ALMA MATER STUDIORUM
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Second Generation of Broadband Interactive Satellite Communications (DVB-RCS-NG): System overview and waveform definition"

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Outline

- SatCom Broadband Communicatios: a fundamental tool for fast internet access (Europe 2020)
- DVB –RCS 2: an open standard for SatCom Broadband communications
  - The DVB Forum
  - The DVB-RCS2 technologies
- DVB-RCS2 efficient waveform design

The Rationale:

Broadband Access - a key element for European Development

The International approach to Broadband Access

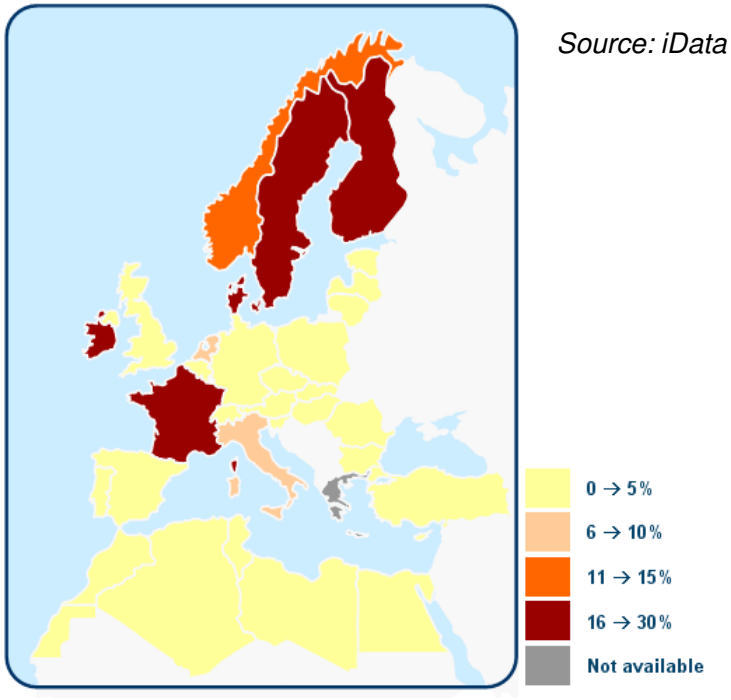
- **Development of "Broadband Access" is considered worlwide as a key element for Economic Recovery:**

- **The US Government issued "the American Recovery and Reinvestment Act" on February 2009**
  - The extension of 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"

- **European Commission Digital Agenda for Europe:**
  - initiative under the Europe 2020 strategy for smart, sustainable and inclusive EU growth
  - seven priorities among which "Digital access for All" and "Fast internet access"
    - 2013 → 100% broadband coverage
    - 2020 → 30 Mbps for 100% of the population and 100Mbps for at least 50% of the population
  - 30% of the European Rural Areas are not reached by broadband access;
  - constant rate investment until 2015 in "broadband access" can produce 1 million jobs and 850 billion economy growth
- **January 20, 2011, EC approved 1.8 bn euro state aids for deployment of broadband access**
  - public funds aimed to ensure that all citizens have access to high speed Internet access in the European Union, including in rural or remote areas.

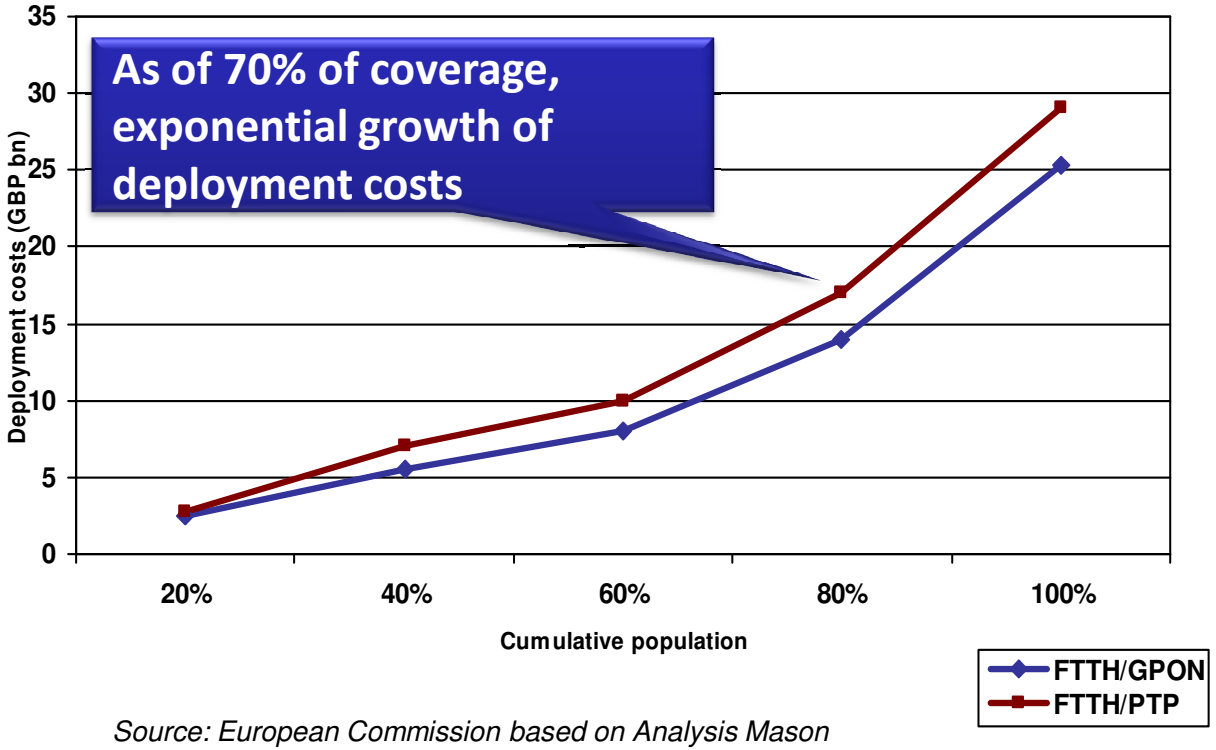
The main candidate for Broadband Access: FTTH

FTTH coverage in 2009 (% of population)



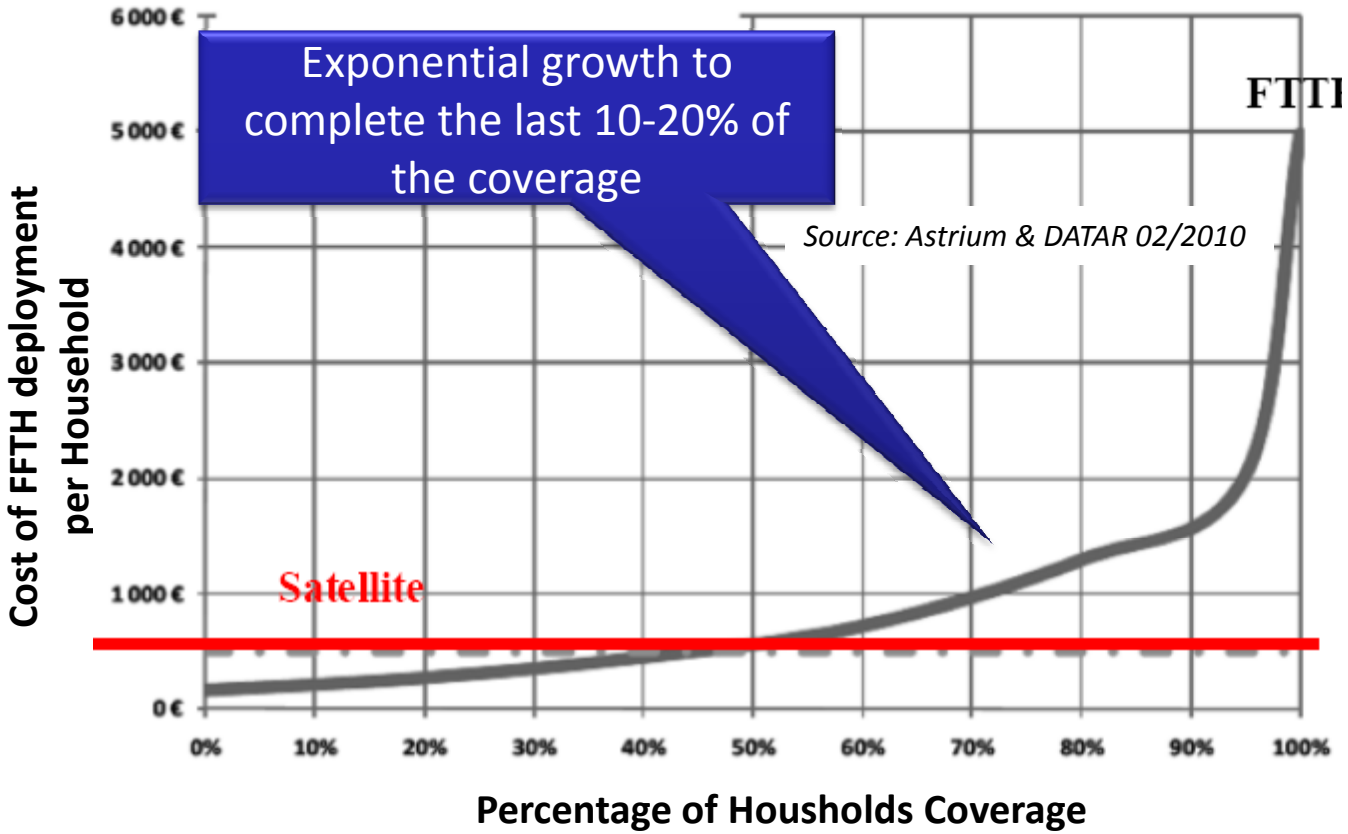
Source: iData

Total deployment cost vs. % population for FTTH



Source: European Commission based on Analysis Mason

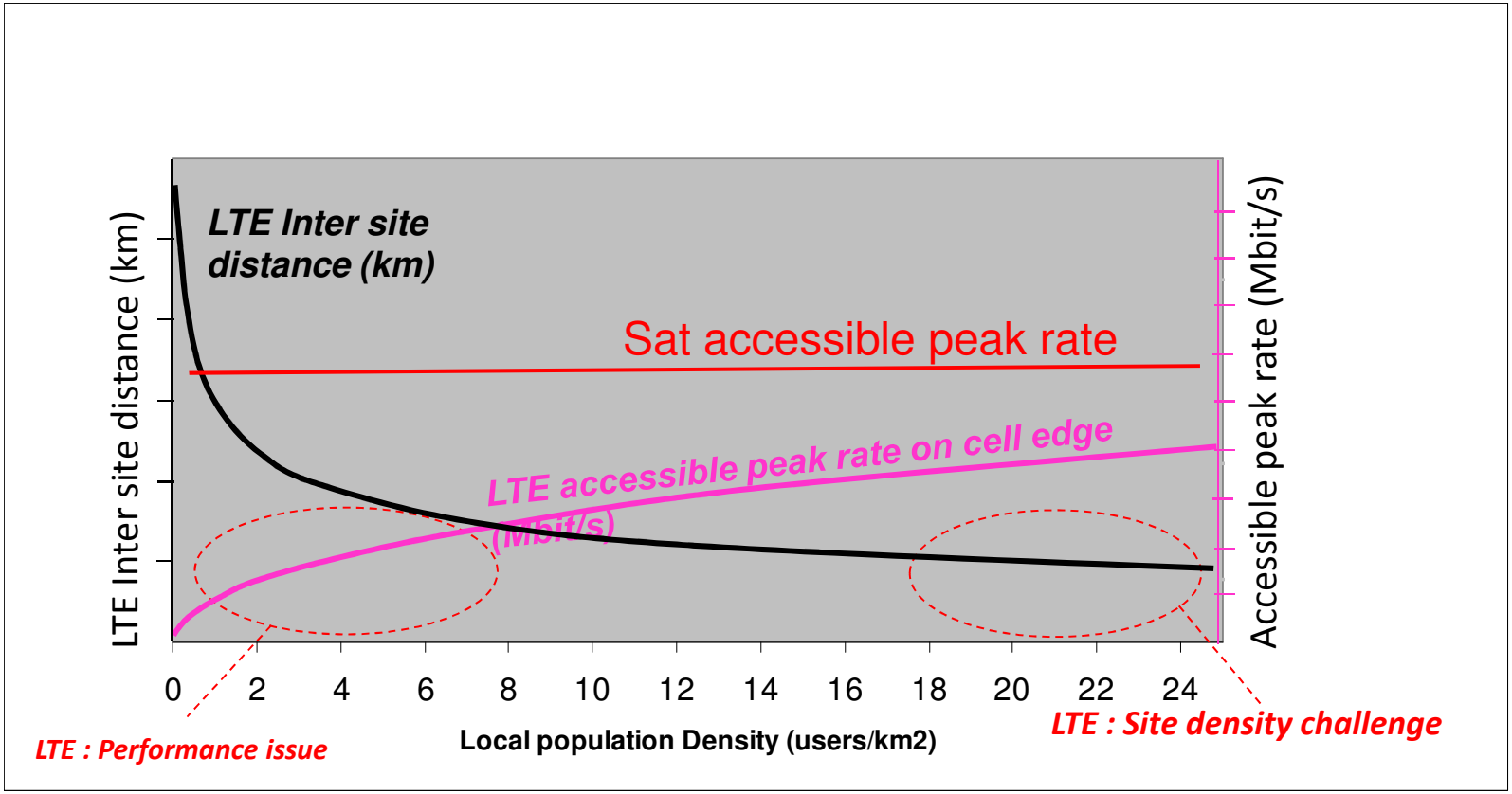
A caveat of FTTH-only coverage



- 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
  - Wireless solutions, among which Satellite Networks, represent a viable and competitive alternative provided that service cost and quality are comparable

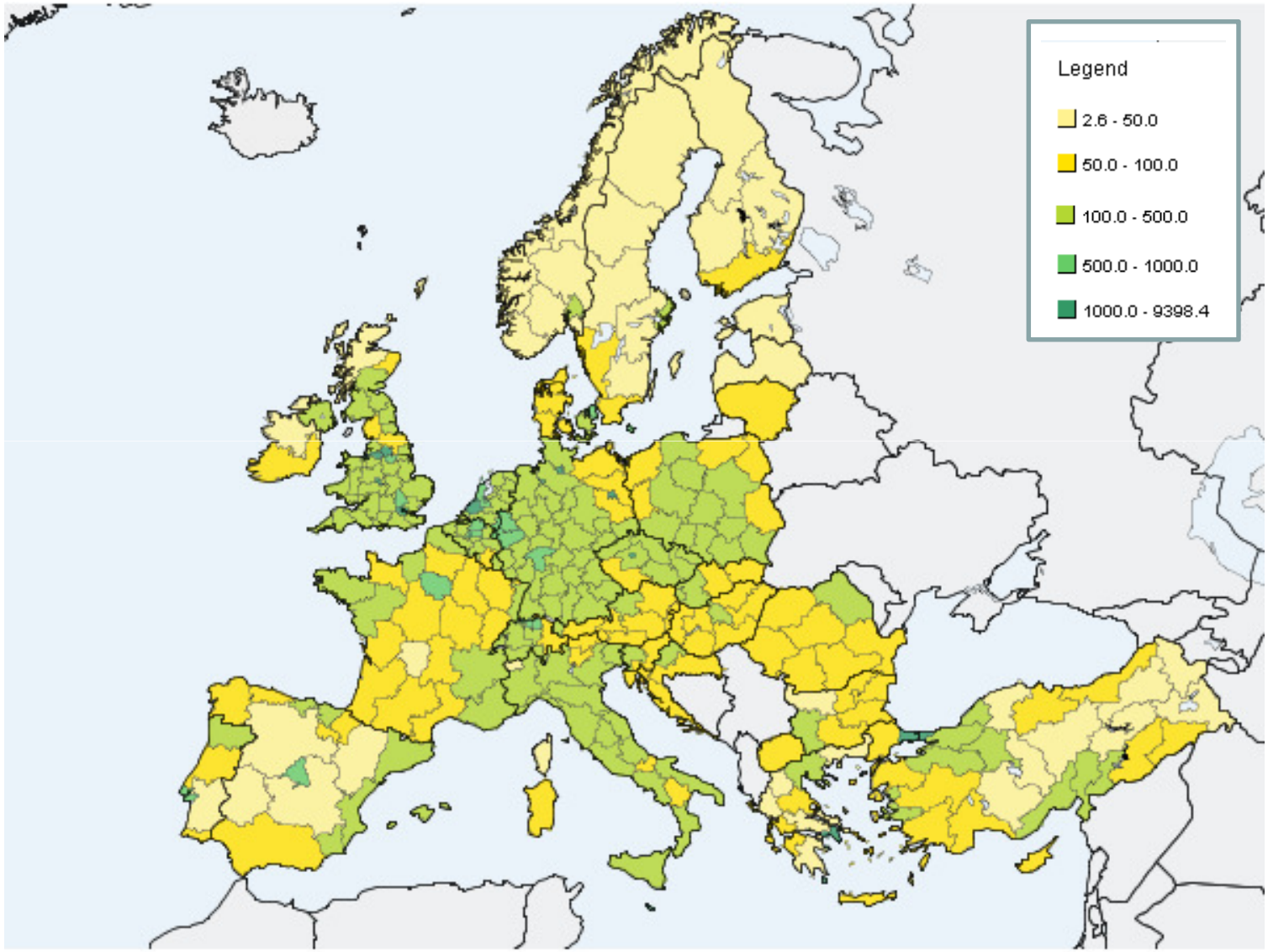
Wireless Access Networks: good candidates for coverage completion

- **Wireless Systems are good candidates to complete the coverage:**
  - **Terrestial systems, e.g., LTE and WiMAX**
  - **Satellite Broadband Systems: proprietary and open standards**
- **Selection between terrestrial and satellite is not unique, e.g., in low density population areas**



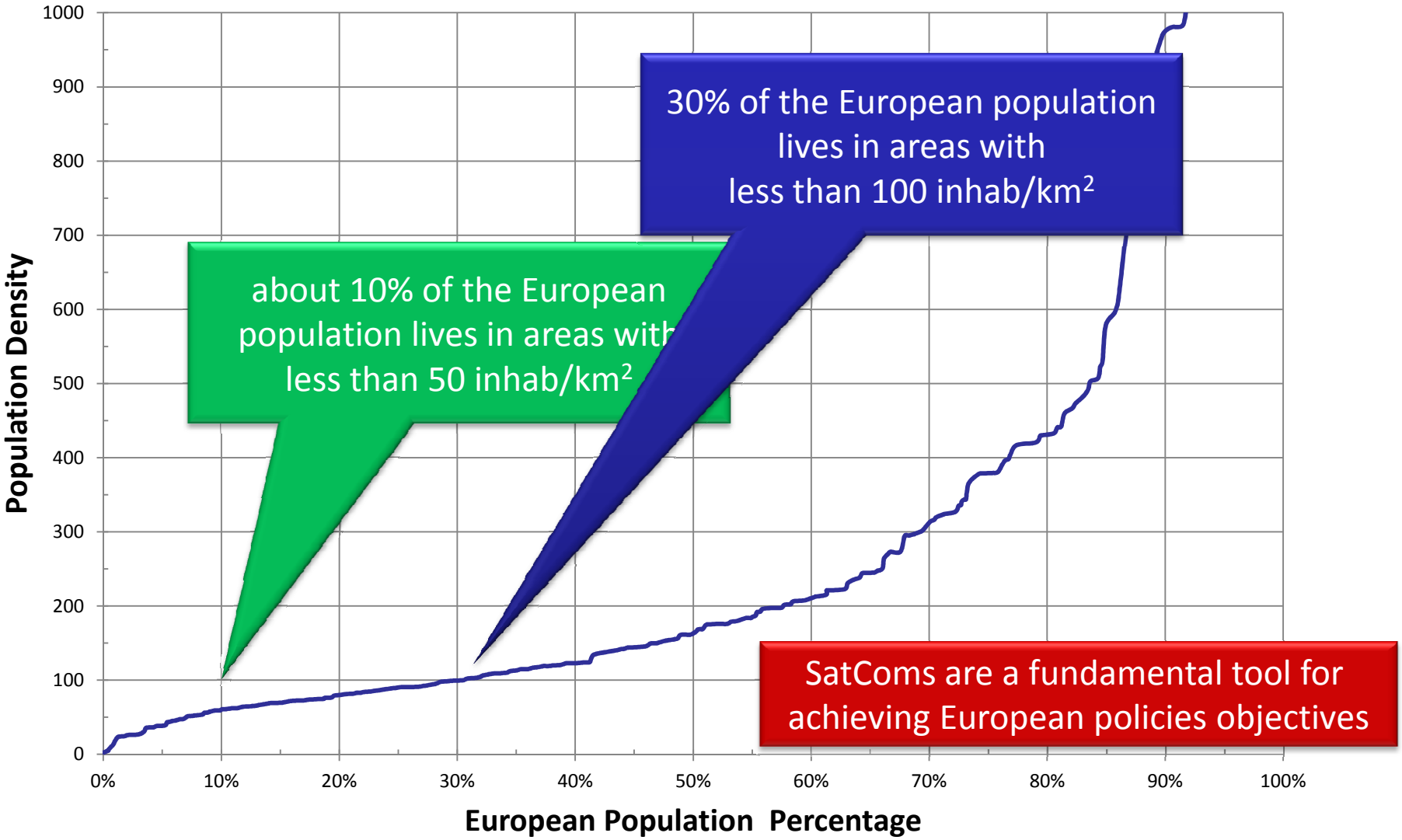
Source: Thales Alenia Space

European Population Distribution (1/2)



Source: EuroStat

European Population Distribution (2/2)



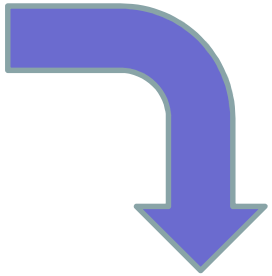
Data Source: EuroStat

The Market Challenges

- Cost of deployment
- Cost of user equipment
- Cost of broadband access
- Capability to compete with triple play offers

Satellite Broadband Access Cost Evolution

2004			
Company/ Service	Upload speed	Download speed	Subscription price
Sat2way	128 Kbps	512 Kbps	99 EUR
Sat2way	256 Kbps	512 Kbps	159 EUR
i-Sat	128 Kbps	512 Kbps	155 EUR
Aramiska	128 Kbps	512 Kbps	299 EUR
Net-Futureway	256 Kbps	512 Kbps	359 EUR

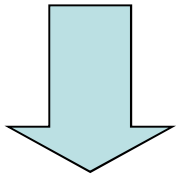


2010			
Company /Service	Upload speed	Download speed	Subscription price
Sat2way Tooway	512 Kbps	3.6 Mbps	30 EUR (2.4 Gb maxi)
Sat2way Tooway	512 Kbps	3.6 Mbps	60 EUR (6 Gb maxi)
Astra2Connect	256 Kbps	3 Mbps	30 EUR (3 Gb maxi)
Astra2Connect	256 Kbps	4 Mbps	80 EUR (unlimited)

Source: iData

Broadband Satellite Access: open standard approach

- **Need for an advanced open standard to ensure**
  - Low cost per bit: advanced and flexible technical solutions
  - Low Non Recurrent Engineering costs: risks and development cost shared by the entire comunity
  - Low cost device: economy of scale in chip development and manufacturing
  - Terminal Interoperability



DVB

Next generation of Digital Video Broadcasting Return Channel via Satellite (DVB-RCS-2)

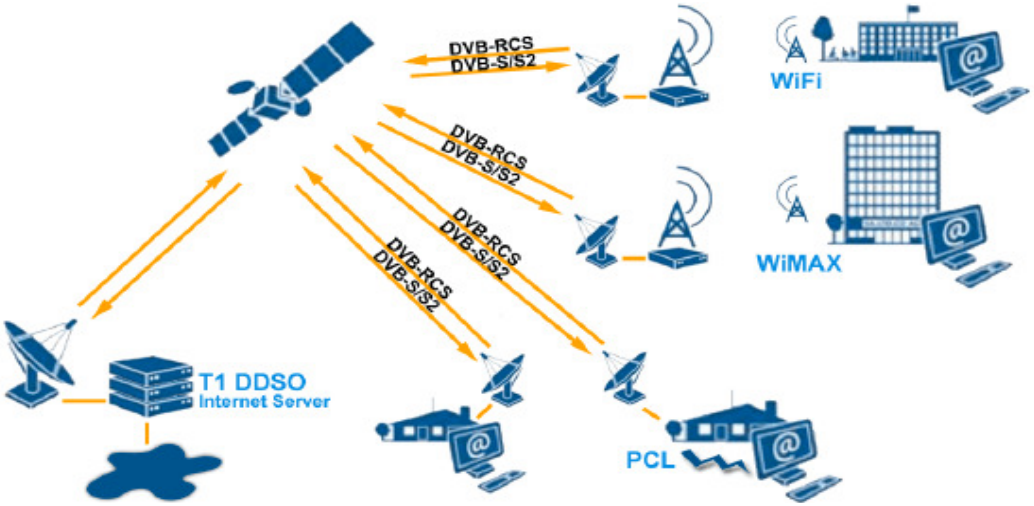
The Second generation of Digital Video Broadcasting Return Channel via Satellite

The Digital Video Brodcasting (DVB) Project

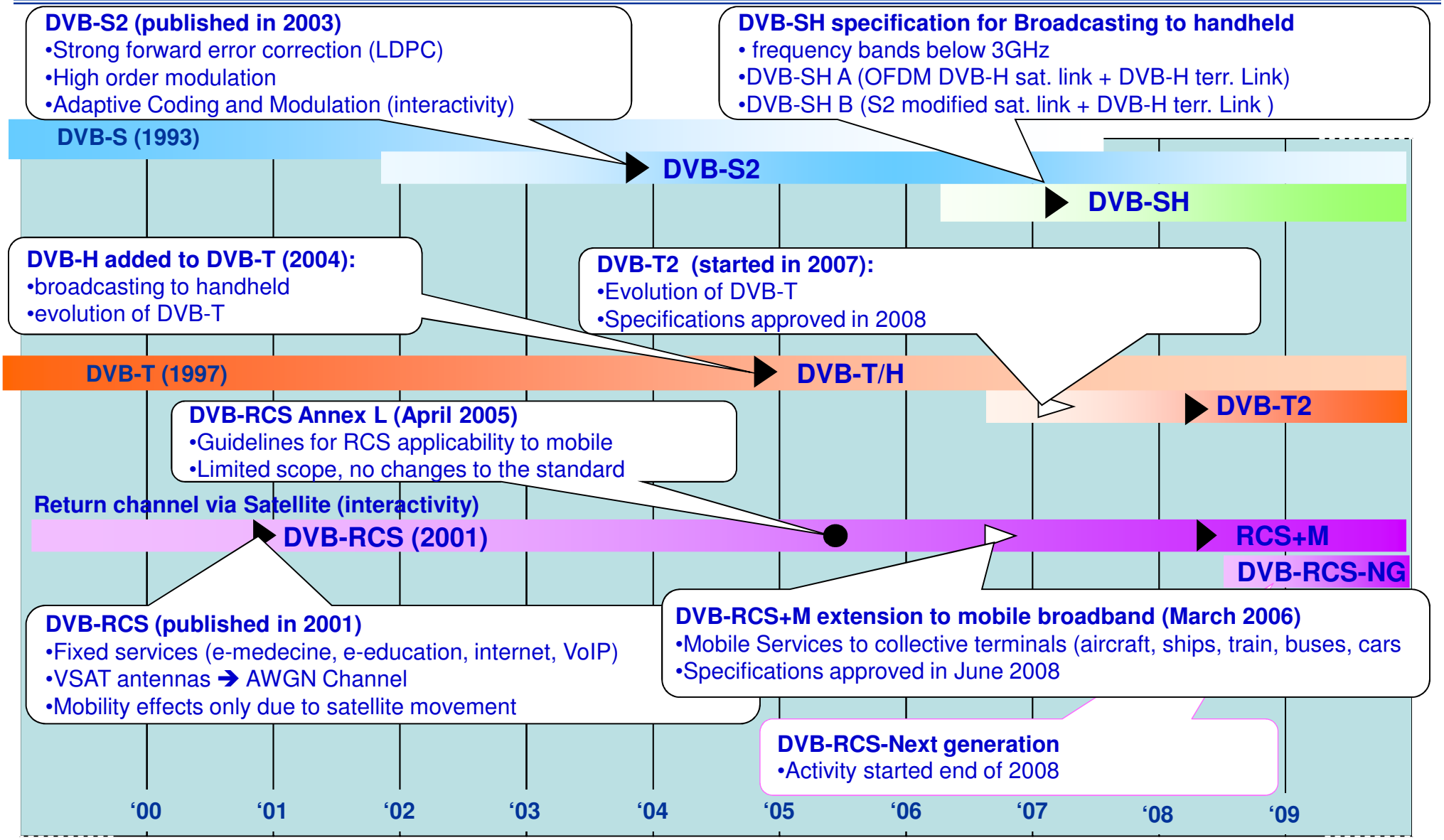
- Point to multipoint transmission standards for large volume of information at high data rate
- Information is mainly audio and video (MPEG2 format) but can also be other data
- Transmission (FL)
  - DVB-S and S2 → Satellite channel
  - DVB-T/H → Terrestrial channel (fixed and mobile)
  - DVB-SSP → 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-RCS Next Generation

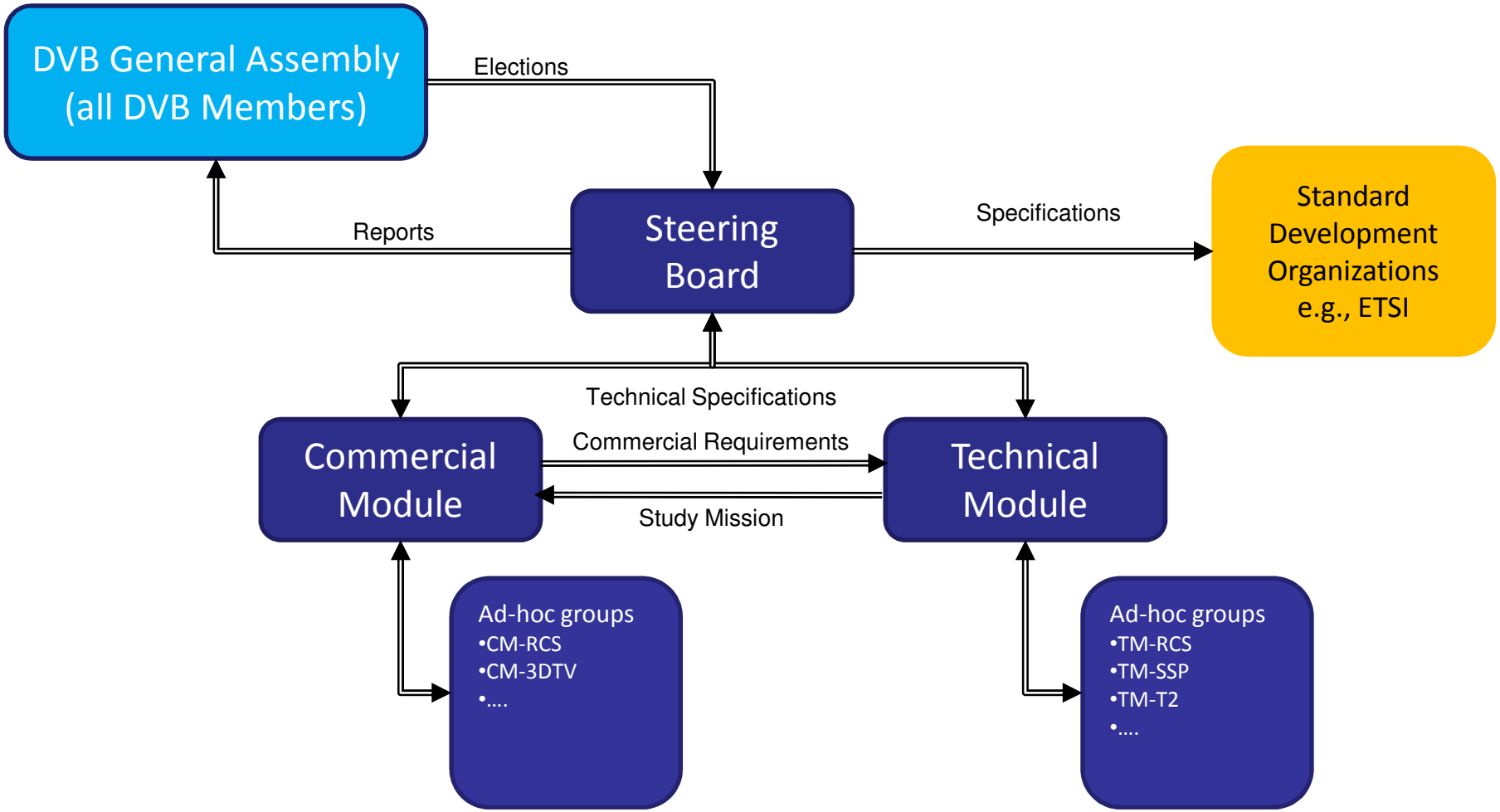
- **What is it?**
  - A broaband access system via satellite for fixed and mobile applications
- **Market segments**
  - Fixed networks
    - Consumer, Multi-dwelling, Corporate, SCADA
  - Mobile networks
    - Aeronautical, Railway, Vehicular, Nomadic, Maritime
- **Objectives**
  - Low cost consumer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



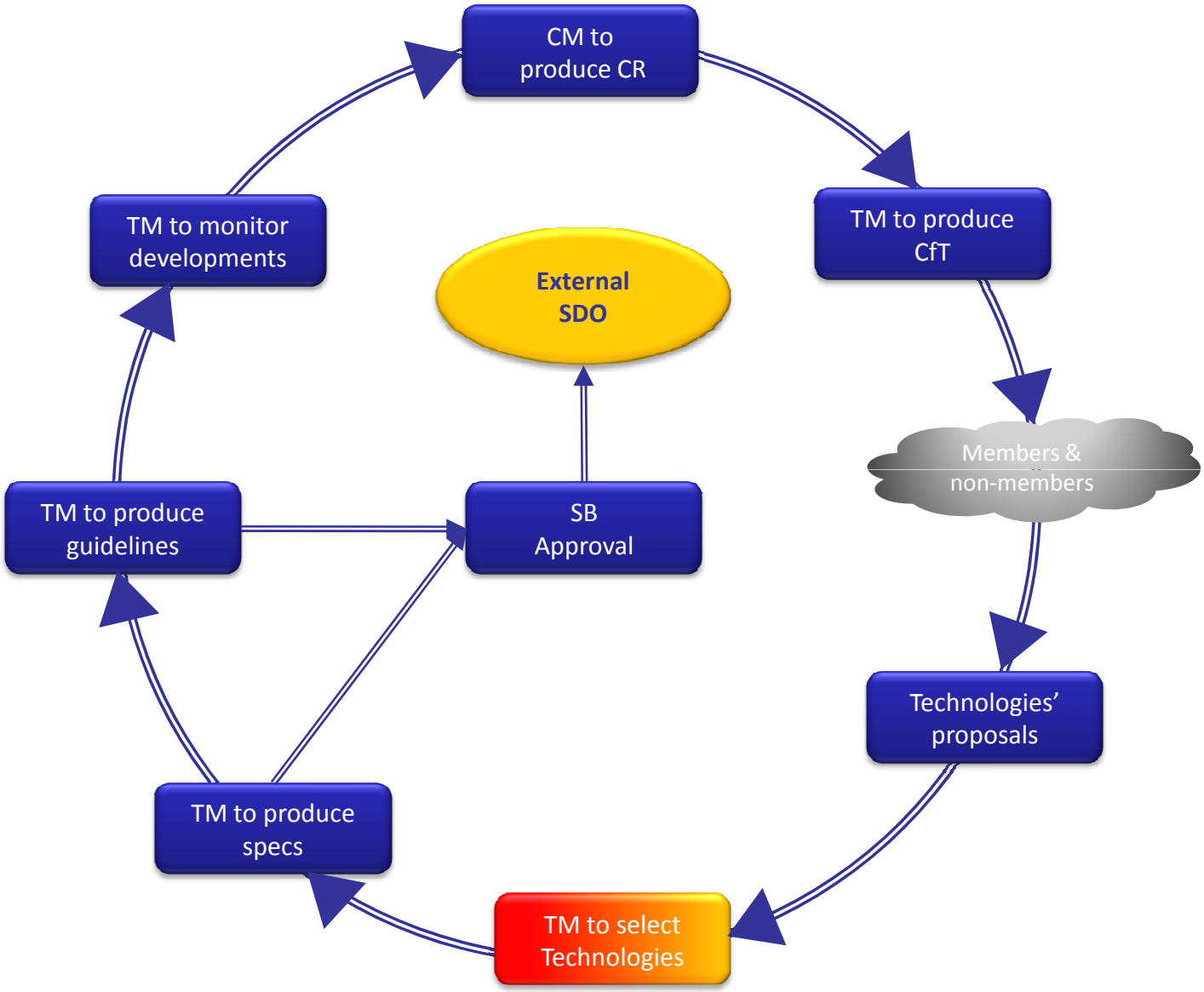
DVB Broadcasting and Broadband Standards



Digital Video Broadcasting Project



Standard production

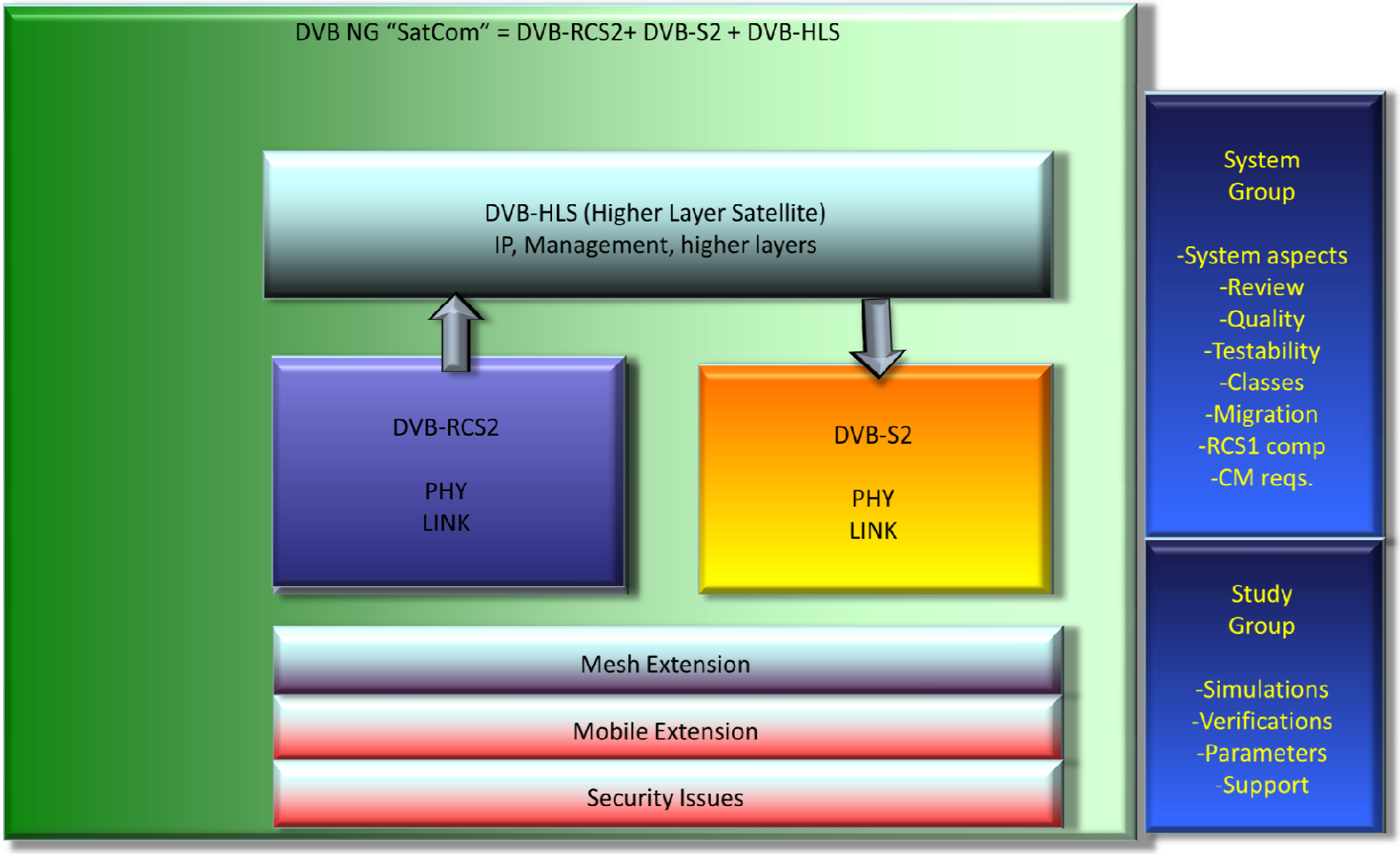


DVB-RCS-2workplan

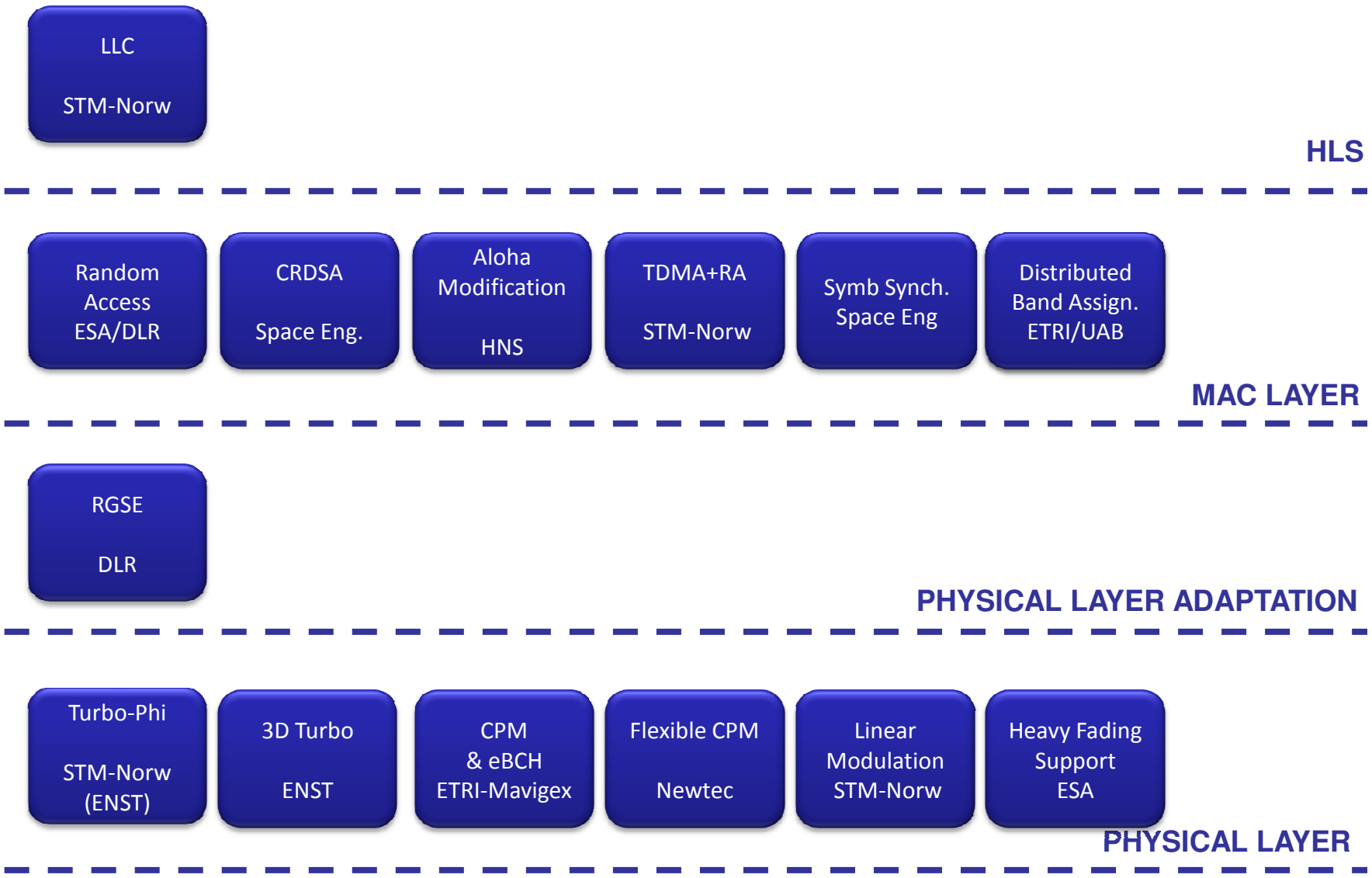
- Start of Activities
  - End of 2008
- Call for Technology:
  - May 4, 2009
- Physical layer definition
  - January 2010 (delayed to November 2010)
- Specifications for fixed systems
  - End 2010
  - Specs delivered on January 24, 2011 to DVB-TM for approval
- Specifications for mobile and mesh systems
  - End 2011

DVB-RCS NG Organization

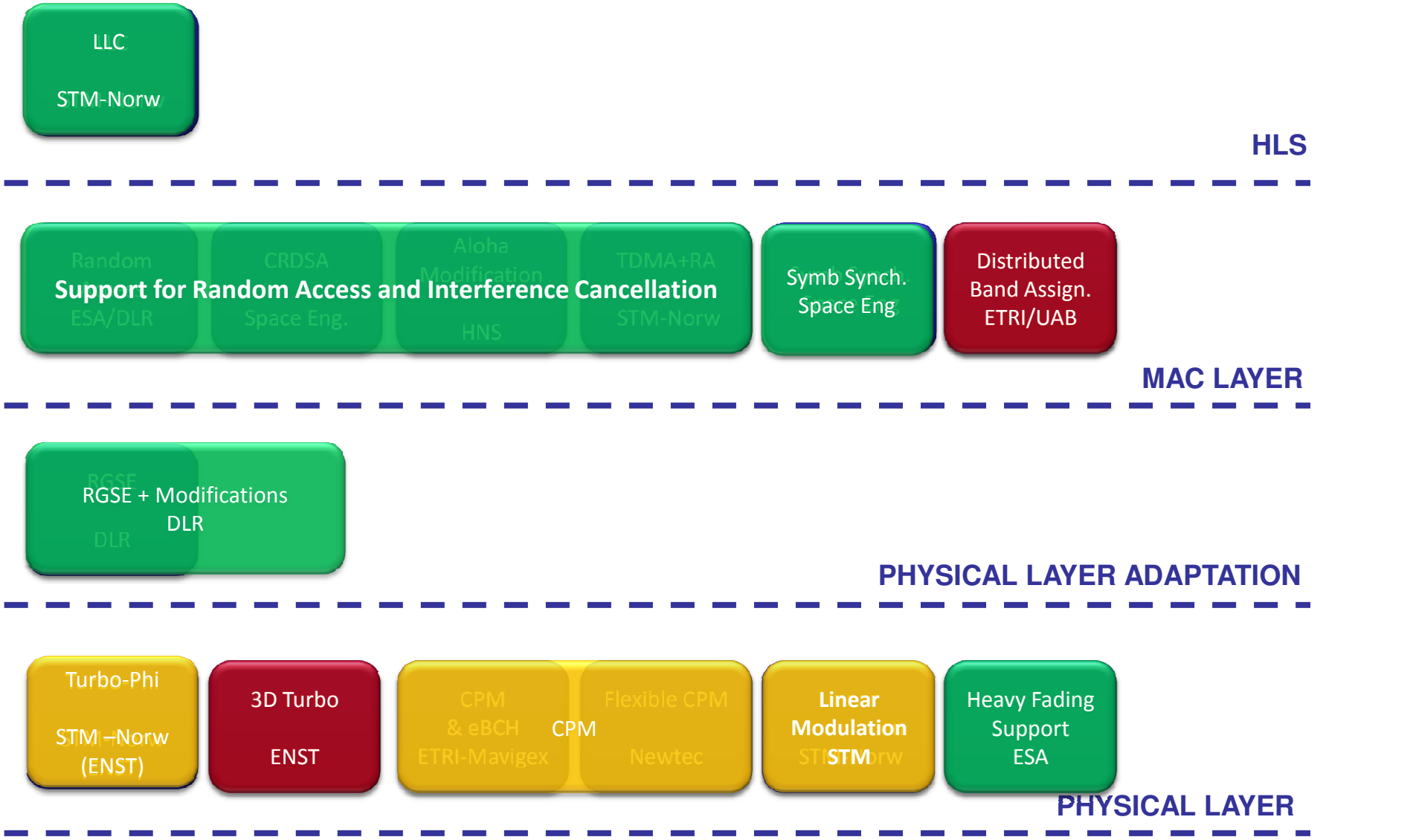
(source *DVB-RCS 1049)*



Proposed Technologies (CfT responses)



Proposed Technologies Selection



THE SECOND GENERATION OF DIGITAL VIDEO BROADCASTING RETURN CHANNEL VIA SATELLITE

Air Interface Definition

Modulation and Coding Proposals

- **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
- **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

Continuos Phase Modulation – a brief detoru

- ***The CPM baseband complex signal is***

$$s(t) = \sqrt{\frac{2E_s}{T_S}} \exp(j\varphi(t))$$

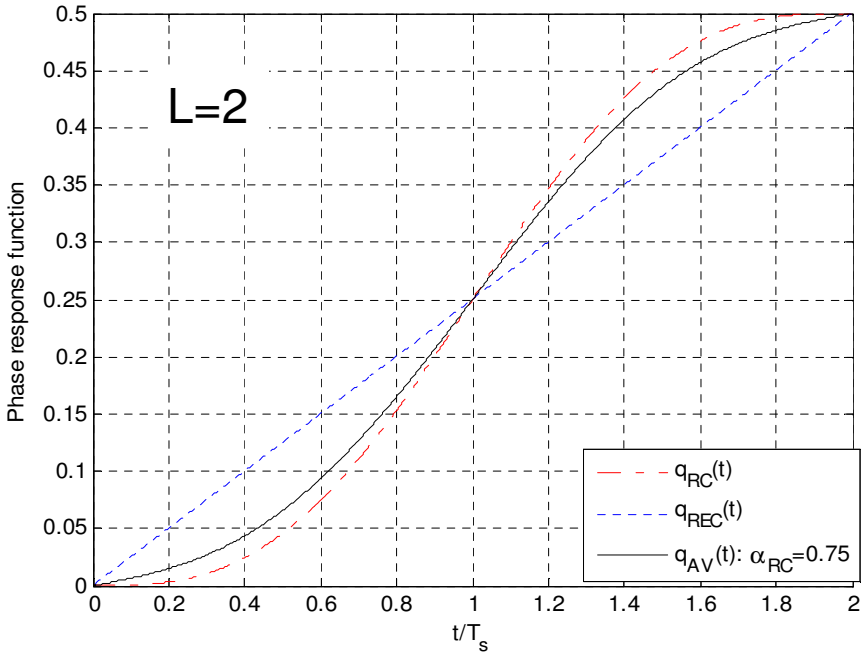
- ***where***

$$\varphi(t) = 2\pi h \sum_{i=0}^{\infty} a_i q(t - iT_s)$$

- **a_i is the input symbol to the modulator**
- **h is the modulation index in the form h =m_h/p_h.**
- **q(t) is the CPM phase response such that**

$$q(t) = \begin{cases} 0 & t \le 0 \\ \int_0^t g(t-\tau)\,d\tau & 0 \le t \le LT_s \\ 0.5 & t \ge LT_s \end{cases}$$

- **L is the memory of the modulation.**



Modulation and Coding Proposals

Linear Modulation

- **FEC**
  - Turbo-Φ coding scheme
- **Modulation scheme**
  - 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
- **Pilots format**
  - Preamble, distributed, and postamble
  - **Pilot overhead**
    - from 3% up to 14% for traffic bursts

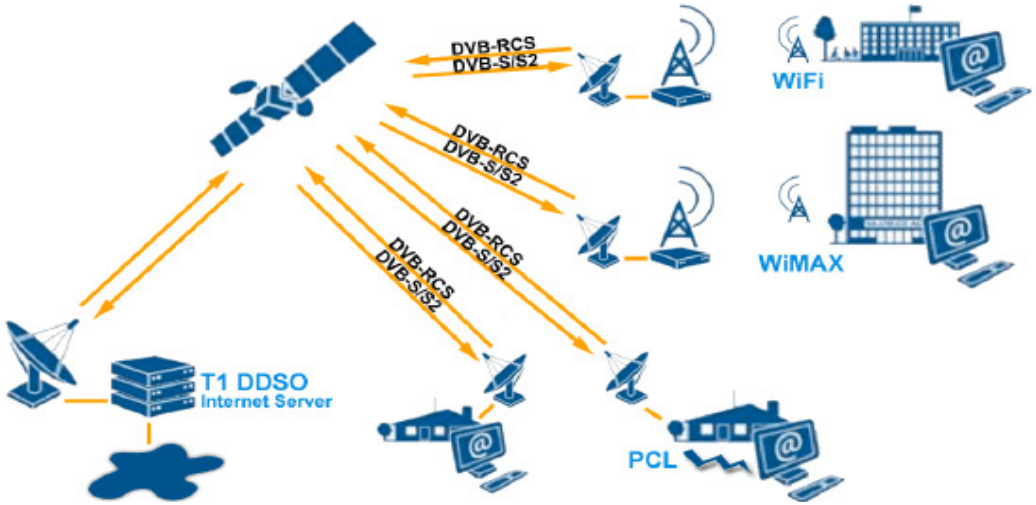
Continuous Phase Modulation

- **FEC**
  - extended-BCH scheme (block code)
- **Modulation scheme**
  - Quaternary CPM waveform
  - Bandwidth limitation 99% and 77%
- **Spectral Efficiency**
  - 0.5 - 0.75 – 1.0 – 1.25 – 1.5 – 1.83 bit/s/Hz
- **Pilots format**
  - Preamble and midamble
  - **Pilot overhead**
    - below 10% for the traffic bursts

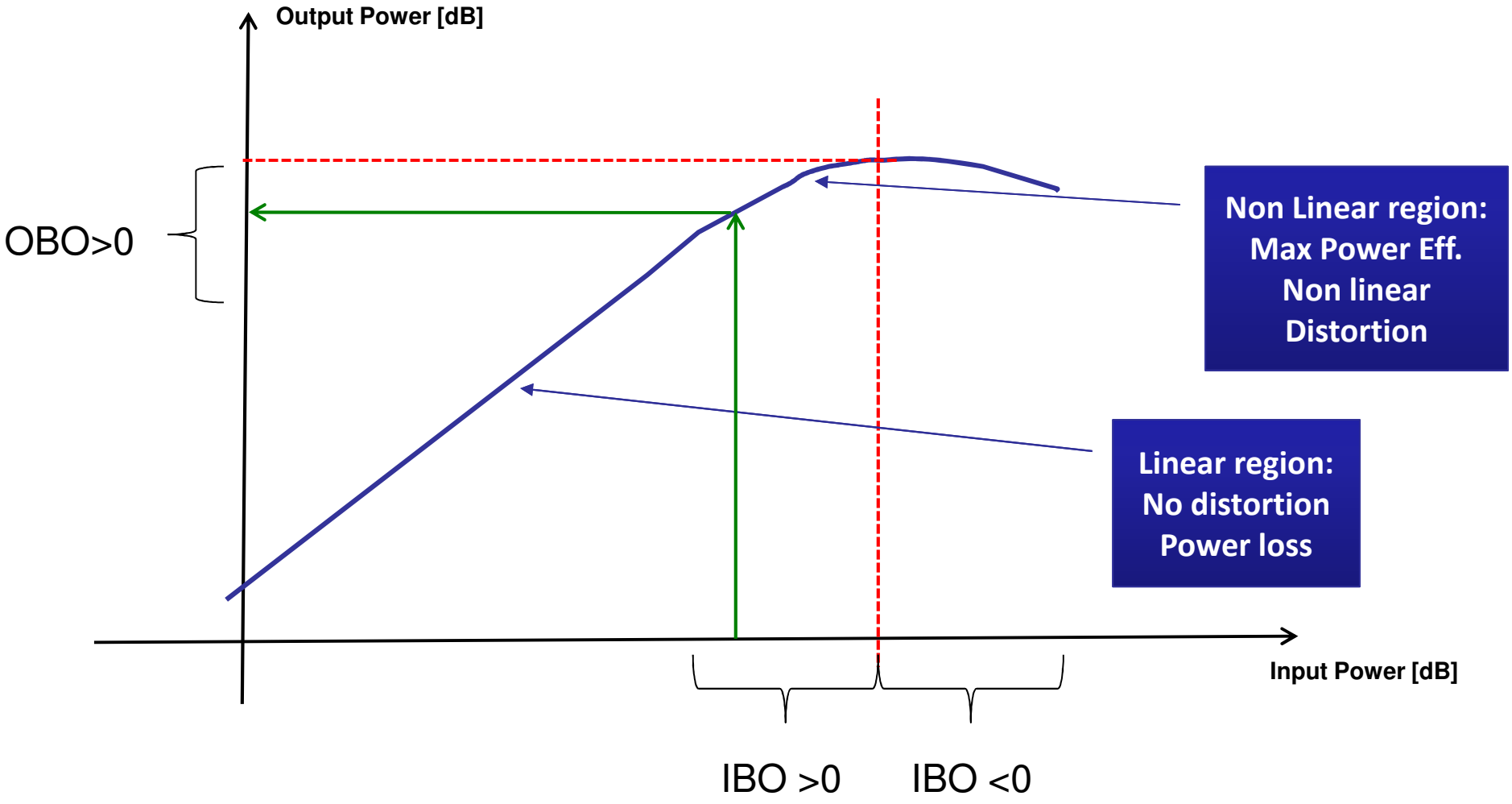
LM overperfom CPM in AWGN, but…

… SatCom scenario

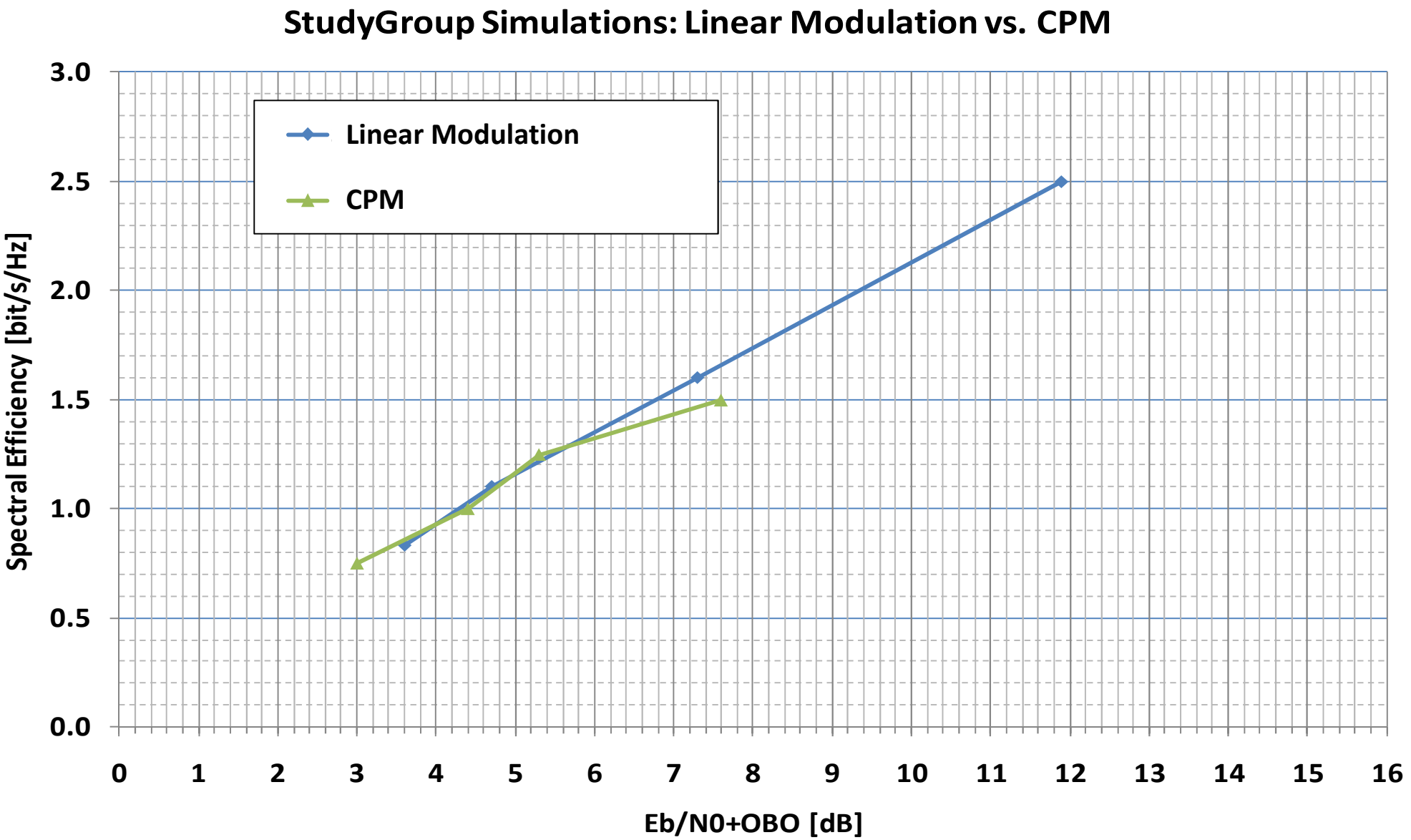
- Phase noise
- Frequency offset
- Non linear distortion (terminal high power amplifier – HPA)
- Adjacient channel interference (antenna's radiation diagram)



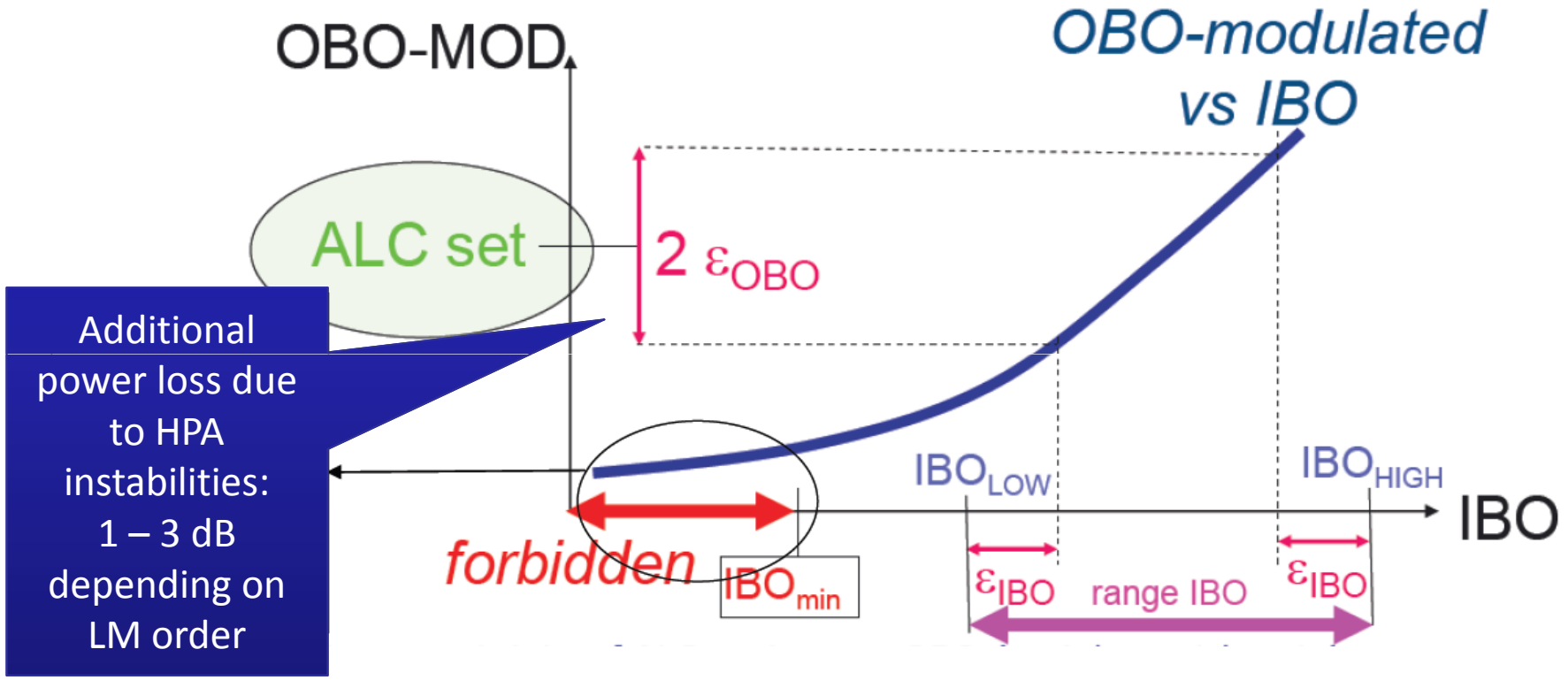
HPA MODEL


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

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

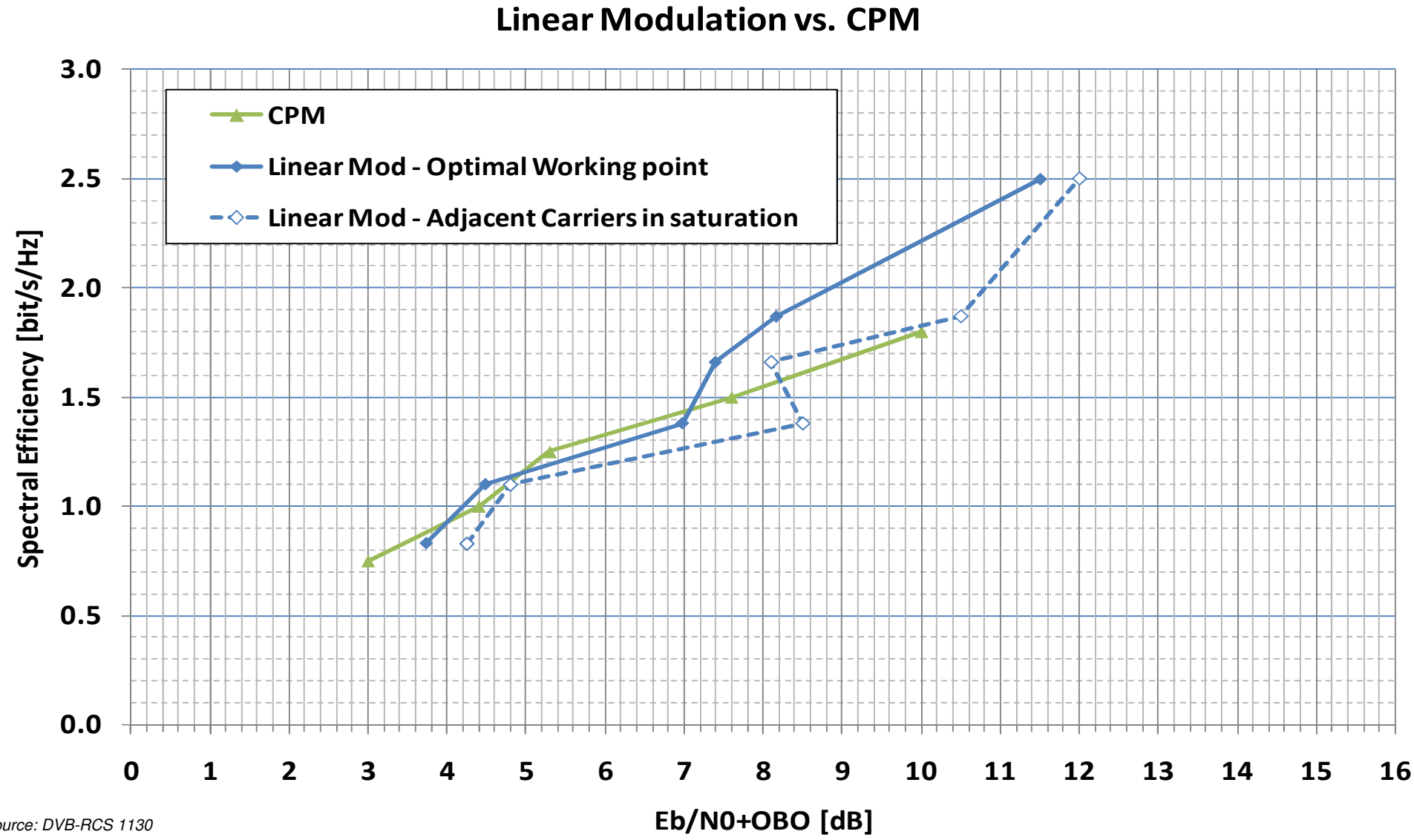


HPA (Out Door Unit) Instabilities Model



Source: DVB-RCS 1130

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



Source: DVB-RCS 1130

PHY Assessment Conclusions

- **Link layer performance**
  - comparable performance 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 better performance when ODU instabilities are considered

- **System level performance simulations**
  - For interference limited scenarios CPM schemes outperform linear modulations in average spectral efficiency when considering ODU instabilities
  - For networks with higher C/I linear modulations outperform CPM, e.g., for low frequency re-use, separate RX/TX satellite antennae, etc.
  - Whenever low terminal output power is considered the CPM approach is preferable

- **Both techniques retained for DVB-RCS-NG**

PHY Assessment Conclusions

- **Link layer performance**
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  - CPM schemes show better performance when ODU instabilities are considered

- **System level performance simulations**
  - For
  - For
  - Wh

- **Both te**

Afterword

•CPM+Convolutional Code proposed in May 2010 by Hughes Networks

• CPM+CC comparable in performance to CPM+eBCH but simpler :
  • CPM+CC included in the DVB-RCS-NG normative document
  • CPM+eBCH included as optional mode

Since CPM promises for further improvements a fexible mode has been included in the standard for future evolution.

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 European “Economic Development”
- Satellite technology is mature for large multi-spot beam satellite networks able to provide for high capacity access
- Key elements to meet the market requirements are
  - Service quality and availability
  - Service Costs
- The definition the second generation of DVB-RCS is on-going to create an open standard able to provide the enablers for low cost and high efficient broadband satellite systems able to stand the challenges and grab the opportunities offered by the broadband market in the next years.

Acknowledgements & References

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

- References

  - The ISI SatCom event, December 1, 2010, http//: www.isi-initiative.org
  - The Digital Agenda for Europe, http://ec.europa.eu/information_society/digital-agenda/index_en.htm
  - EuroStat http://epp.eurostat.ec.europa.eu/portal/page/portal/population/data/main_tables

Thank you!

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