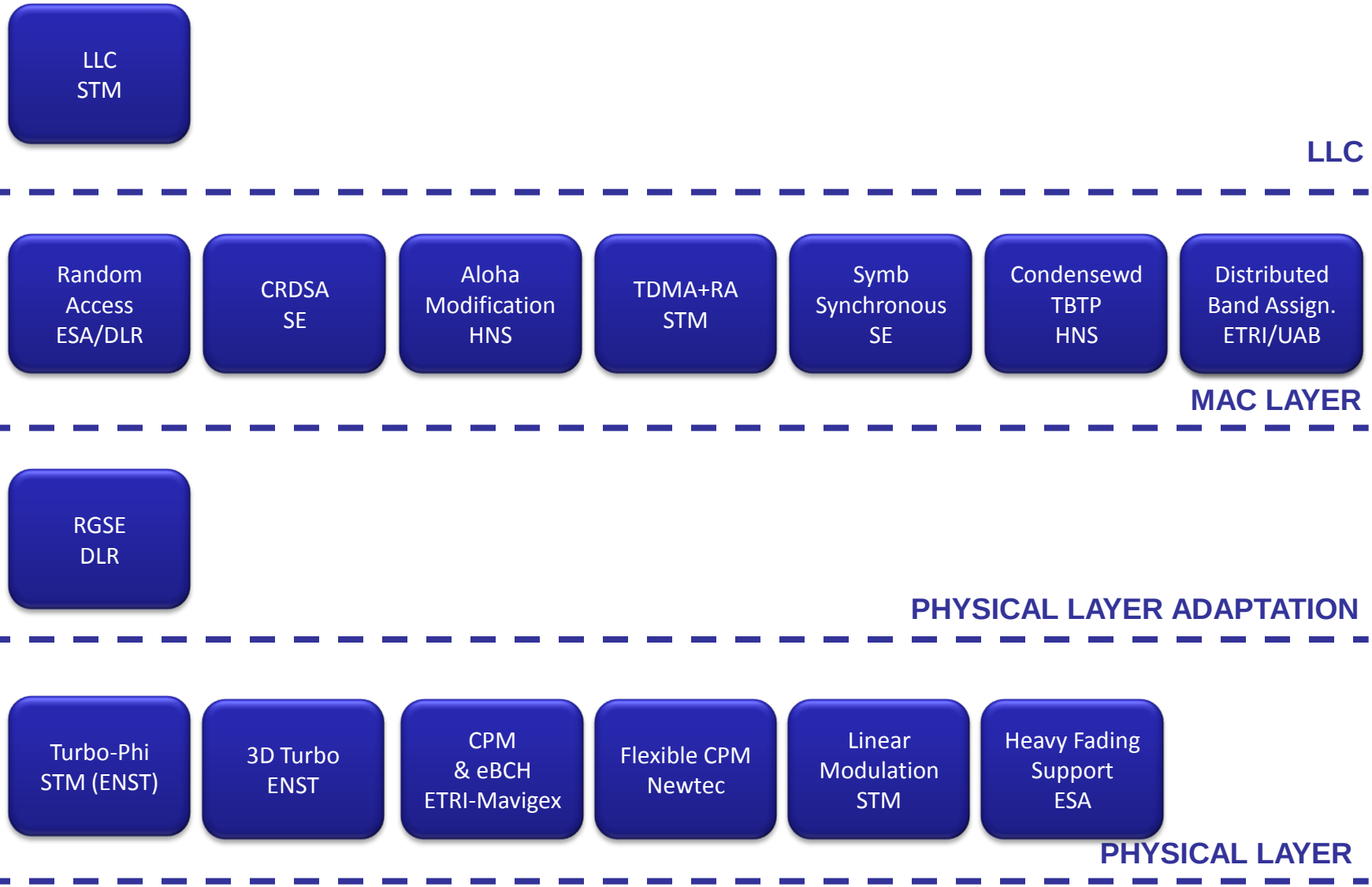
DVB-RCS-NG Organization (source: DVB-RCS 1049, TM-RCS)



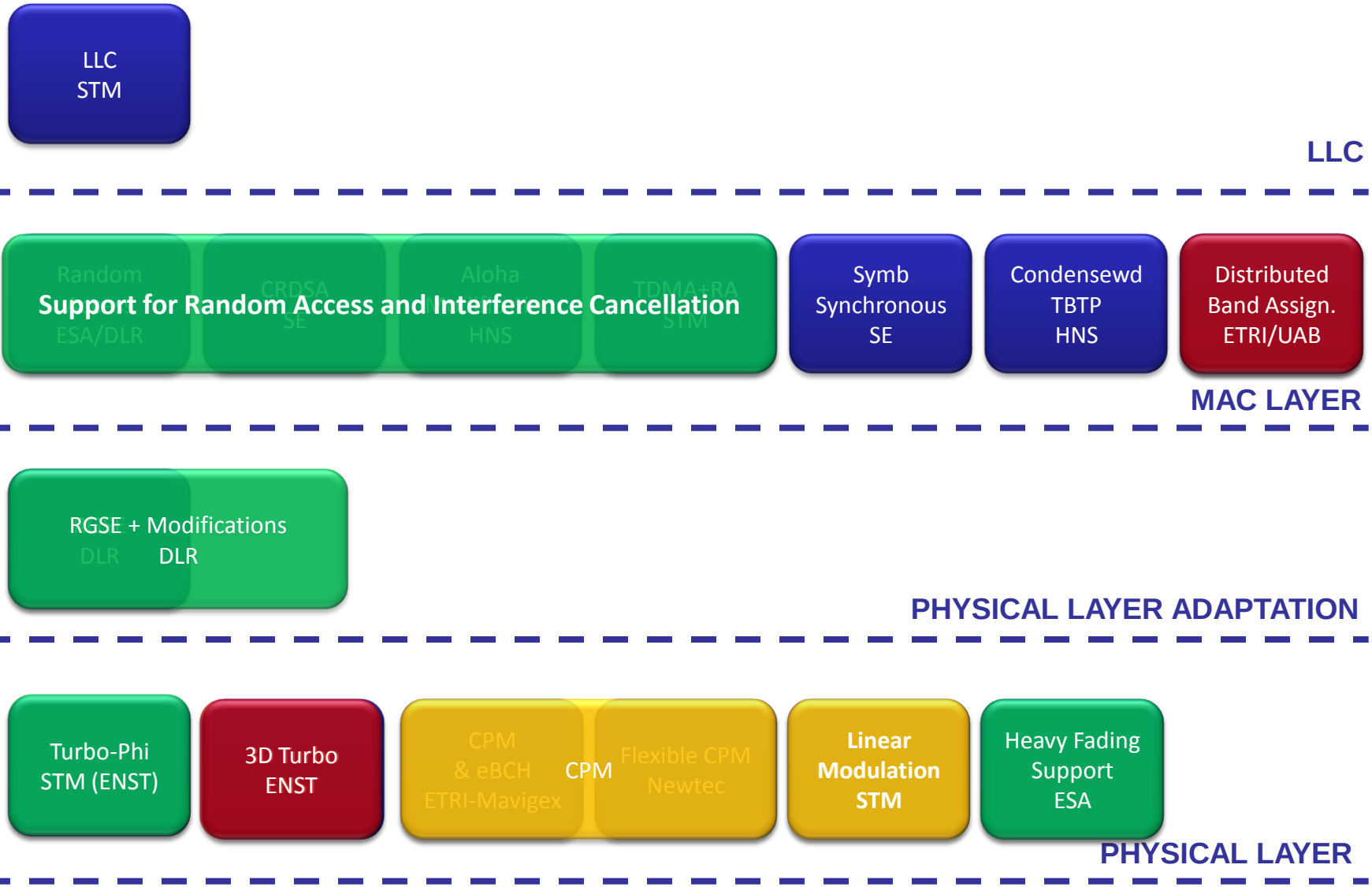
DVB-RCS-NG Call For Technologies (from TM-RCS)

Technology Area	Aspects	Example of Technology Proposals
Section A		
Physical Layer	Coding	Turbo-Phi, 3D Turbo, LDPC
	Modulation	BPSK, QPSK, 8PSK, M-APSK/M-QAM, CPM, ACM, SRRC with low rolloff factor
	Framing	Pilot symbol insertion, Enhanced Framing
	Advanced Techniques	Co-/Adjacent-channel interference cancellation
Lower Link Layer (MAC)	Access Scheme	Enhanced Random Access Channel integrated with DAMA
		Continuous carrier integrated with DAMA
	IP Encapsulation	GS profile with GSE encapsulation
	Transport of Return Link Signalling	Optimized Signalling
Section B		
Upper Link Layer	Virtual Satellite Networks	MPLS, VLAN (IEEE 802.1Q), VPN
	Differentiated QoS & Bandwidth Management	Request classes, QoS mapping
	Support for TRANSEC	Hooks for TRANSEC
IP and Upper Layers	Header Compression	ROHC
	Performance Enhancing Proxy	TCP acceleration, web caching
	IP QoS Differentiation	Diffserv
	Support for COMSEC	COMSEC and PEP integrated solution
Management and Control	FCAPS	Interfaces towards terrestrial broadband networks
		Service management interfaces
		Management protocols
		SW download protocols
		C2P
	Installation Procedures	Plug&Play Tools
		Terminal configuration

Proposed Technologies at lower layer



Proposed Technologies Selection



PHY LAYER SELECTION DETOUR

Physical Layer Proposals Selection

- **Continuous Phase Modulation**
  - Good performance against nonlinear effect/ freq. instability
  - Reduce the ODU cost against linear modulation
  - More flexibility to select ODU component according to IDU function/capability
- **Linear Modulation**
  - High spectral efficiency can be achieved
  - Evolutionary approach wrt RCS 1° generation
  - Suitable for high end terminals (e.g., professional)
  - Less robust wrt non-linear distortion

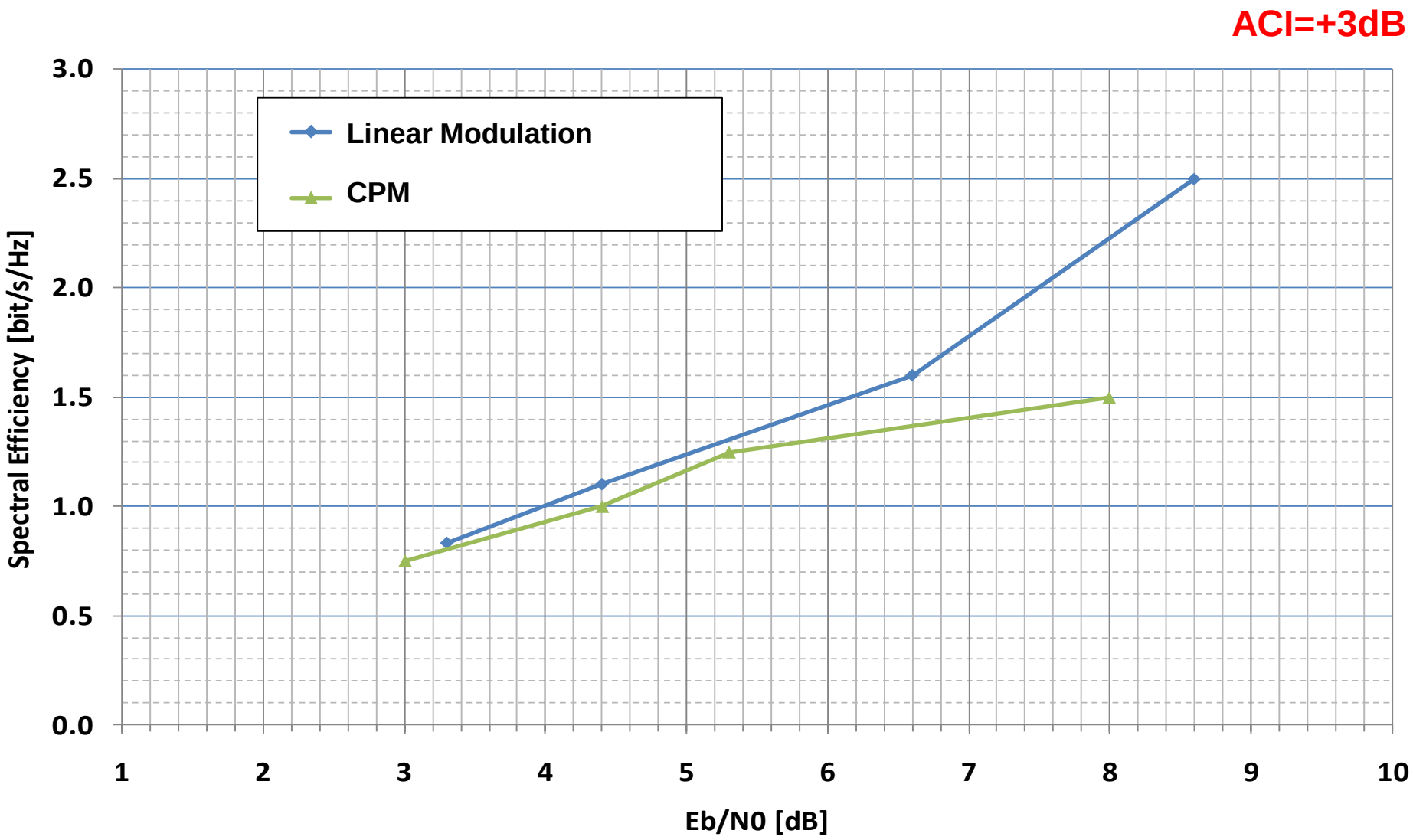
Physical Layer based on Linear Modulation (STM proposal)

- **FEC**
  - Turbo-Φ coding scheme
  - Several burst size (Log-on, Control, Short and Long)
  - 5 vs. 8 iterations according to the burst size
- **Modulation scheme**
  - Linear modulation: QPSK, 8PSK, and 16QAM
- **Pulse shaping**
  - Fixed roll-off factor: 0.20
- **Spectral efficiency**
  - From 0.55 bit/s/Hz to 2.80 bit/s/Hz
- **Frame format**
  - Preamble, distributed pilots and postamble (size and distribution depends on the code-modulation pair)
  - Known symbols overhead
    - about 35% for Log-on/Control bursts
    - from 3% up to 14% for traffic bursts
  - Bursts should match a slot-grid

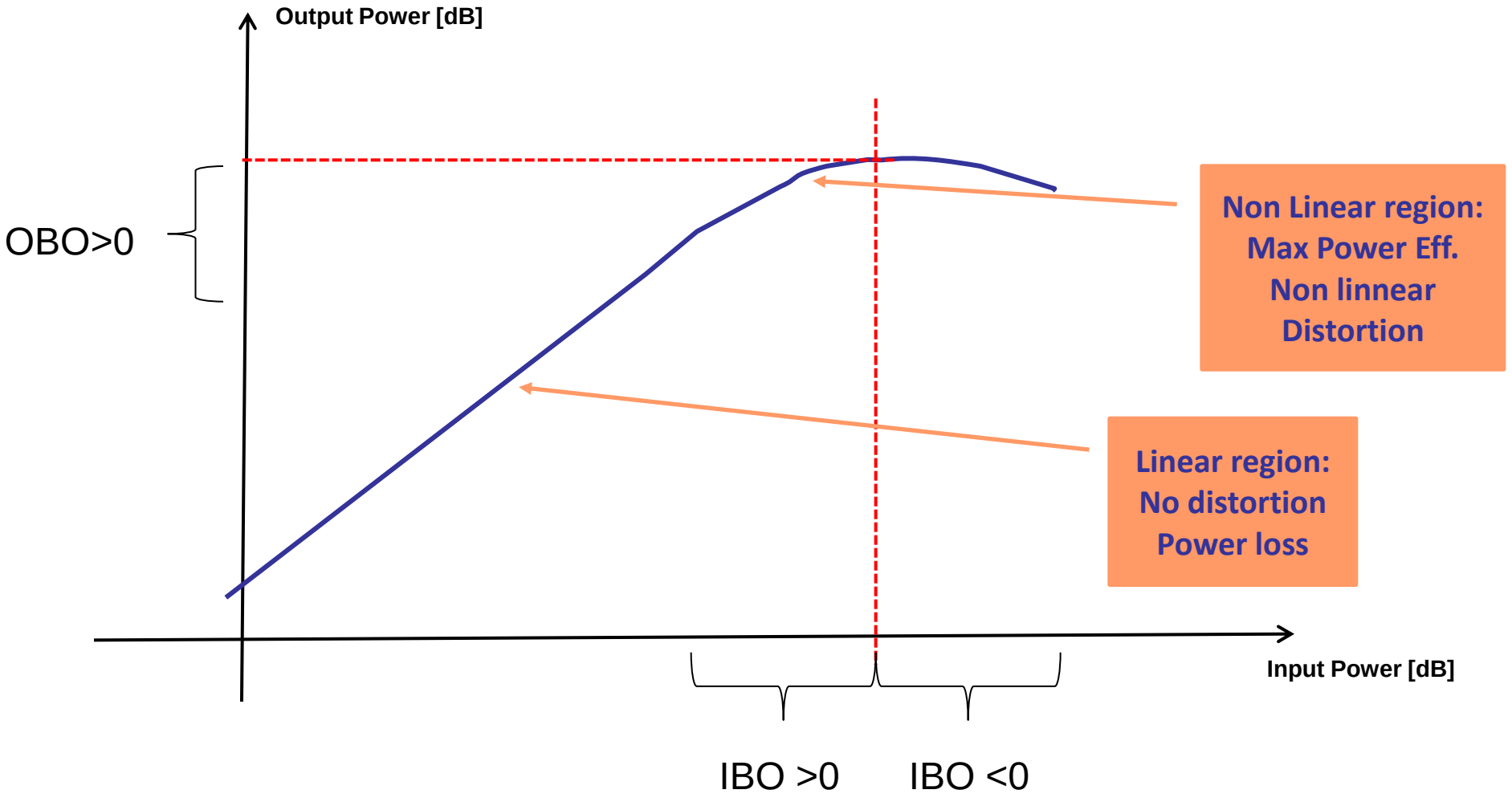
Physical Layer based on Continuos Phase Modulation (ETRI proposal)

- **FEC**
  - extended-BCH scheme
  - Continuous packet sizes
- **Modulation scheme**
  - Quaternary CPM waveform
  - Bandwidth limitation 99% and 77%
- **Spectral Efficiency**
  - 0.75 – 1.0 – 1.25 – 1.5 – 1.83 bit/s/Hz
- **Frame format**
  - Preamble and midamble: always 32+32 known symbols
  - Overhead below 10% for the traffic bursts

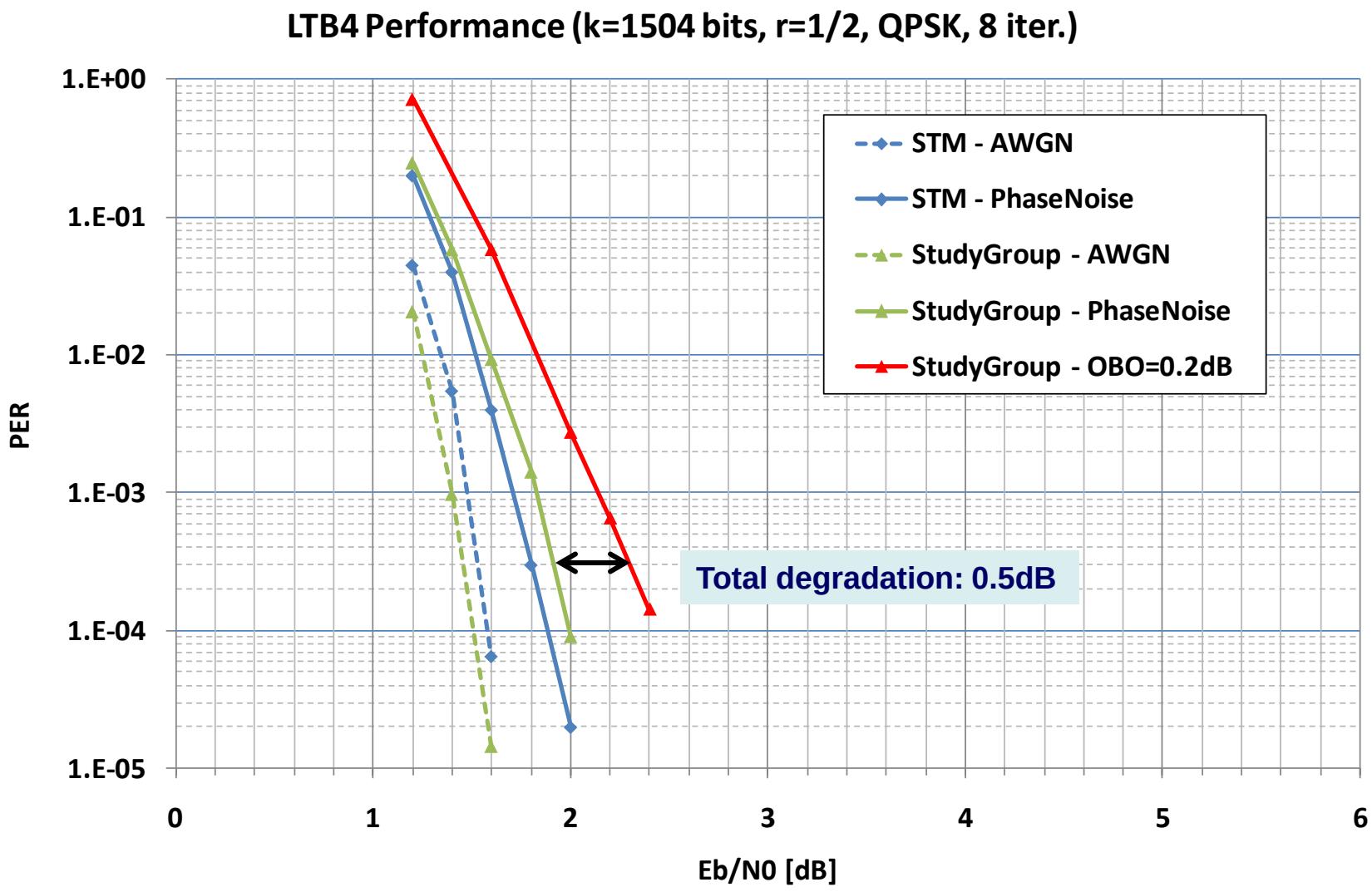
DVB-RCS-NG physical layers: link capacity analysis



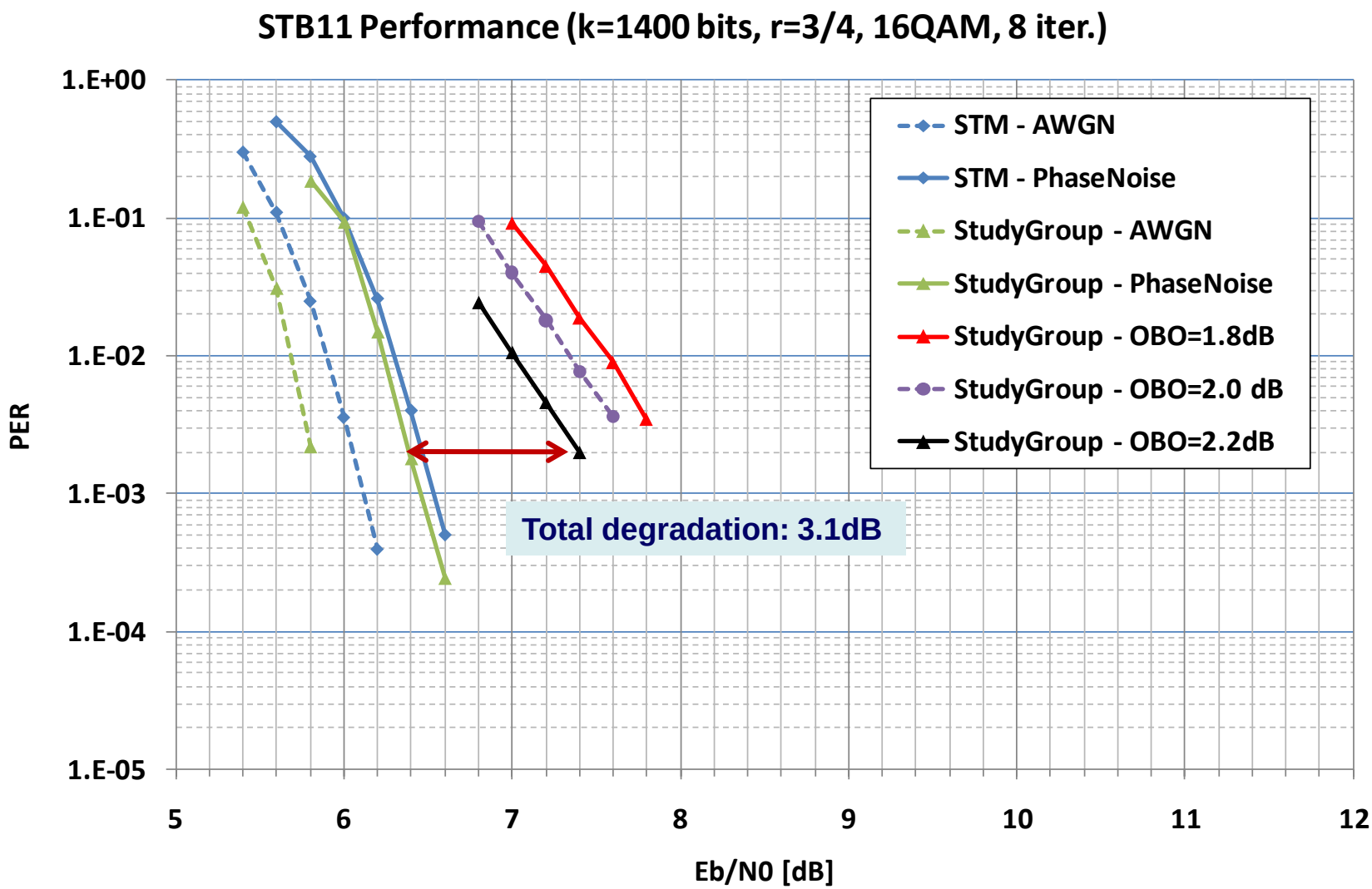
HPA MODEL


Output Power [dB]
OBO>0
Non Linear region:
Max Power Eff.
Non linnear
Distortion
Linear region:
No distortion
Power loss
Input Power [dB]
IBO >0
IBO <0

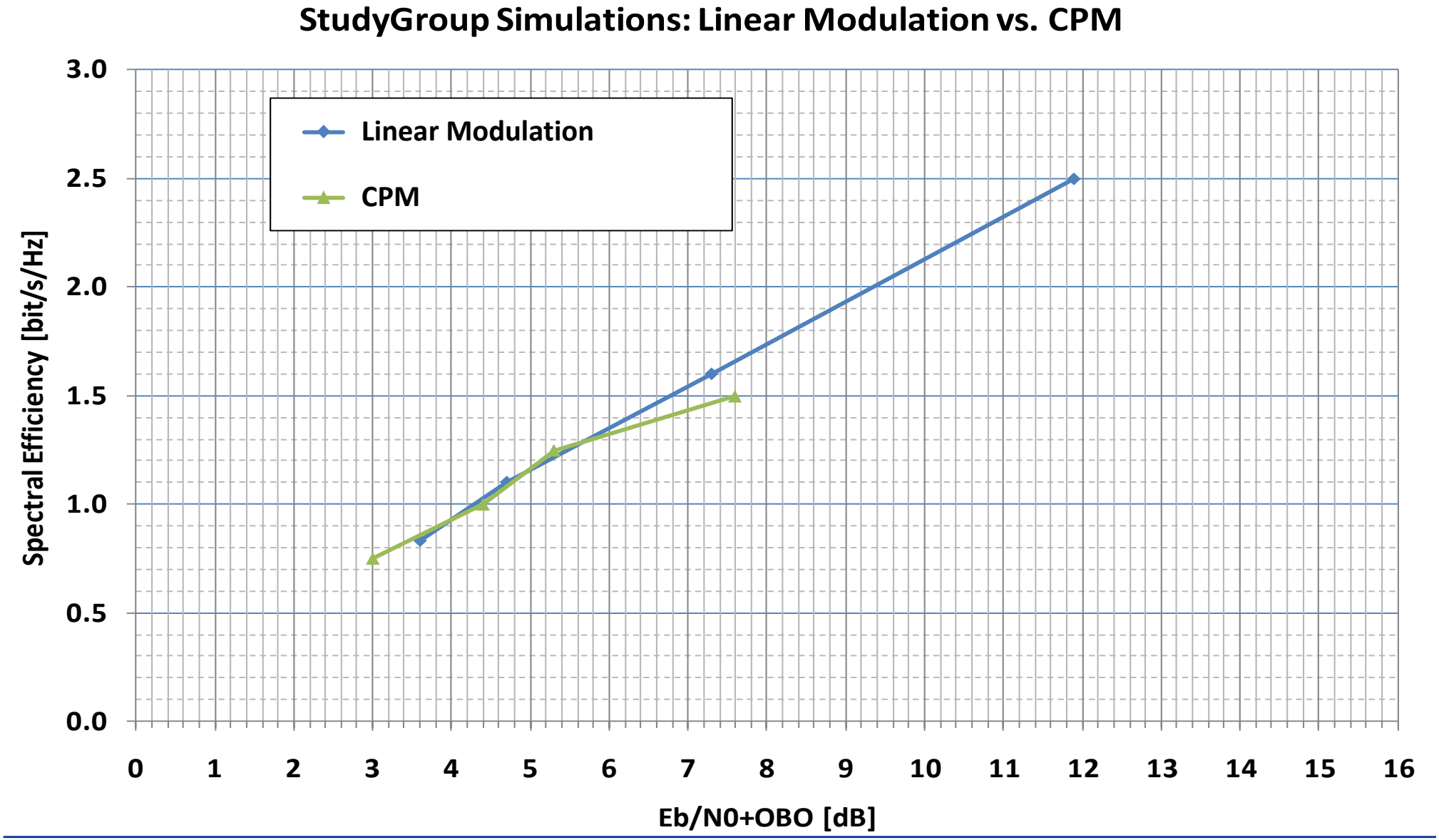
Performance example: QPSK



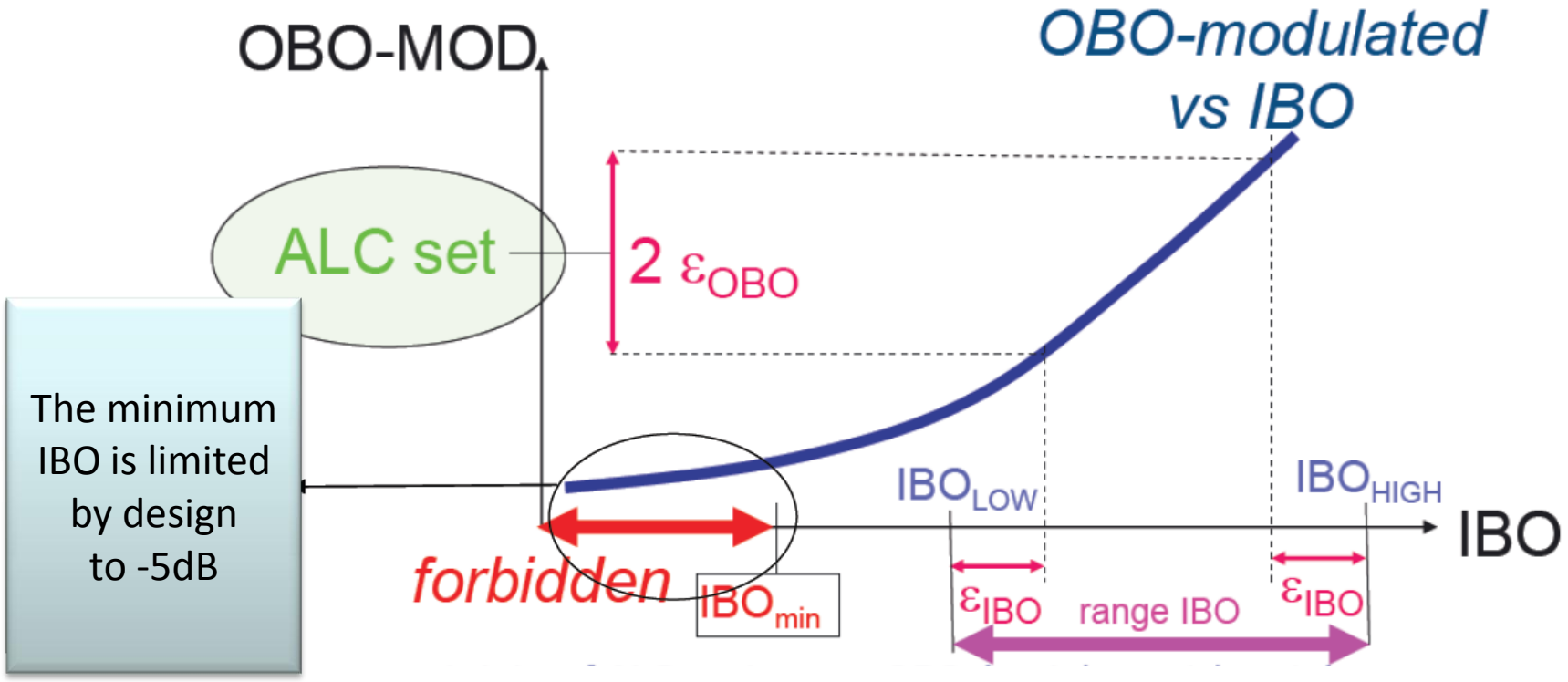
Performance Example: 16-QAM



DVB-RCS-NG physical layers: link capacity analysis - OBO impact

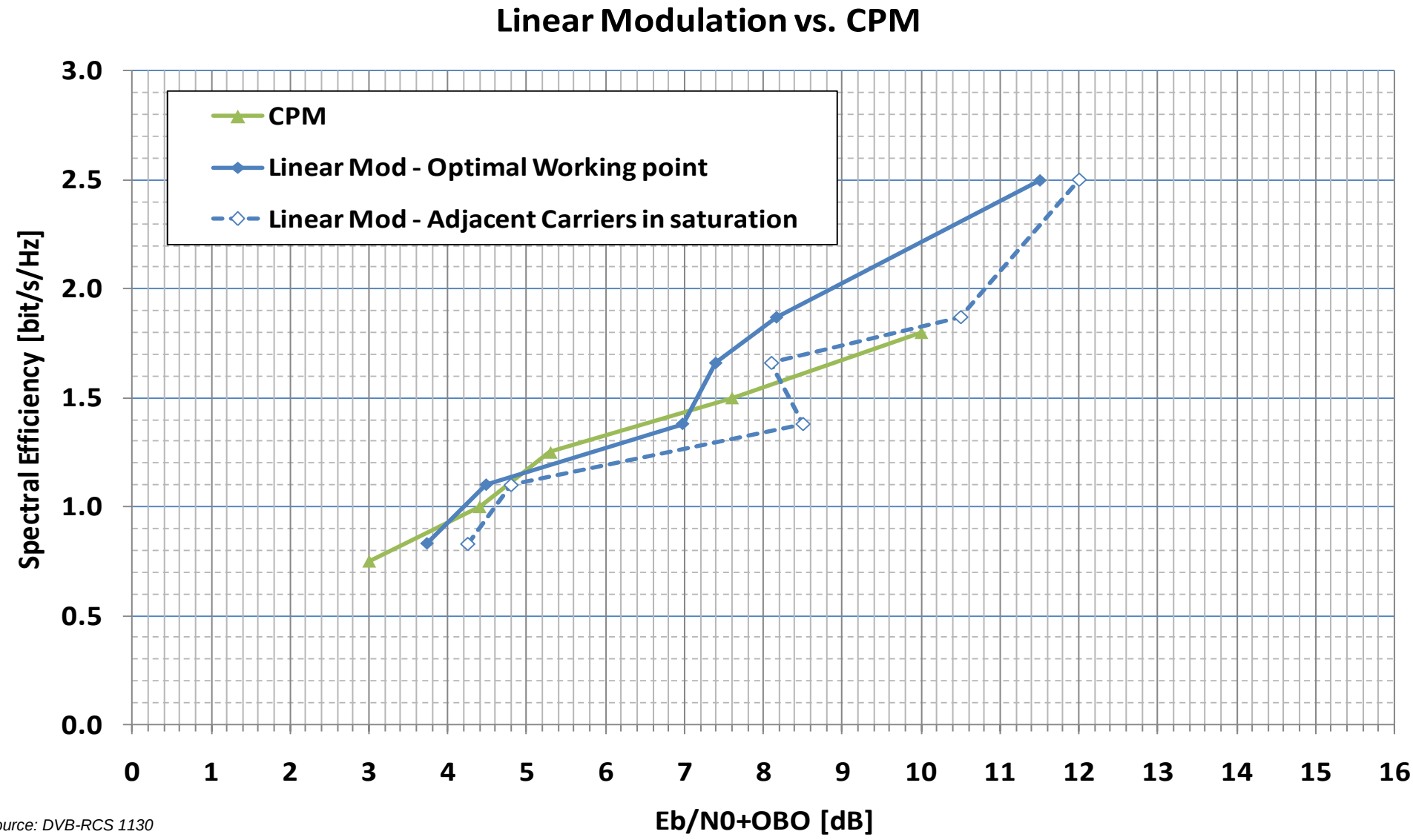


HPA (Out Door Unit) Instabilities Model



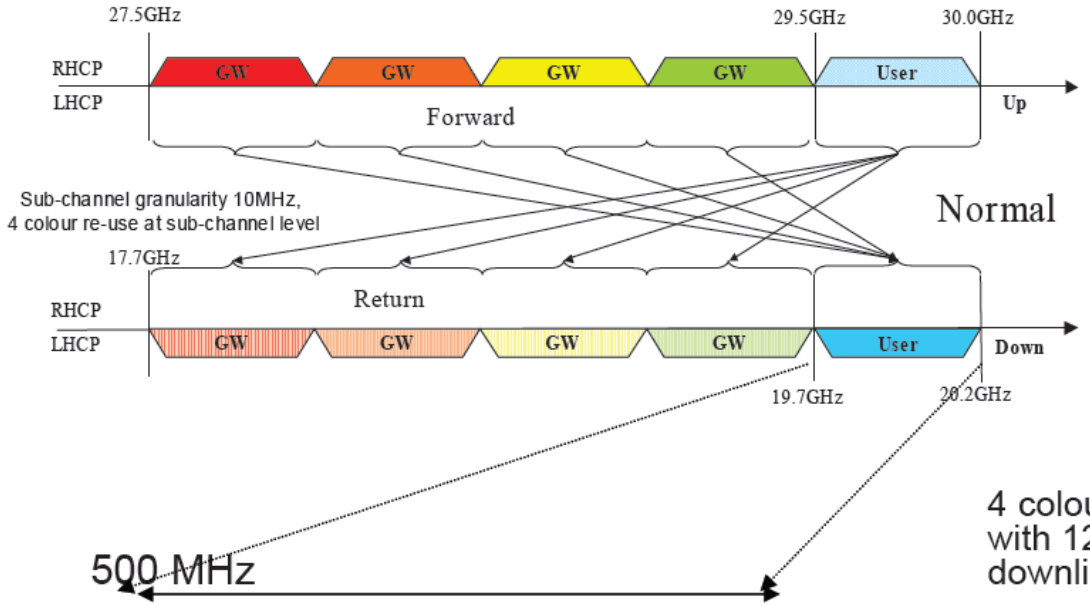
Source: DVB-RCS 1130

DVB-RCS-NG physical layers: link capacity - ODU instabilities



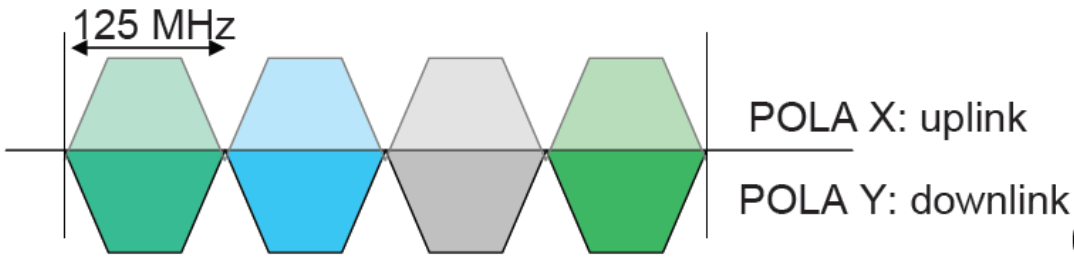
Source: DVB-RCS 1130

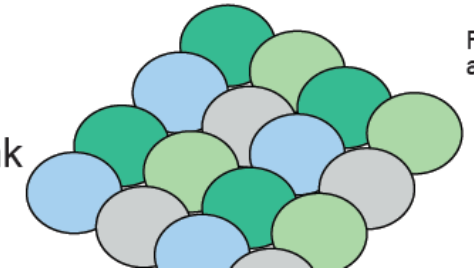
DVB-RCS-NG physical layers: System capacity (1/2)



100 beams (0.4°)

4 colour frequency re-use pattern over the 500 MHz with 125 MHz per colour on both user up and downlink (opposite polarisations in Tx/Rx).





Frequency re-use among the beams

Source: DVB-RCS 1130

DVB-RCS-NG physical layers: System capacity (2/2)

	CPM	Linear Modulation			
		OBO var 1 dB		OBO var 3 dB	
		Nominal	Worst	Nominal	Worst
Average b/s/Hz	1.36	1.45	1.35	1.35	1.07
Max baud rate [Mbaud]	10.67	7.2	7.2	7.2	9.6

Source: DVB-RCS 1130

DVB-RCS-NG physical layers: comparisons and conclusions

- **Link layer performance**
  - Linear modulations have comparable performance to the CPM modulations up to about 1.8 b/s/Hz when considering operations at the ODU optimum working point and no ODU instabilities
  - At higher spectral efficiency linear modulations perform better than CPM's
  - CPM schemes show significantly better performance than linear modulations when ODU instabilities are considered
- **System level performance simulations**
  - For the considered network scenario (interference limited) CPM schemes outperform linear modulations in average spectral efficiency when considering ODU instabilities
  - For networks with higher C/I in the uplink linear modulations could perform better (example lower frequency re-use, separate RX/TX satellite antennae) than CPM
  - Whenever low terminal output power is considered CPM approach is preferable

- **Decision not yet taken ➔ DVB-RCS Commercial Module to select one of the following two configurations:**
  - Linear modulation for high end terminals and CPM for low cost terminals
  - Linear modulation only for both high end and low cost terminals

Lessons Learned from PHYL Selection

- Performance is not everything in system design!
- Robustenss is a plus
- Commercial Interests are also important in standardization bodies

The final decision will be the best weighted trade-off among performance, robustness, flexibility, and commercial support

END OF DETOUR

DVB-RCS-NG workplan

- Activity started:
  - End of 2008
- Call for Technology deadline:
  - May 4, 2009
- **Physical layer definition:**
  - **January 2010**
- **Specifications for fixed systems:**
  - **End 2010**
- **Specifications for mobile systems:**
  - **End 2011**

Conclusions

- Broadband Access is recognized as cornerstone for economic development
- Satellite broadband communication market has huge potential and can play a significant role in the “Economic Recovery”
- Satellite technology is mature for large multi-spot beam satellite networks able to provide for high capacity access competitive with DLS connection
- Key elements to meet the market requirements are
  - Service quality and availability
  - Service Costs
- A new initiative (DVB-RCS-NG) is on-going to create an open standard able to provide the enablers for low cost and high efficient broadband satellite systems
- The new standard is foreseen to be available by mid/end 2010

Acknowledgements

- The ESA “2° Generation DVB-RCS Standardization Support” project
- The DVB-RCS Study Group
- The Digicomm Group of the University of Bologna

Thank you!