Ingegneria delle Telecomunicazioni

Satellite Communications

13. Satellite Services and Standards

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PART 1 - SATELLITE SERVICES

Classification of Commercial Satcom Services

- **Broadcast services**
  - Television and radio broadcasting to home or cable head ends
  - The most successful commercial satellite application currently declining
- **Fixed services**
  - Point-to-point communication partly overcome by terrestrial fiber
  - Satellite News Gathering
- **Broadband fixed access**
  - Covering digital divide areas (no terrestrial Internet access) or private networks
  - Increasing market share
- **Mobile access to individual users and large platforms**
  - Complementing terrestrial network coverage at regional or global level (rural areas, emergency, military forces, airplanes, ships, trains)
  - Market with up and downs

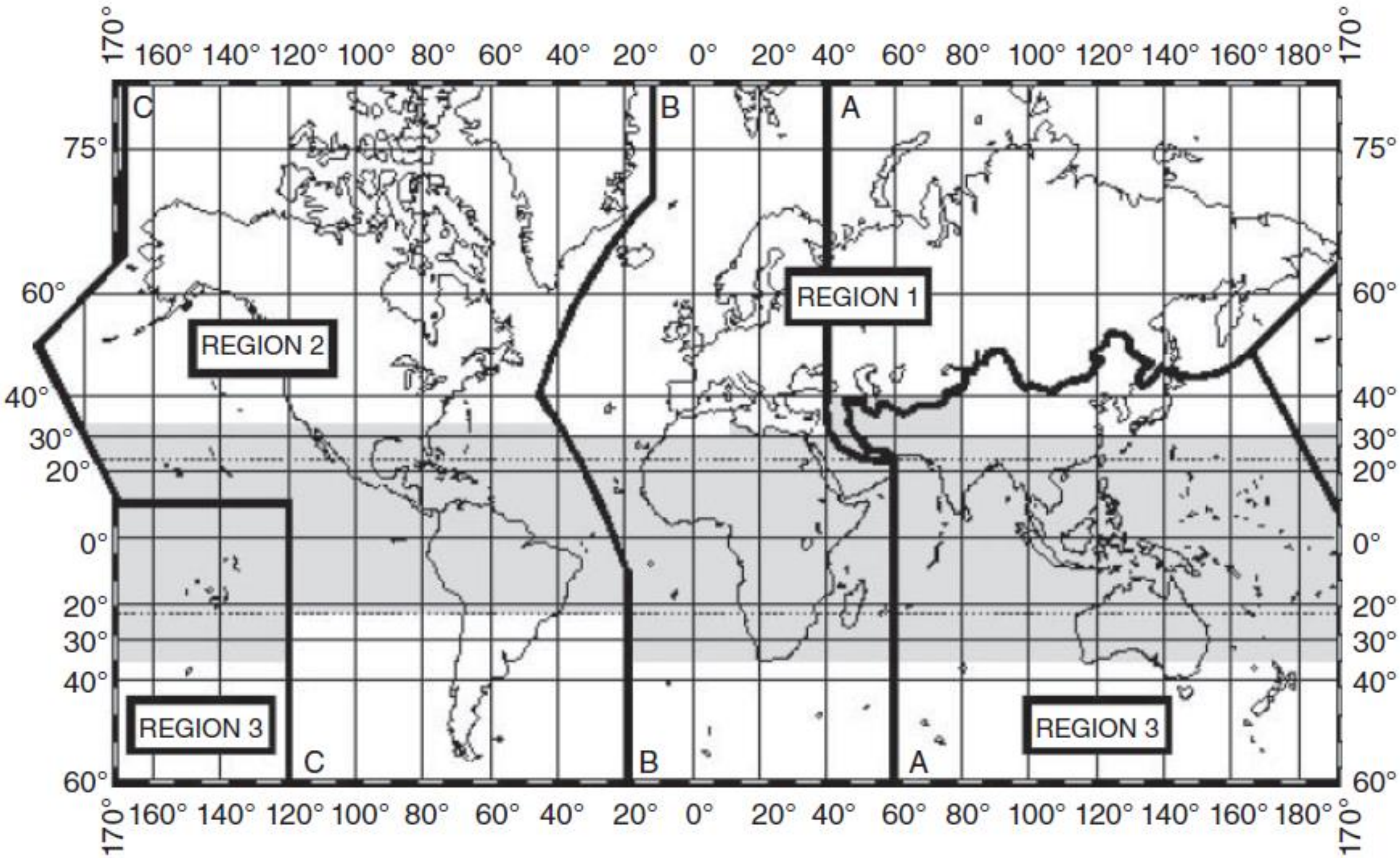
Satellite Frequency Bands and Regulations

- The Radio Regulations (RR) are by the ITU, a UN organization based in Geneva
- RR defines the rules to be applied in using the spectrum, as well as the rights and obligations resulting from this use
- Periodically reviewed by the ITU World Radio Conferences/Regional Radio Conferences
- RR can be downloaded from https://www.itu.int/pub/R-REG-RR
- Official ITU space radiocommunication services covered by the RR are:
  - Fixed-satellite service (FSS)
  - Mobile satellite service (MSS)
  - Broadcasting satellite service (BSS)
  - Earth exploration satellite service (EES)
  - Space research service (SRS)
  - Space operation service (SOS)
  - Radiodetermination satellite service (RSS)
  - Inter-satellite service (ISS)
  - Amateur satellite service (ASS)

Frequency (GHz)	Band
1–2	L
2–4	S
4–8	C
8–12	X
12–18	Ku
18–27	K
27–40	Ka

Satellite Frequency Bands and Regulations

- The ITU RR regions – frequency allocations are region dependent

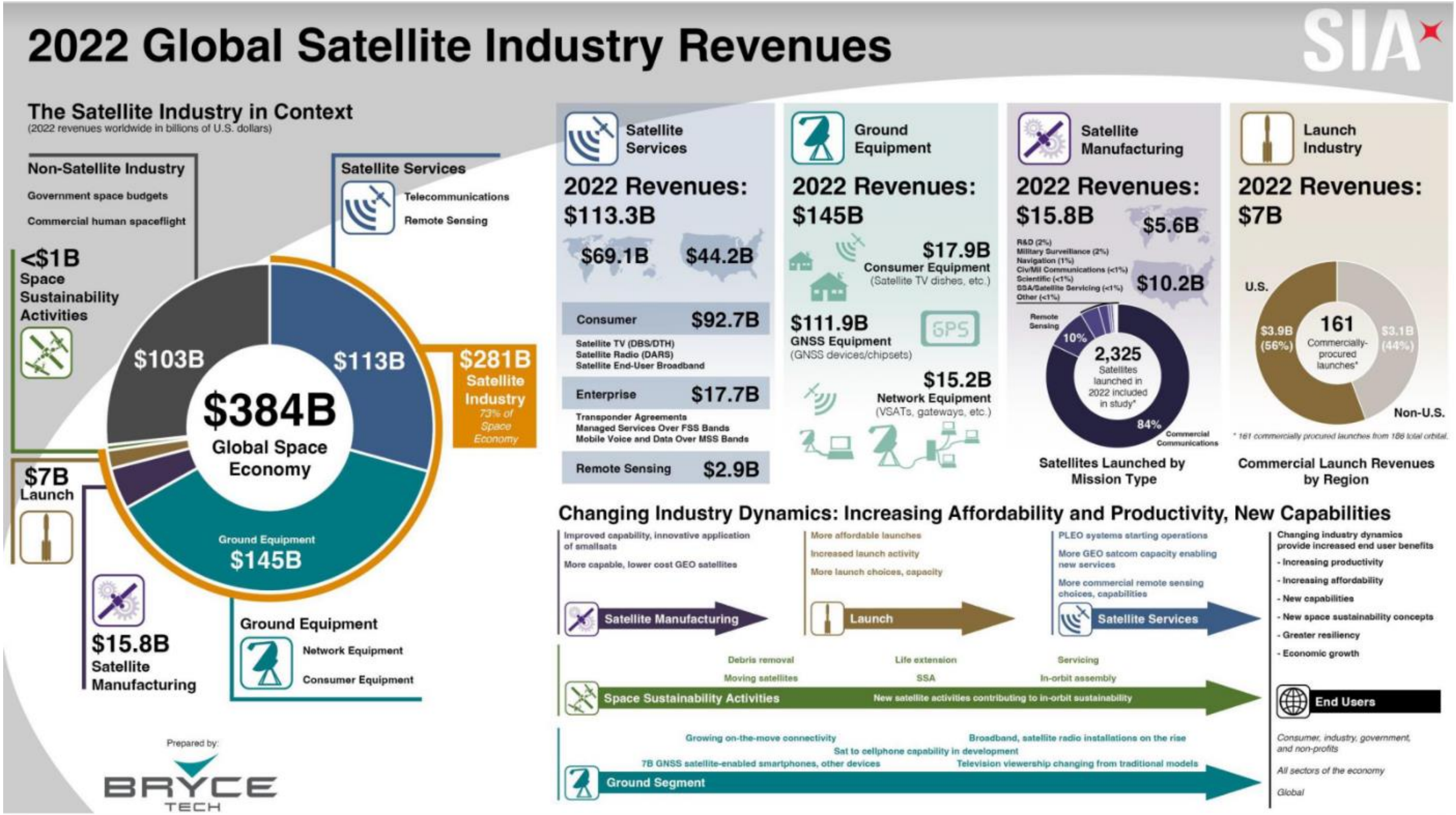


Satellite Frequency Bands and Regulations

- Simplified ITU RR frequency bands mapping on services

Radiocommunications service	Typical frequency bands for uplink/downlink (GHz)	Usual terminology
Fixed-satellite service (FSS)	6/4	C band
	8/7	X band
	14/12–11	Ku band
	30/20	Ka band
	50/40	V band
Mobile satellite service (MSS)	1.6/ 1.5 and 2.0-2.2	L band S band
	30/20	Ka band
Broadcasting satellite service (BSS)	2/2.2	S band
	12	Ku band
	2.6/2.5	S band

The Satellite Market 2022



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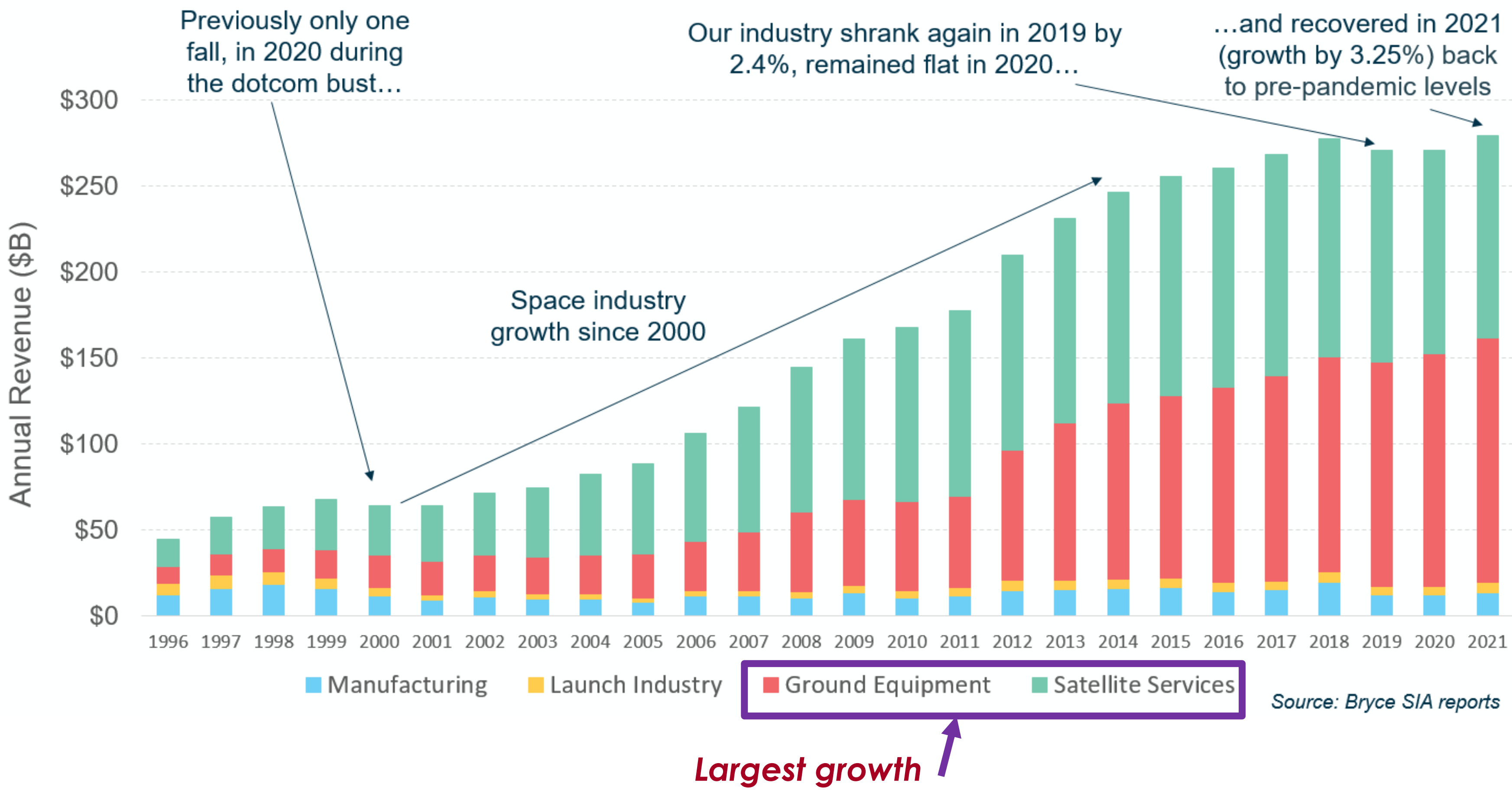
The Satellite Market 2022

- **The market is dominated by:**
  - Satellite ground equipment (145 B US$) and services (113 B US$)
  - Sizeable budget for governmental and human spaceflight (103 B US$)
  - 7 billions of GNSS enables mobile devices – the largest satellite market!

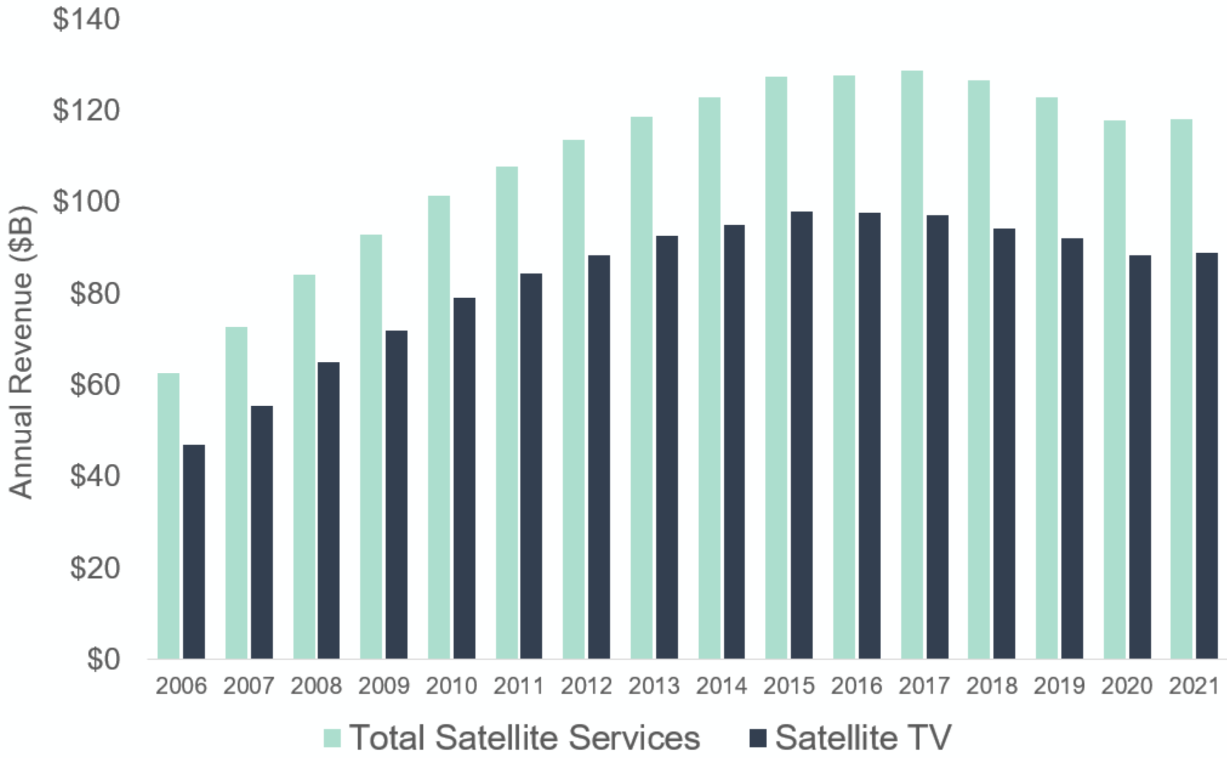
- **The riskiest business is where there are less revenues:**
  - Satellite manufacturing 15.8 B US$
  - Launch industry 7 B US$
  - Heavily subsided sector as large innovation required, and volumes often limited
  - Europe facing heavy competition from USA, India and China

The Satellite Market Evolution



Source: Bryce SIA reports

The Satellite Market Evolution



Source: Bryce SIA reports

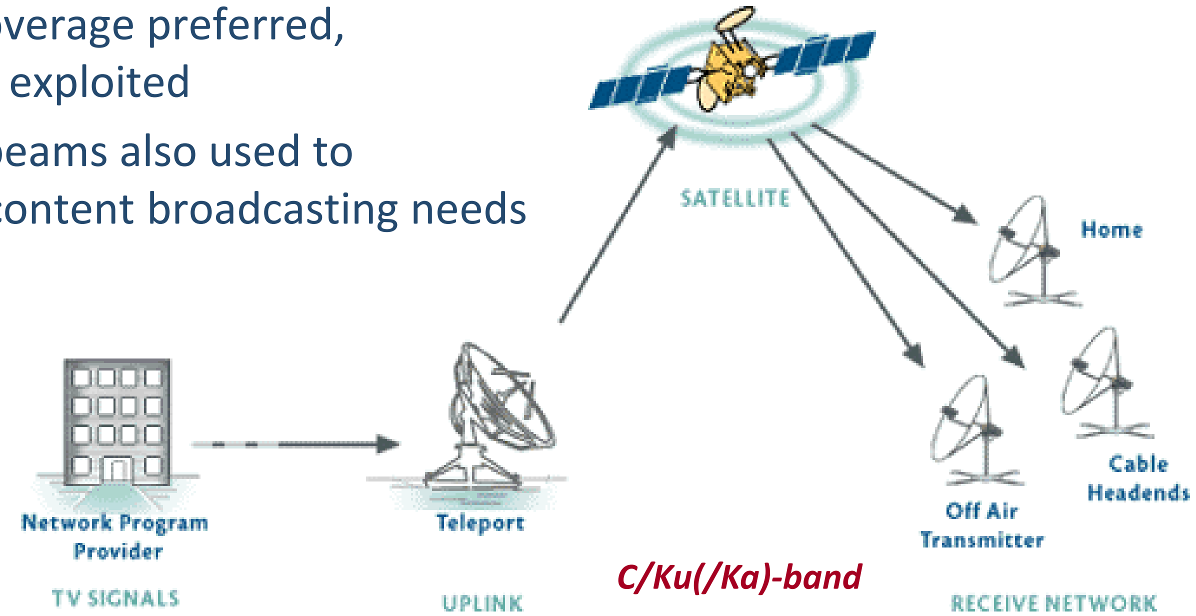
- **Satellite services revenue peaked** in 2017, pulled down by falling satellite TV revenue.
- **Inflection point expected in 2022** when revenue for other services grow more quickly than satellite TV slowly declines.
- **New SatCom markets required** to offset decline in Satellite TV and to sustain and grow the SatCom market.

GSO Systems Architecture: Broadcasting Satellite System

Satellite Broadcasting System Architecture:

- Gateway connected to the network program provider(s)
- Feeder uplink connecting the terrestrial gateway to the satellite
- User downlink connecting the satellite to the users
- Satellite acting as a bent pipe transponder from the gateway to users (home, head-ends)
- Typically, wide area coverage preferred, and C or Ku(Ka)-bands exploited
- Regional or linguistic beams also used to best match linguistic/content broadcasting needs

The acronym DTH applies (also) to similar services transmitted over a wider range of frequencies (including Ku- and Ka-band) not specifically designated for BSS



C/Ku(/Ka)-band

GSO Systems: Broadcasting Satellite System

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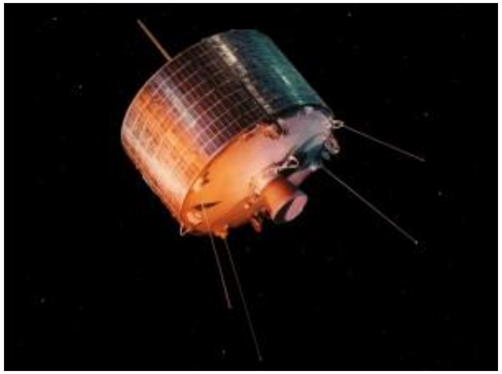
Satellite Communications

INTELSAT 1 (Early Bird)
April 6, 1965 by Hughes (USA)



The Europe dawn: ESA OTS-2 (1977)
first GEO sat with six Ku-band transponders by British Aerospace - Few analogue TV channels

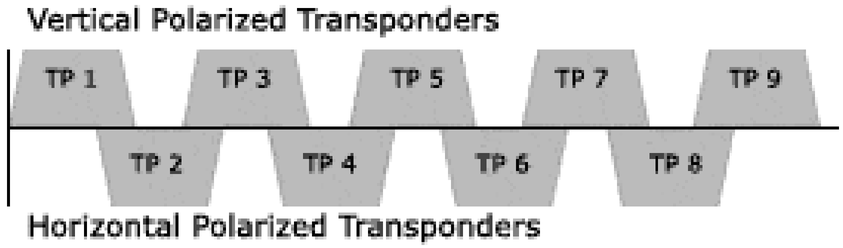
Satellite broadcasting evolution 1965-2023

Today: Aribus Eutelsat Hot Bird 12F/FG AD 2023
7 premium TV platforms, over 600 pay-TV channels, 300 free-to-air channels, and 500 HDTV and UHD channels. With its unique pan-European coverage, in Europe alone, Hotbird reaches 130 million homes

DTH services in Ku-band

Europe:

- Downlink frequencies: 10.7-12.75 GHz
- Uplink frequencies: 12.75-14.5 GHz



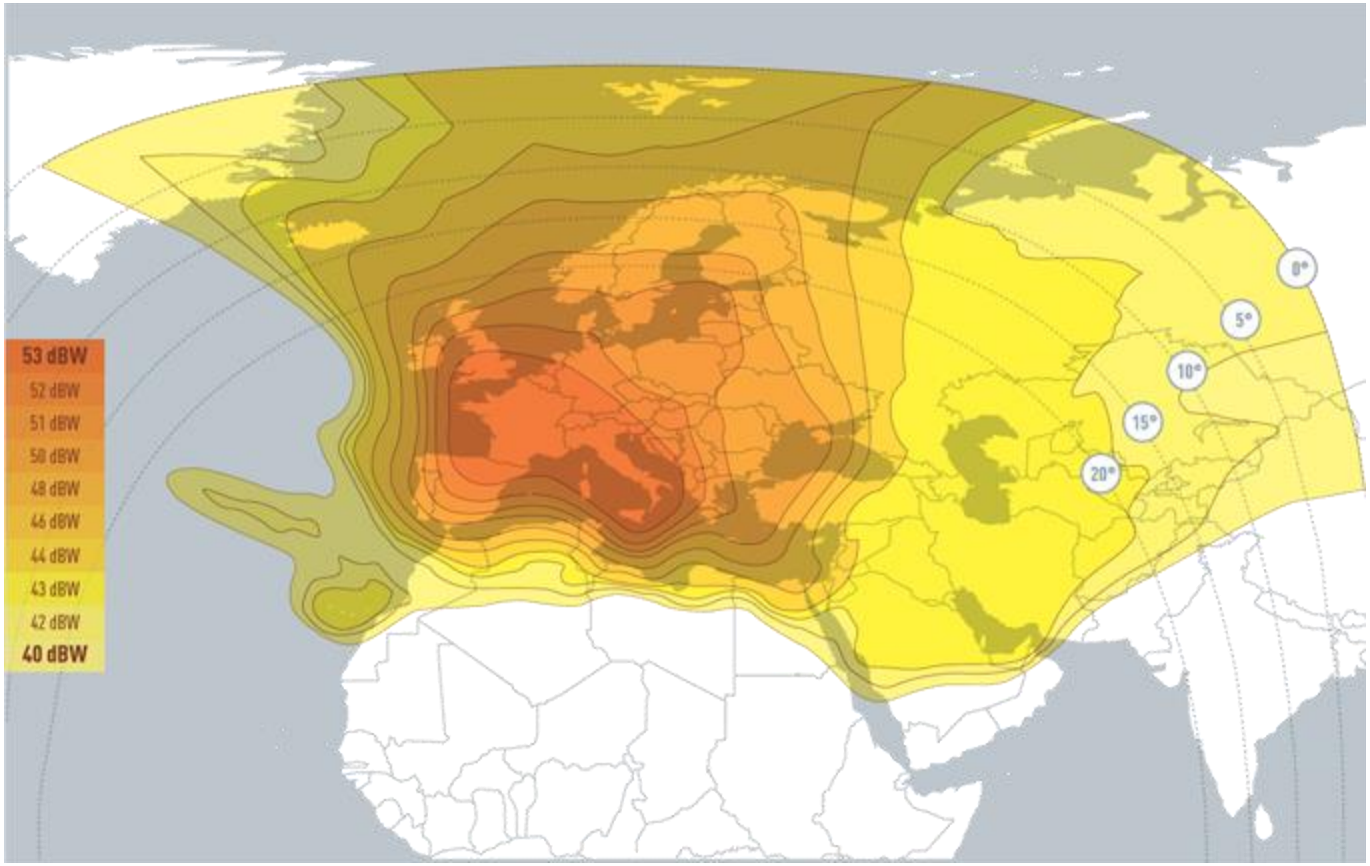
- Adjacent transponders may be transmitted with alternate polarity (to increase channel isolation with reduced carrier spacing). The user terminal LNB is capable of switching between signal polarity

- Typical DTH transponder bandwidth is 36 MHz but also 27, 33, 54 and 72 MHz
- Number of Ku band transponders per satellite depends on the platform: recent SES-6 satellite (E3000 platform) contains 48 transponders (36 MHz equivalent) – DTH satellites typically take up to ~64 transponders

- Transponder transmit power 100-300 W (typical 150 W)
- Satellite antenna size diameter: 1-2 m – user terminal antenna 40-60 cm
- Single beam DTH satellites covering Europe needs small antenna size (to cope with the large service area). DTH satellites with linguistic beams might use larger antenna size

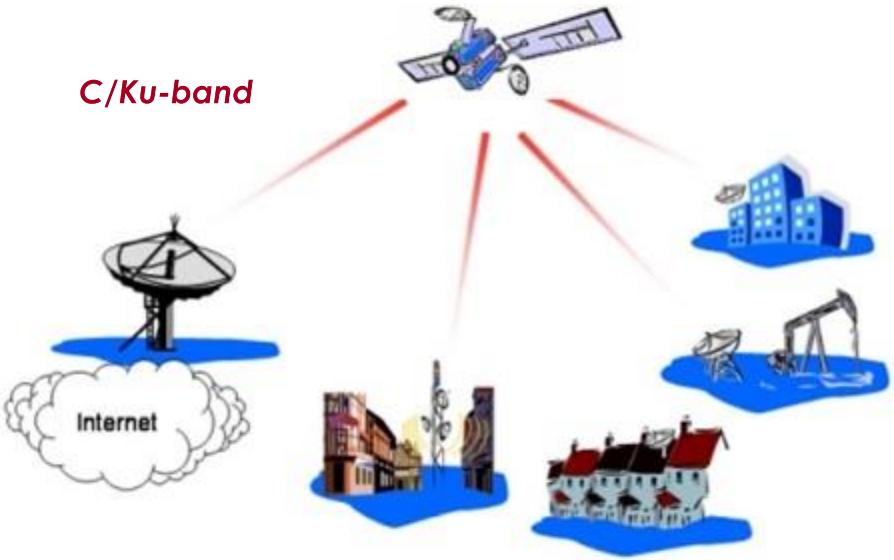
GSO Systems: Broadcasting Satellite System

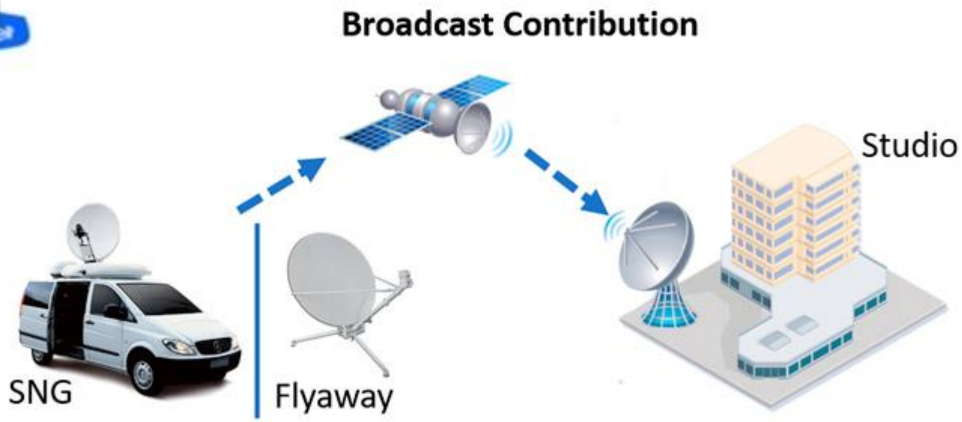
Typical Eutelsat Hot Bird BSS coverage



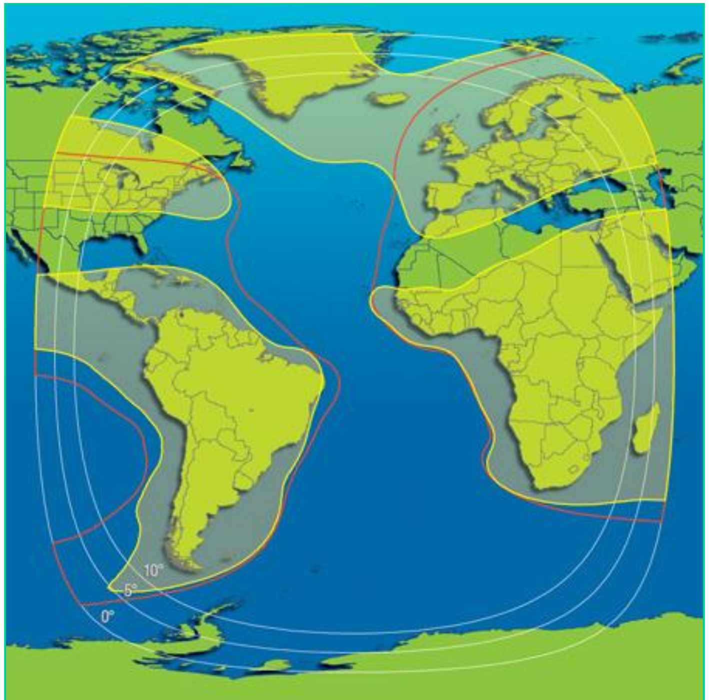
GSO Systems: Fixed Services Satellite System

Satellite Fixed Satellite Services System Architecture:



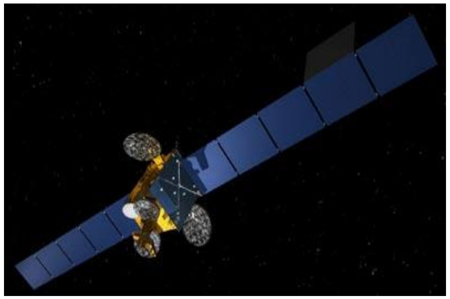


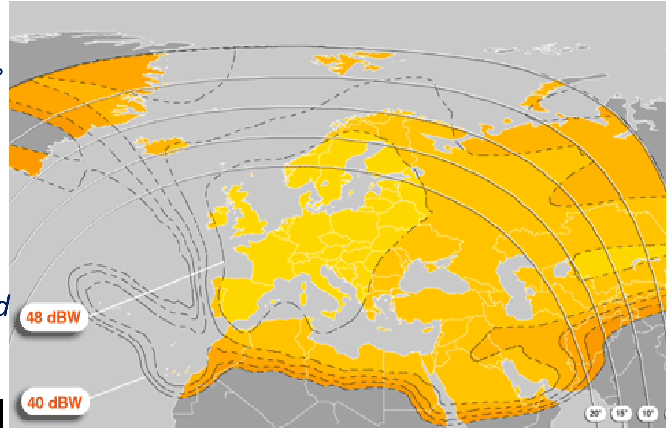
Typical regional and multi-regional FSS coverage

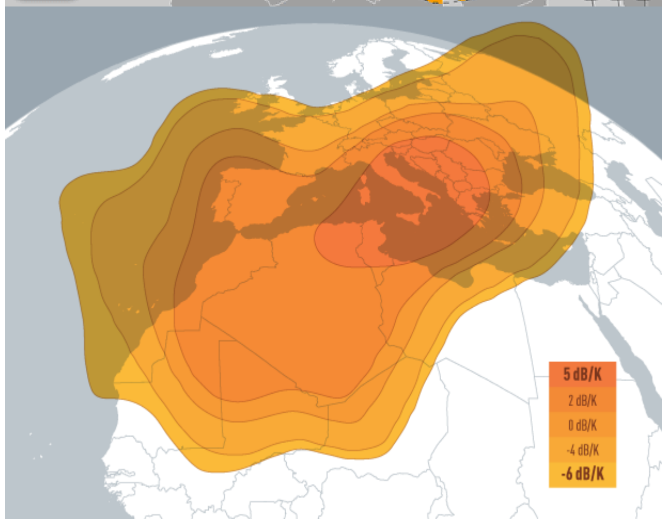


EUTELSAT 3A, deployed at 3° East, delivers users coverage of Europe and North Africa for services that include mobile backhaul, data networks, IP backbone connectivity and maritime applications.

Launched on 1/5/2007. 24 C band transponders

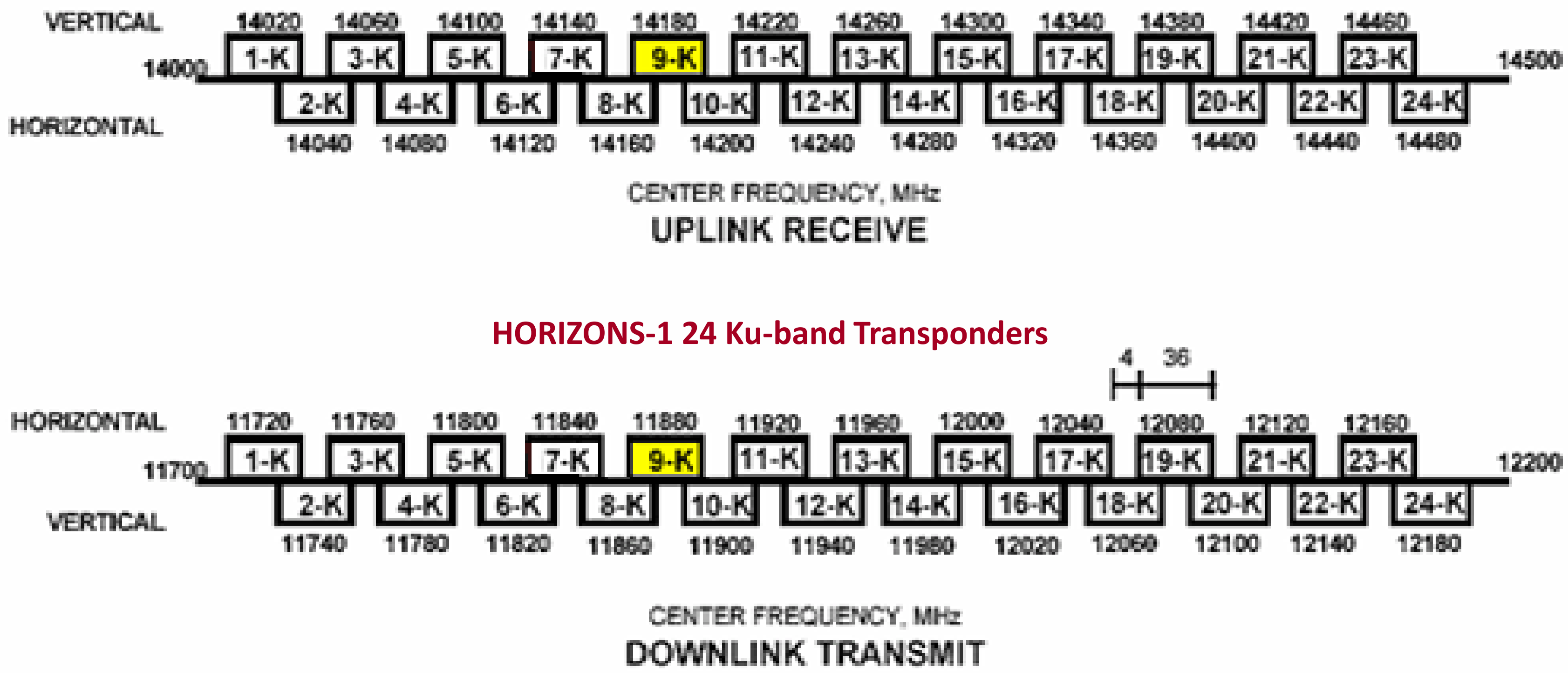






- *INTELSAT 907 Launched on February 17th, 2003 carries 22 Ku-band and up to 76 C-band transponders (in 36 MHz equivalents),*
- *Data connectivity and voice communication for passengers and operational purposes in the cruise, ferry and offshore sectors.*
- *Ku-band services: DBS, VSAT, Maritime connectivity, backhauling for DTH*

FSS Typical frequency plan /satellite transponder layout



- Dual use of polarization, different frequency bands for uplink and downlink, 40 MHz spacing (transparent payload)

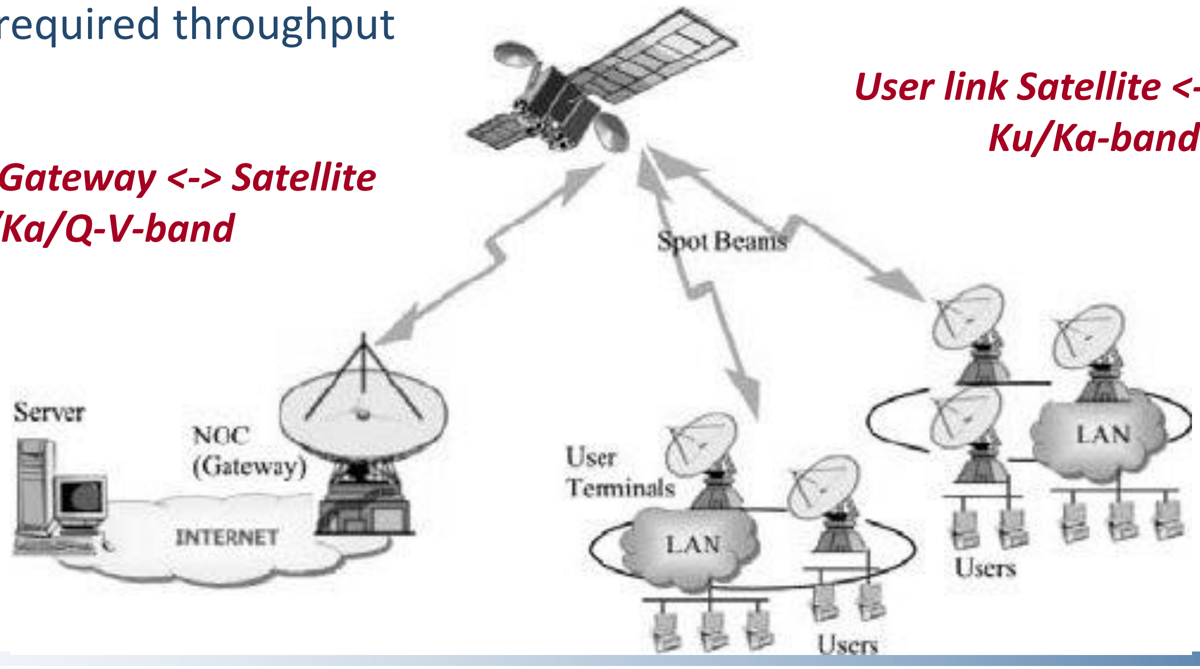
- A single channel can relay up to hundreds of Mbps, if a suitable antenna, power amplifier and modulation equipment is used on the ground.

GSO Systems Architecture – Broadband Access System

- Gateway(s) connected to terrestrial high-speed backbone
- Feeder link connecting the satellite to the terrestrial gateway
- User link connecting the users to the satellite
- Satellite acting as a bent pipe transponder from/to gateway to/from users
- Multiple beams to increase the frequency reuse and satellite antenna gain
- For high throughput satellites multiple gateways spatially separated are required to support the required throughput

User link Satellite <-> Users
Ku/Ka-band

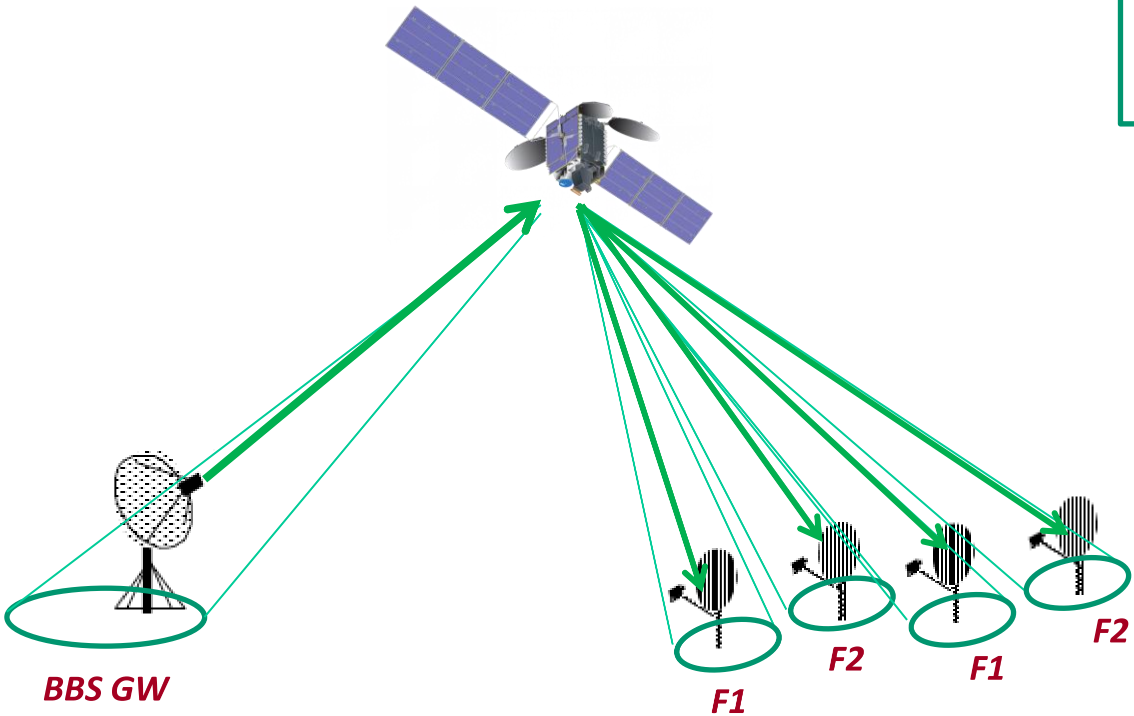
Feeder link Gateway <-> Satellite
Ku/Ka/Q-V-band

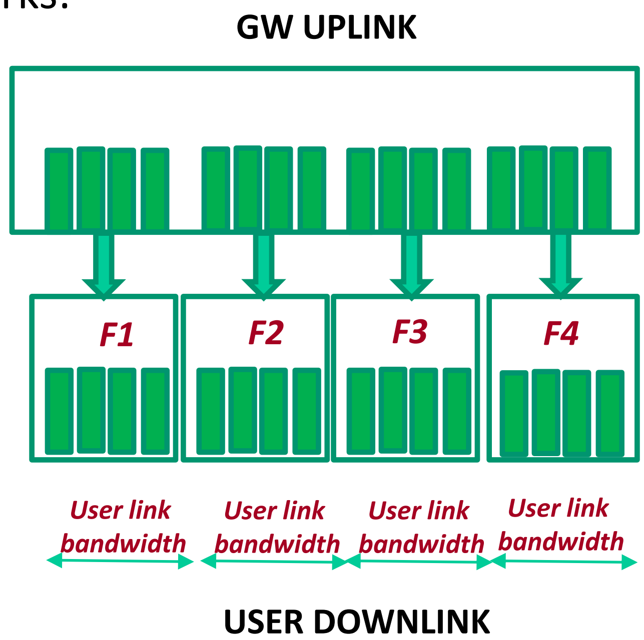


GSO Systems Architecture – Broadband Access System

Solution borrowed from terrestrial wireless cellular networks:

SPATIAL DIVERSITY + FREQUENCY RE-USE





The user link bandwidth is re-used several times within the service area=> network capacity increase

GSO - Inter-Satellite (external-system) Interference

REQUIREMENT on emission:

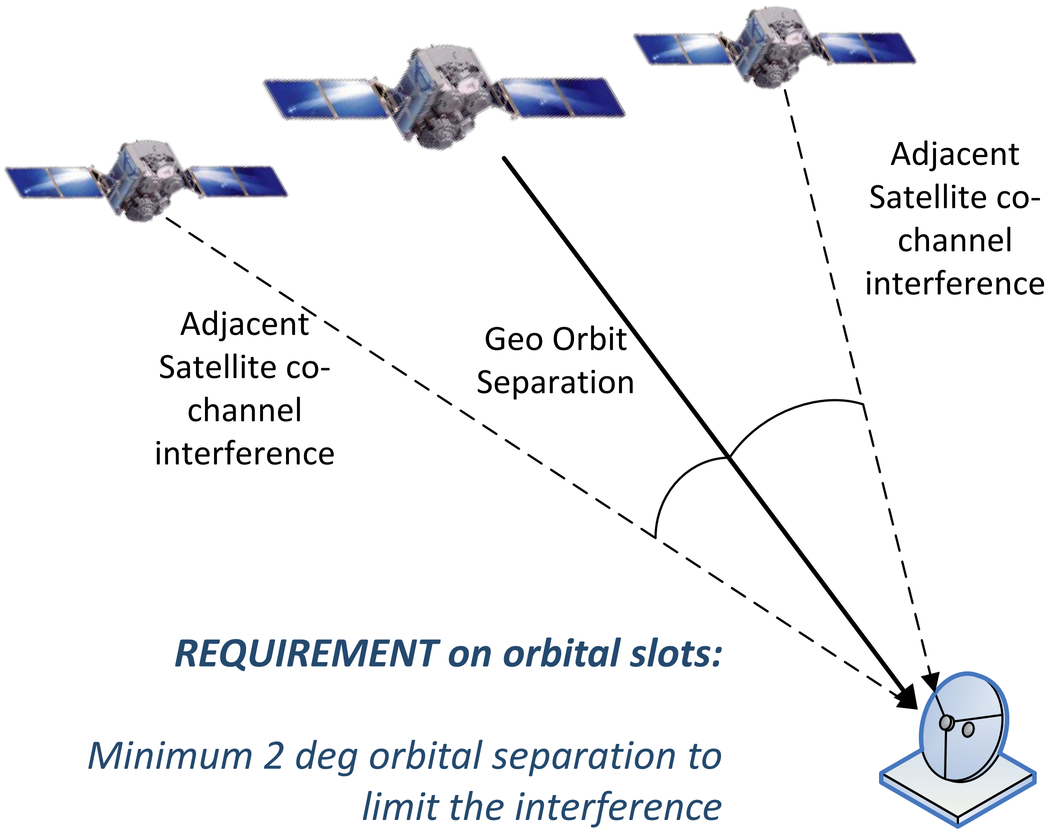
No coordination policy required if external interference < 6% of system noise level: considering the two nearest interferers, for the victim satellite we should have

$I_0 < 0.12\, N_0$ or $I_0/N_0 < -9.2$ dB

Example:

C/N_0 =81 dBHz

How much is the external interference degradation?



REQUIREMENT on orbital slots:

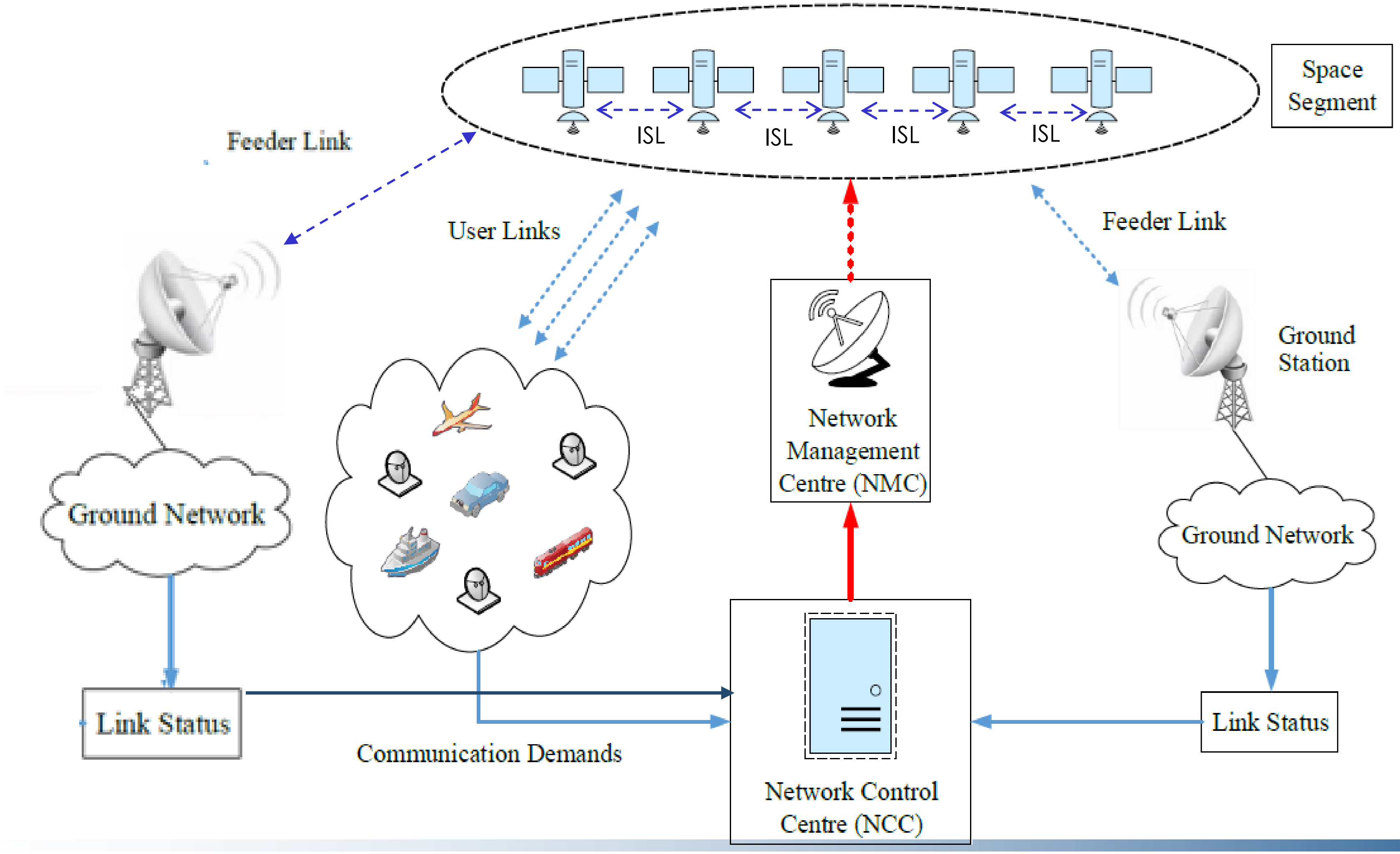
Minimum 2 deg orbital separation to limit the interference

For Ku-Band services in Europe the minimum is 3 degrees

NGSO System Architecture

- Service provided:
  - Mobile voice/data links (e.g. Iridium, Globalstar)
  - Broadband access (O3B, Starlink, Kuiper)
- Gateway(s) connected to terrestrial high-speed backbone (for non real time services e.g. IoT one may be enough)
- Feeder link connecting the satellite to the terrestrial gateways
- User link connecting the users to the satellite
- Satellite acting as a regenerative or bent pipe transponder from/to gateway to/from users
- Multiple beams to increase the frequency reuse and satellite antenna gain
- Multiple gateways required to achieve the required throughput
- ISL to reduce the number of gateways

High level architecture of an NGSO system



PART 2 - SATELLITE STANDARDS: A CASE STUDY

Satellite Standards - DVB-S2: History

DEFINIGN A STANDARD is not an easy task. All started with:

- US interest to include 8PSK on top of QPSK already present in the DVB-S standard
- Possible FEC enhancement wrt the concatenated convolutional + Reed Solomon
- The DVB group issued in 2002 a call for proposals in two rounds: 1) FEC contest; 2) PHY and framing

FEC Proposals Performance Comparison

Proponent	Average loss from capacity (dB)	Performance figure	Ranking
COMTECH (USA)	1.49	1.507	6
CONNEXTANT (USA)	1.38	1.284	5
ESA (NL)	1.00	0.995	2
HNS (USA)	0.73	0.727	1
PHILIPS (F)	1.28	1.276	4
SPACE BRIDGE (CDN)	0.81	0.817 (discarded for excessive complexity)	N/A
TURBO CONCEPT (F)	0.97	0.973	2

Satellite Standards - DVB-S2: History

- HNS (USA) won the FEC contest: ESA+Polito runner-up with Turbo concept (F)
- HNS LDPC FEC allowed higher parallelization than European Turbo Codes ☹
- ESA proposal for Amplitude Phase Shift Keying (16 and 32-APSK), Adaptive Coding and Modulation (ACM) and pilot-aided synch accepted by DVB TM ☺

The Modulation/Framing Winner

- QPSK for efficiencies < 2 b/s/Hz
- 8PSK for efficiencies < 3 b/s/Hz
- 16APSK for efficiencies < 4 b/s/Hz [ESA]
- 32APSK for efficiencies < 5 b/s/Hz [ESA]
- Pilot-aided carrier synchronization and channel estimation optional as suggested by ESA
- Physical layer I-Q scrambling as suggested by ESA
- Framing structure as proposed by RAI
- Preamble coding as proposed by HNS
- Pre-distortion techniques proposed by Tandberg and ESA

Satellite Standards - DVB-S2: History

- ESA provided the reference model for assessing end-to-end performance
- The hard work was completed in 2003 with celebration in Turin and standard publication in 2004
- Lessons learned on FEC: look at the implementation on top of performance aspects!

ETSI EN 302 307 V1.1.1 (2004-01)

European Standard (Telecommunications series)

Digital Video Broadcasting (DVB)
Second generation framing structure, channel coding and modulation systems for Broadcasting, Interactive Services, News Gathering and other broadband satellite applications

Satellite Standards - DVB-S2: Features

Applications

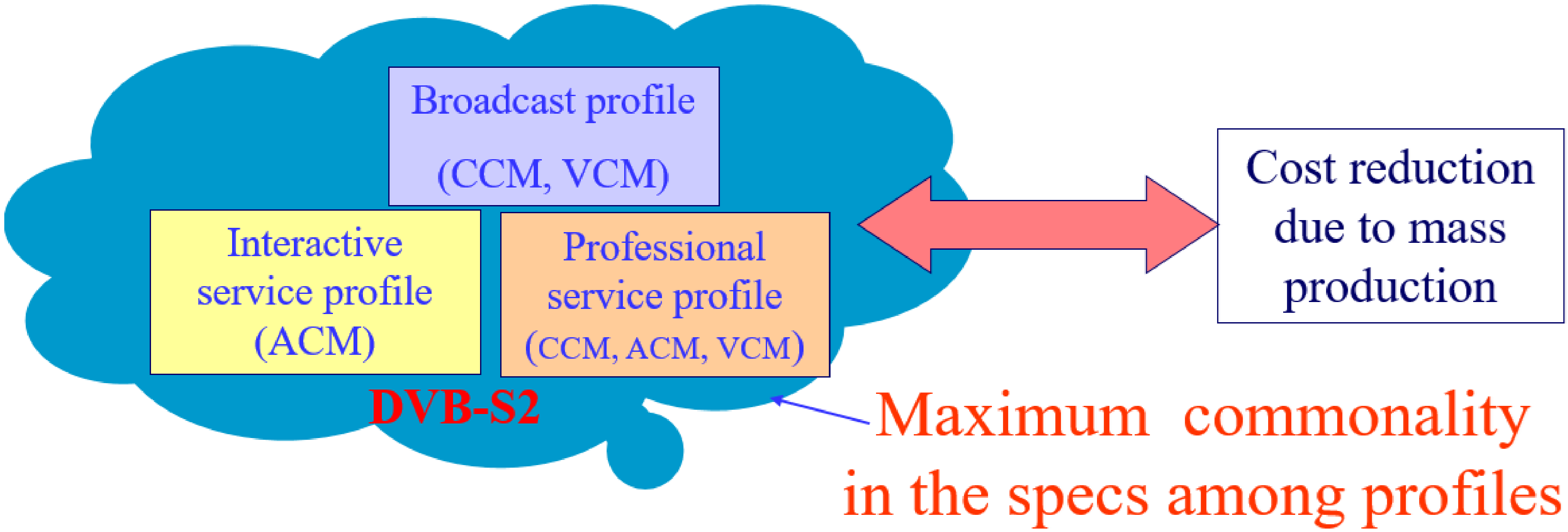
- Broadcasting of standard definition and high-definition TV (SDTV and HDTV)
- Interactive services, including Internet access, for consumer applications
- Professional applications, such as digital TV contribution and news gathering
- Data content distribution and Internet trunking

Key features

- Near-Shannon physical layer performance thanks to powerful LDPC FEC
- Wide range of power and spectral efficiencies with CCM/VCM/ACM
- Satellite channel optimized modulation formats (APSK) suitable to pre-distortion
- Pilot-aided channel synchronization
- Optional channel bonding
- Super-framing allowing support for beam-hopping and pre-coding

Satellite Standards - DVB-S2(X): Features

DVB-S2 is a single system for the various application scenarios



Satellite Standards - DVB-S2: Features

Much more extended for DVB-S2X

Table 1: System Configurations and Application Areas

System configurations		Broadcast Services	Interactive Services	DSNG	Professional Services
QPSK	1/4 ;1/3; 2/5 ; 1/2,3/5,2/3,3/4,4/5,5/6, 8/9, 9/10	O N	N N	N N	N N
8PSK	3/5, 2/3,3/4,5/6, 8/9, 9/10	N	N	N	N
16APSK	2/3, 3/4,4/5,5/6, 8/9, 9/10	O	N	N	N
32APSK	3/4, 4/5,5/6, 8/9; 9/10	O	N	N	N
CCM		N	N (*)	N	N
VCM		O	O	O	O
ACM		NA	N(**)	O	O
FECFRAME (normal)	64800 (bits)	N	N	N	N
FECFRAME (short)	16200 (bits)	NA	N	O	N
Single Transport Stream		N	N(*)	N	N
Multiple Transport Streams		O	O(**)	O	O
Single Generic Stream		NA	O(**)	NA	O
Multiple Generic Streams		NA	O(**)	NA	O
Roll-off 0.35, 0.25 and 0.20		N	N	N	N
Input Stream Synchroniser		NA (***)	O(***)	O(***)	O(***)
Null Packet Deletion		NA	O(***)	O(***)	O(***)
Dummy Frame insertion		NA(***)	N	N	N
N=normative, O=optional, NA=not applicable					

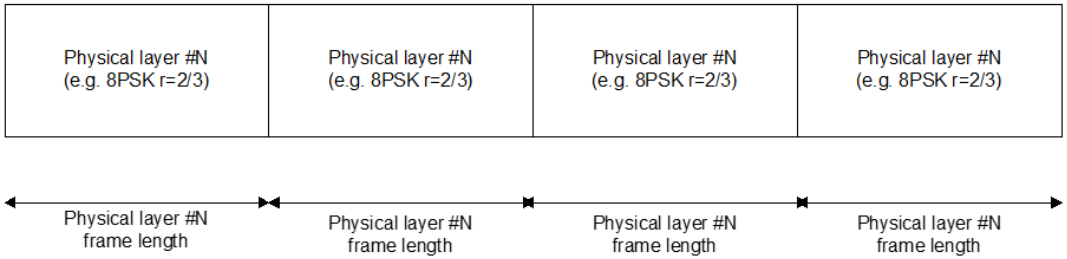
* Interactive Service receivers shall implement CCM and Single Transport Stream

** Interactive Service Receivers shall implement ACM at least in one of the two options: Multiple Transport Streams or Generic Stream (single / multiple input)

*** Normative for ACM/VCM or for multiple TS input stream(s) combined with CCM

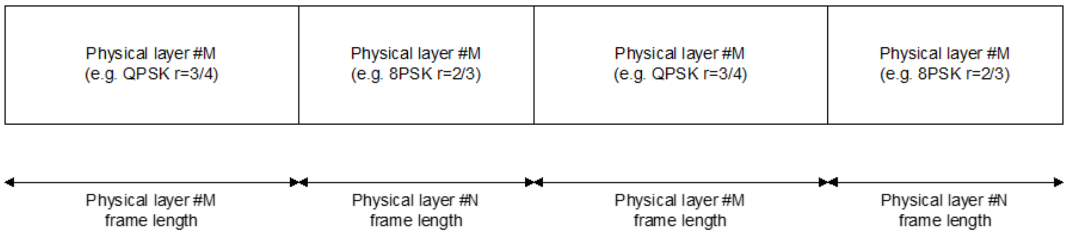
Satellite Standards - DVB-S2: Features

– Constant Coding and Modulation (CCM) – repeating frame configuration



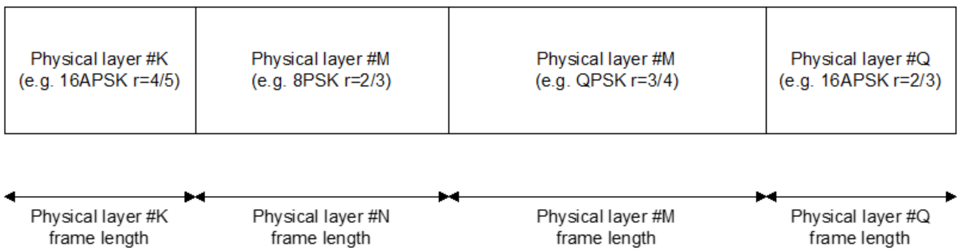
Typically used for broadcasting systems

– Variable Coding and Modulation (VCM) – periodic frame configuration



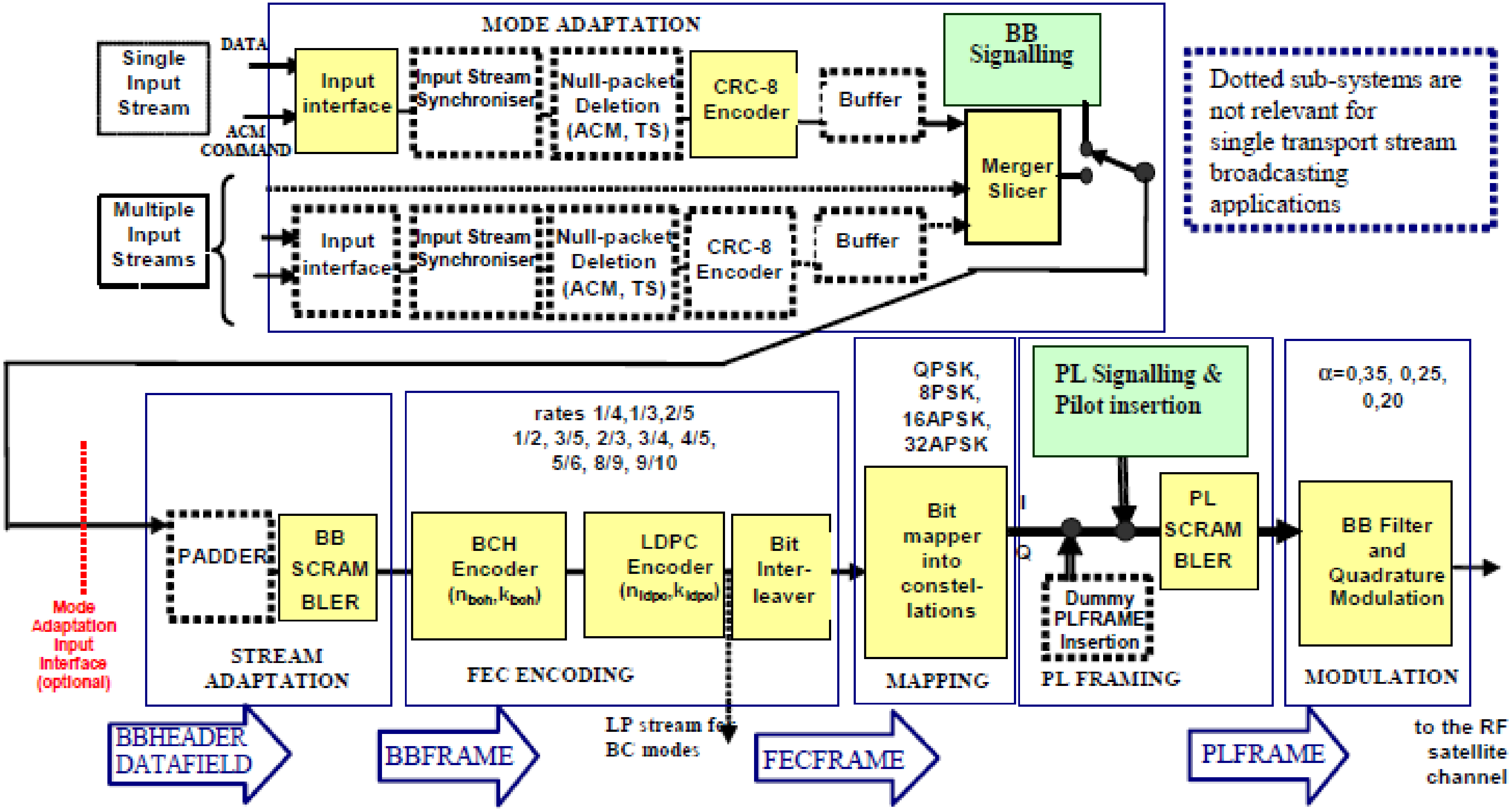
Broadcasting systems with different QoS (e.g. SDTV+HDTV with different FEC)

– Adaptive Coding and Modulation (ACM) – irregular frame configuration



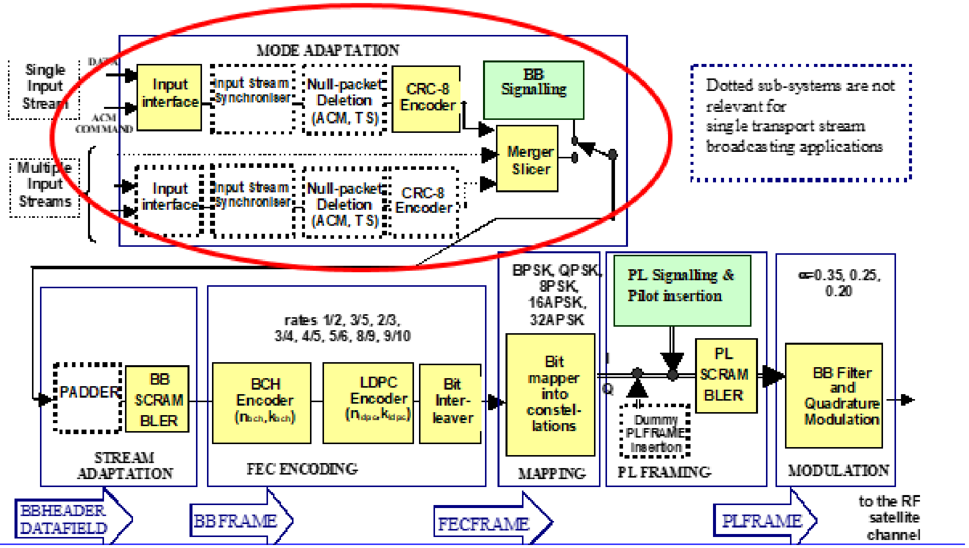
Interactive systems, trunking etc..

DVB-S2 modulator architecture



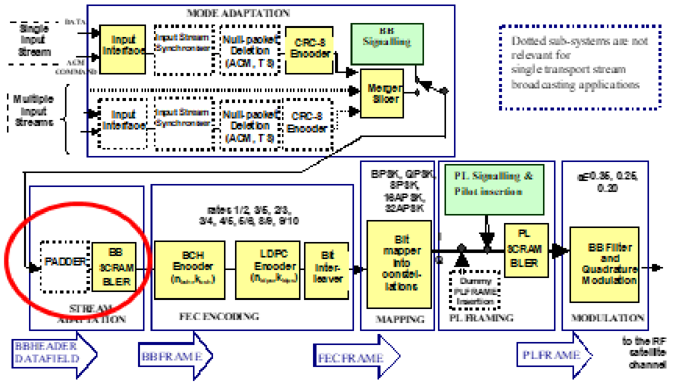
MODE ADAPTATION

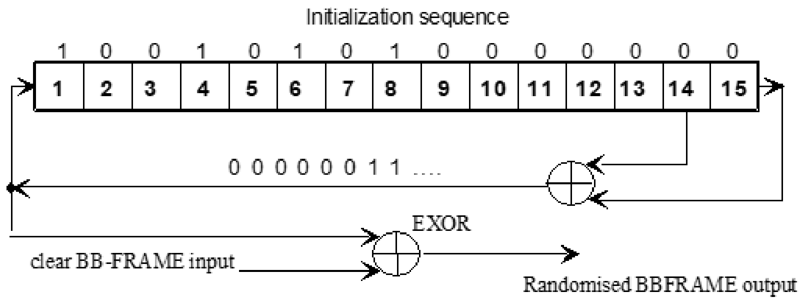
- Input stream interfacing
- Input stream synchronization (TS optional)
- CRC encoding (for packetised TS input only)
- Merging of input streams (for multiple input streams)
- Slicing in data fields

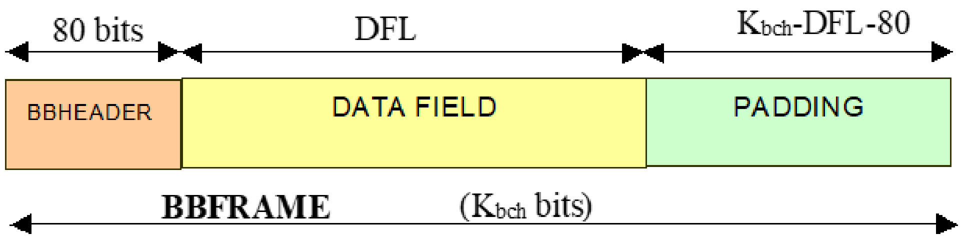


STREAM ADAPTATION

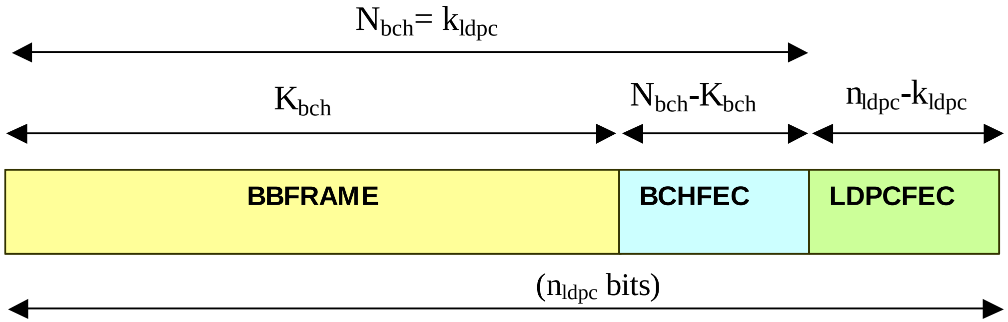
- Padding is required when data is not sufficient to fill the BBFRAME [unicast mode only]
- Stream adaptation provides padding to complete a constant length (K_{bch} bits) BBFRAME and scrambling
- K_{bch} is coding rate dependent (see Table 5-a)
- BB scrambler to randomize information bits at the encoder input





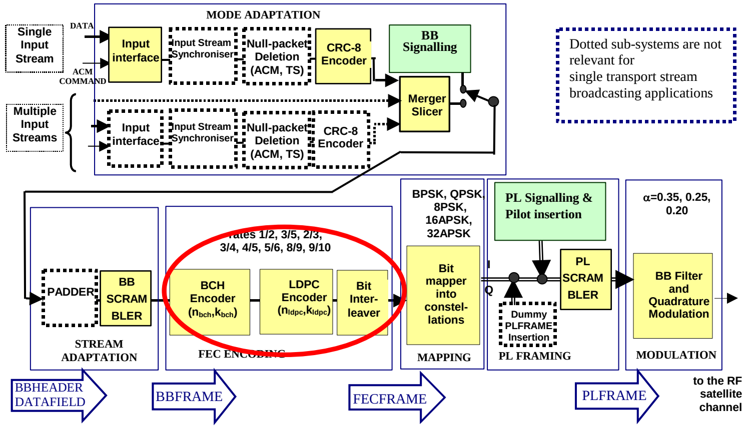


Satellite Standards - DVB-S2: Physical Layer



FEC encoding

- This block performs:
  - BCH outer encoding
  - LDPC inner encoding
  - Bit interleaving before M-ary modulator (Bit Interleaved Coded Modulation)
- FEC Encoding operations
  - Each BBFRAME (K_{bch} bits) is processed by the FEC coding subsystem, to generate a FECFRAME (n_{LDPC} bits).
  - The parity check bits (BCHFEC) of the systematic BCH outer code shall be appended after the BBFRAME, and the parity check bits (LDPCFEC) of the inner LDPC encoder shall be appended after the BCHFEC field



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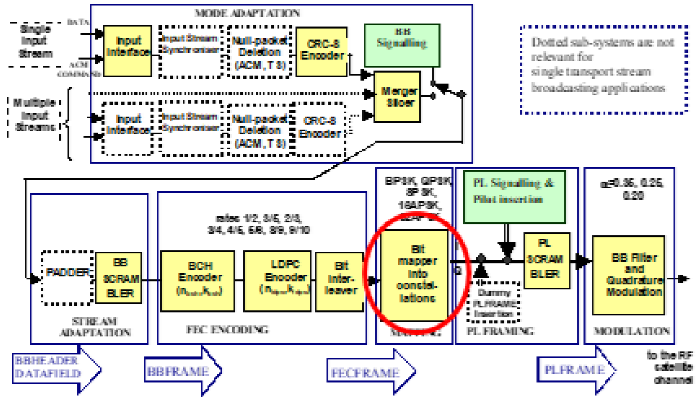
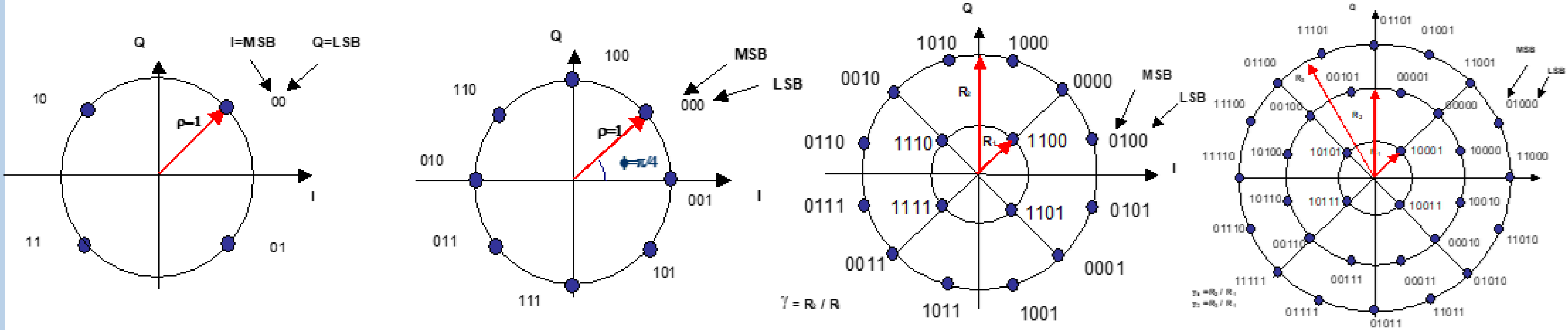
MAPPING & MODULATION

- Four modulation formats, all optimised to operate over non-linear transponders (external points over circles):
  - **QPSK** **(2 bit/s/Hz)**
  - **8PSK** **(3 bit/s/Hz)**
  - **16APSK** **(4 bit/s/Hz): 4-12-APSK**
  - **32APSK** **(5 bit/s/Hz): 4-12-16 APSK**
- Gray mapping

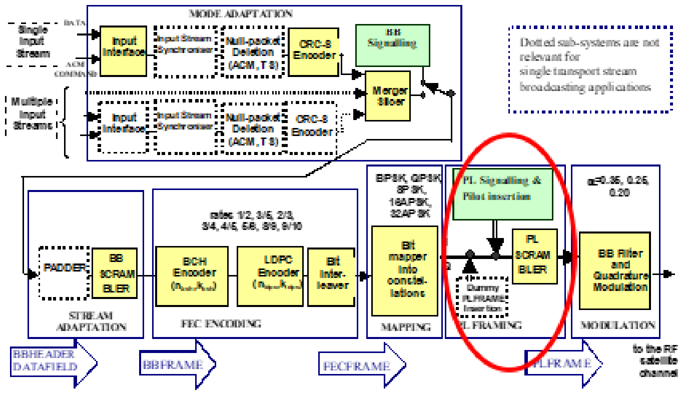


More modulation formats in DVB-S2X



PHYSICAL LAYER FRAMING

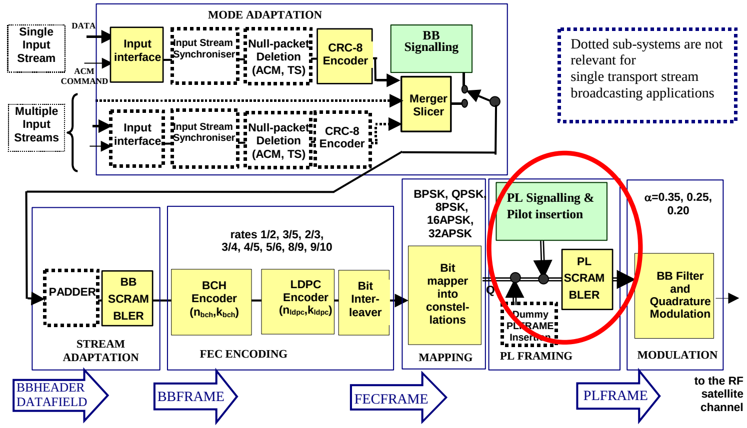
- Inclusion of physical layer signalling
- Generation of dummy PLFRAMEs
- Generation of physical layer scrambling
- Optional introduction of pilot symbols



Satellite Standards - DVB-S2: Physical Layer

Why pilot symbols?

- Phase recovery for 8PSK and higher modulation order in the presence of the specified phase noise appears impossible without pilot symbols
- Allows for frequency/phase recovery independently from the current frame physical layer configuration [ACM]
- No need for frame re-acquisition for users not able to decode the current frame (due to fading and/or bad C/I) [ACM]
- Allows for accurate data–aided channel estimation which is a must for ACM
- Solution: Optional pilot symbols at regular interval after the PLHEADER (36 pilot symbols every 1440 symbols)

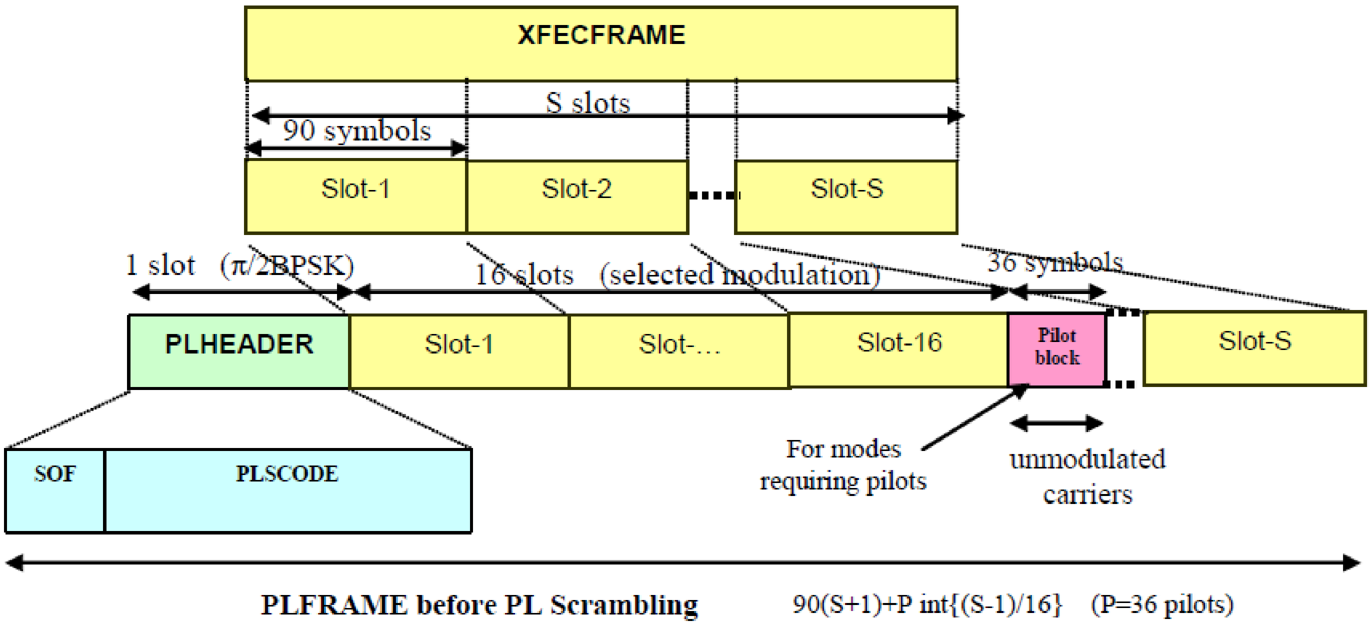


Why pilot scrambling?

- To identify the transponder
- To avoid correlated interference from other beams interference

Satellite Standards - DVB-S2: Physical Layer

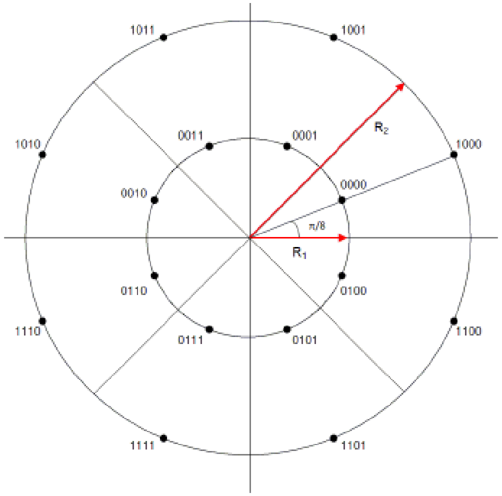
- The PL frame payload is composed of a different number of modulated symbols depending on the FEC length (64 800 or 16 200) and the modulation constellation
- Excluding the optional pilots, the payload length is always a multiple of a slot of 90 symbols
- PLFRAME periodicity can be exploited by the frame synchronizer in the receiver

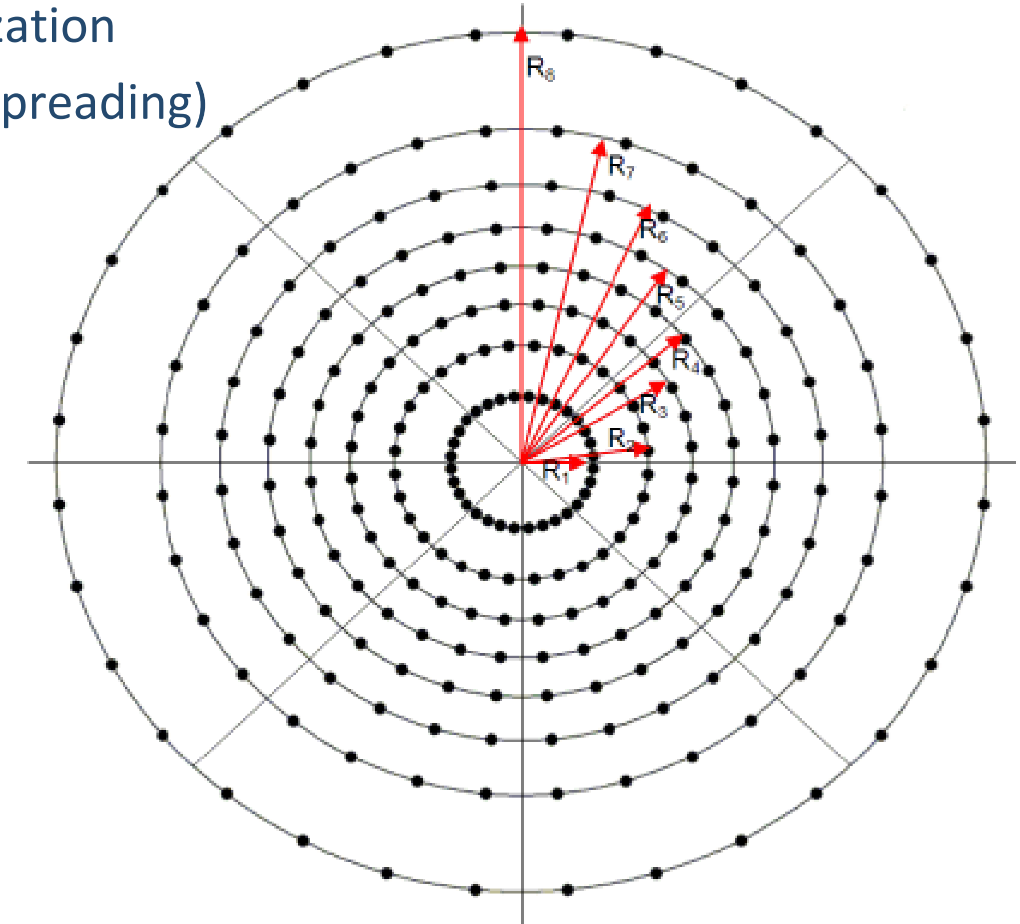


Satellite Standards - DVB-S2X: Physical Layer

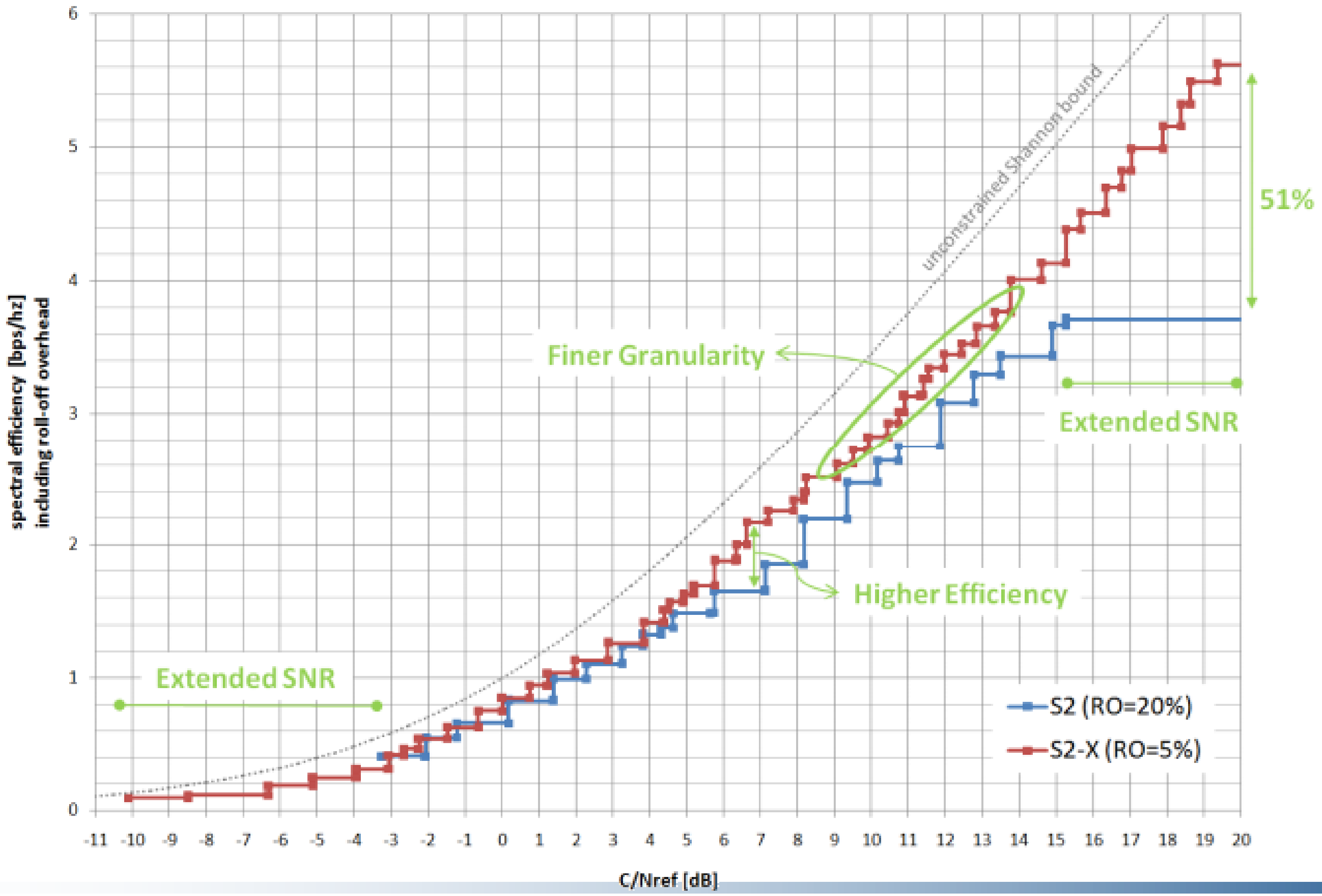
ACM

- Powerful LDPC FEC with BICM mapping onto constellations
- Joint FEC and constellation optimization
- Modulation formats from BPSK (+spreading) to 256APSK
- Extended SNR range and finer MODCODs granularity
- SRRC roll-off factor down to 0.05



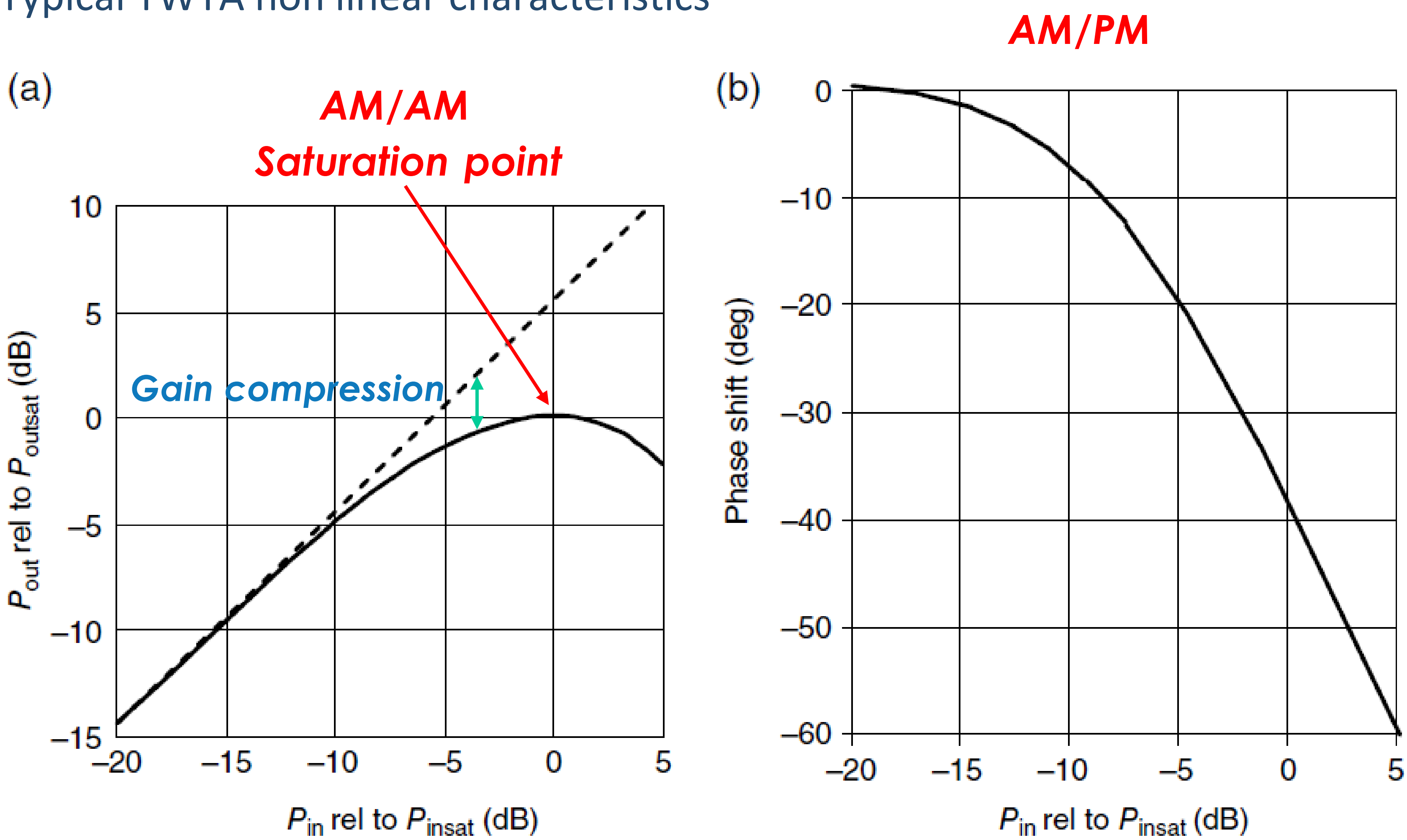


Satellite Standards - DVB-S2X: Physical Layer



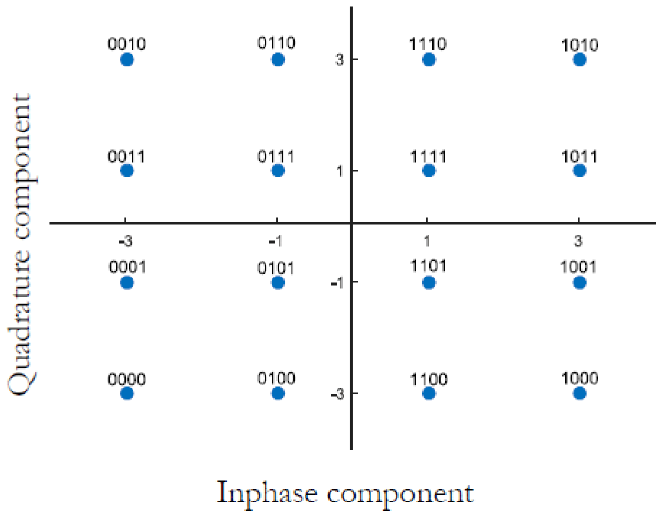
The satellite nonlinear channel challenge

- Typical TWTA non linear characteristics

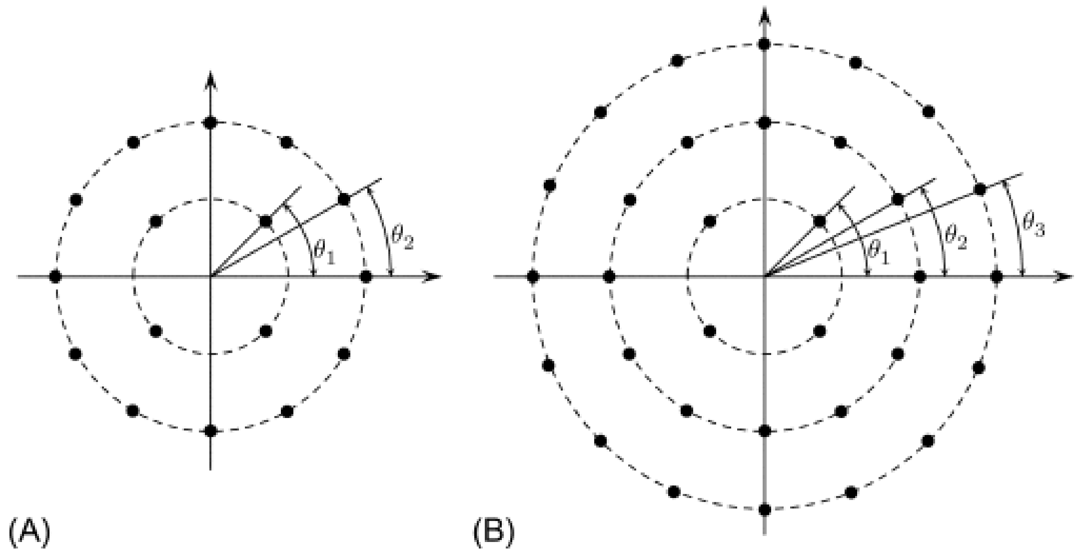


Satellite Standards - DVB-S2X: Physical Layer

- SRRC pulse shaping is causing envelope fluctuations even for QPSK, PAPR grows with higher order modulations
- APSK although not constant envelope is easier to pre-compensate than QAM: high-amplitude “corner” points are missing



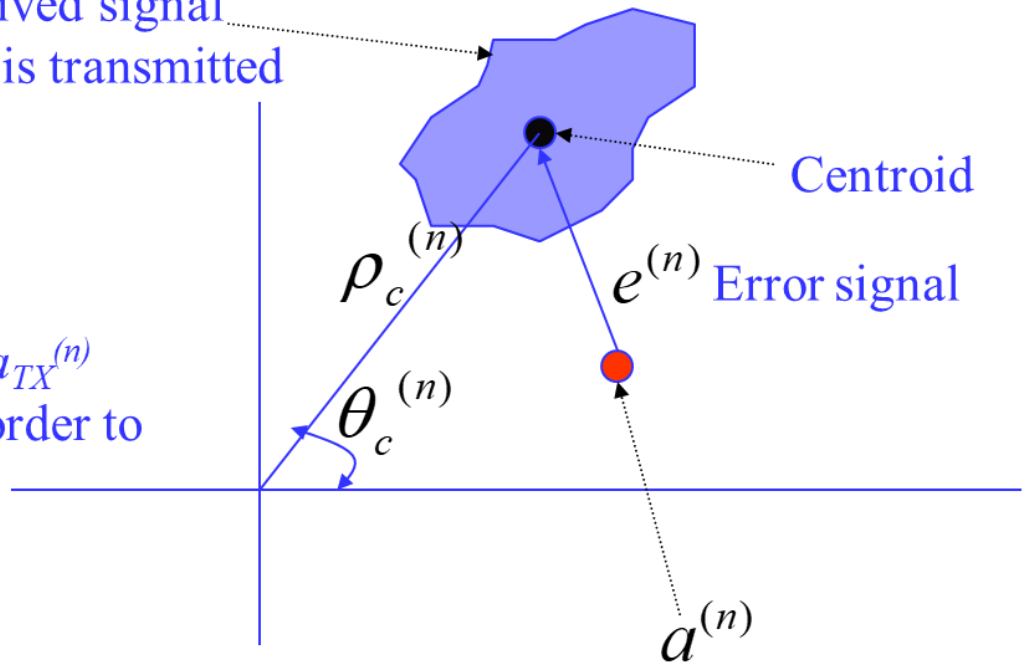
16-QAM



16-APSK

32-APSK

Static pre-distortion technique:



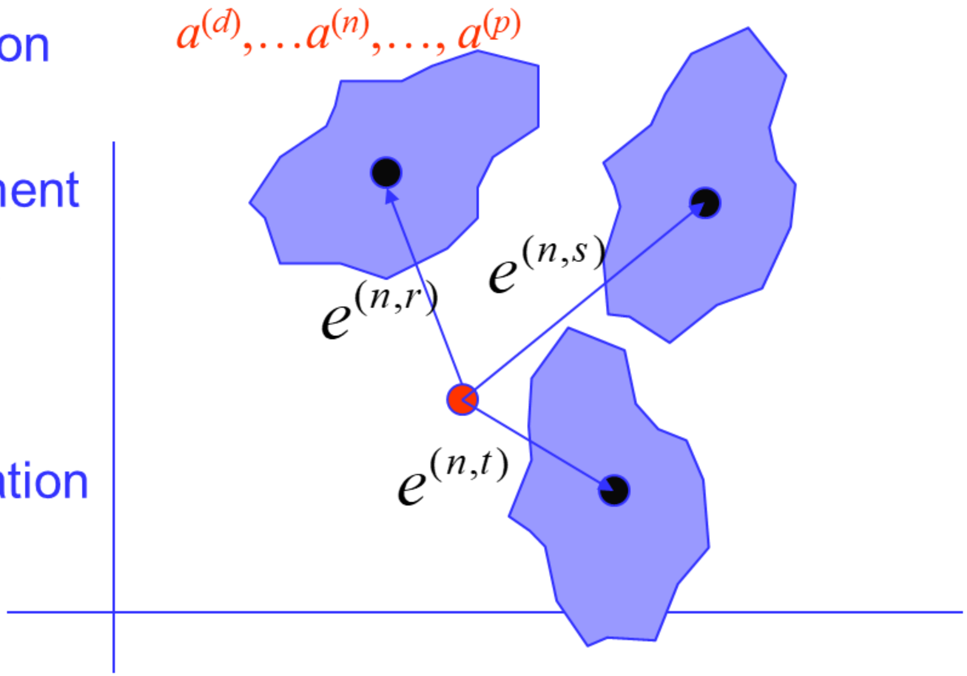
If the centroid is estimated the transmit constellation point $a_{TX}^{(n)}$ could be adjusted iteratively in order to reduce the error signal $e^{(n)}$:

$$\rho_{a_{TX}}^{(n)}(m+1) = \rho_{a_{TX}}^{(n)}(m) - \gamma_\rho \left|e^{(n)}(m)\right|$$

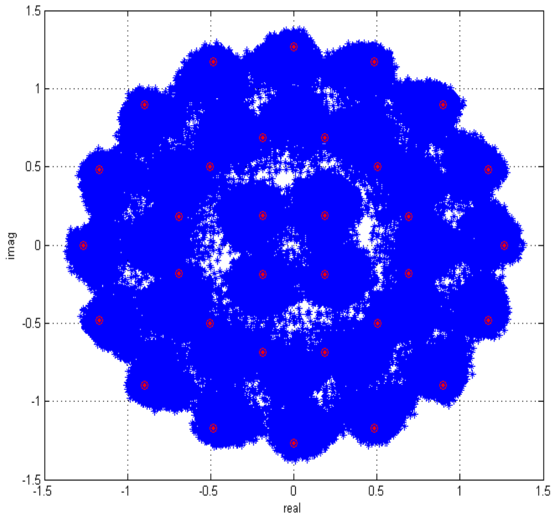
$$\theta_{a_{TX}}^{(n)}(m+1) = \theta_{a_{TX}}^{(n)}(m) - \gamma_\theta \arg\{e^{(n)}(m)\}$$

Dynamic pre-distortion technique:

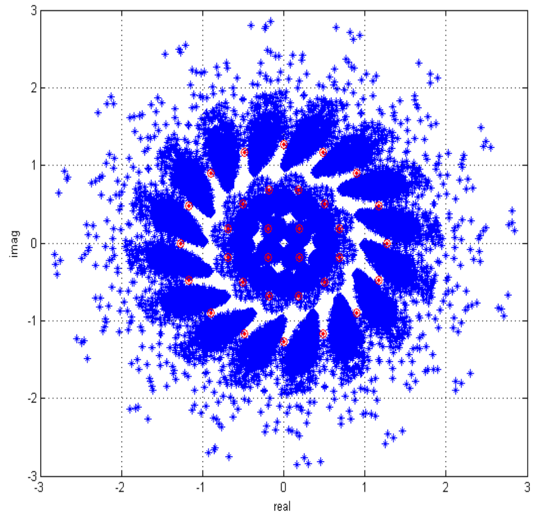
- The same technique as the static pre-distortion is applied but here the centroids are computed over clouds belonging to a given pattern of L symbols
- L is the memory of the pre-distortion technique
- The iterative constellation adjustment is performed over the $a^{(n)}$ transmit symbol, but there are in total $M^{(L-1)}$ adjustments and eventually $M^{(L-1)}$ transmit constellation points



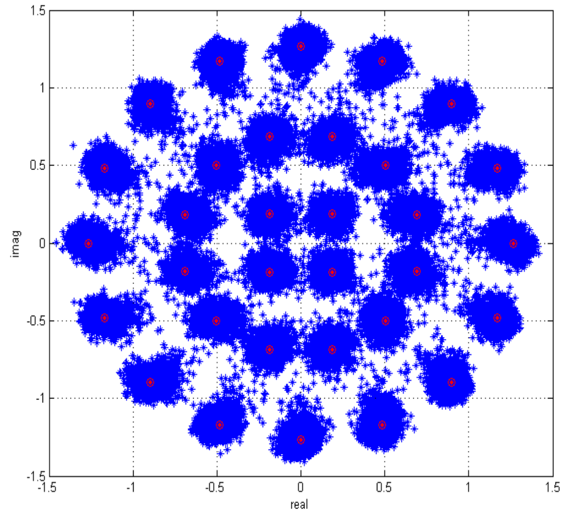
Dynamic pre-distortion technique



Received constellation without pre-distortion



Pre-distorted TX constellations

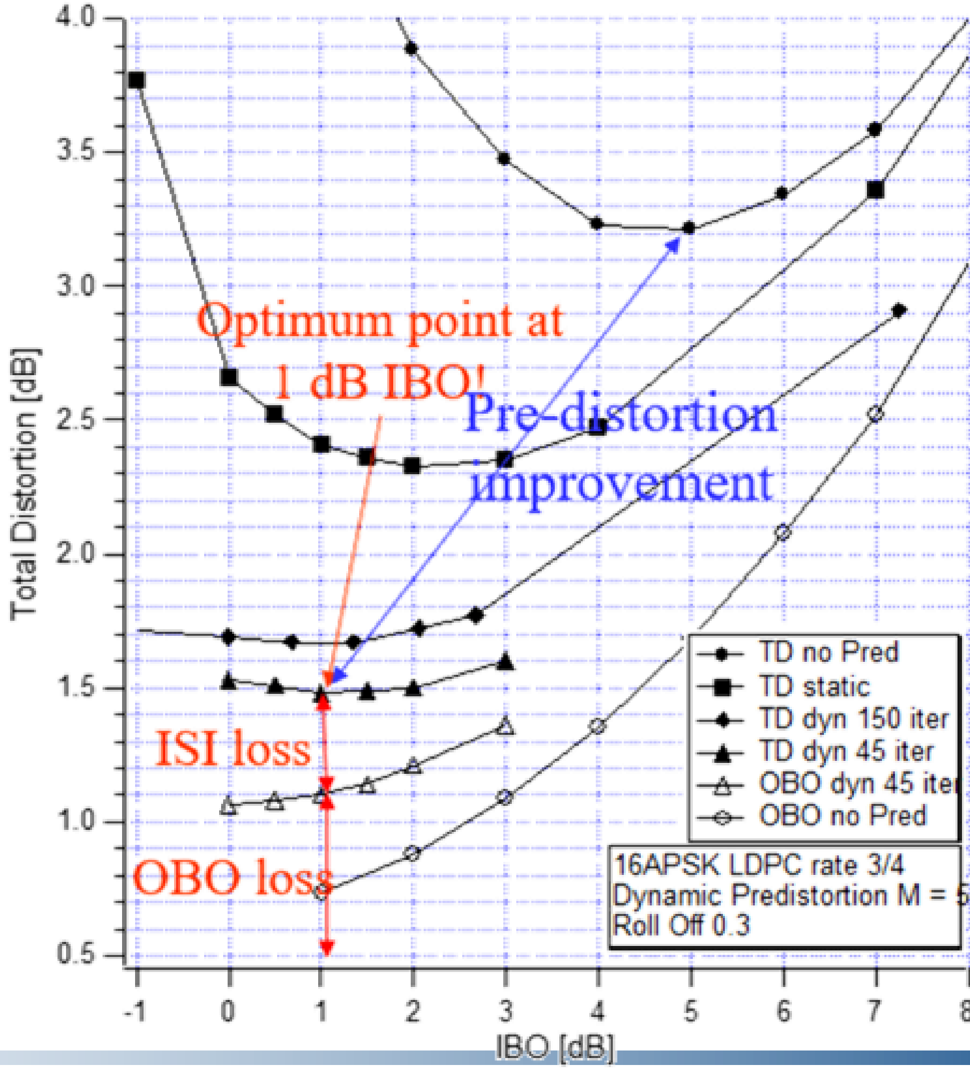


Received constellation with pre-distortion

Satellite Standards - DVB-S2X: Physical Layer

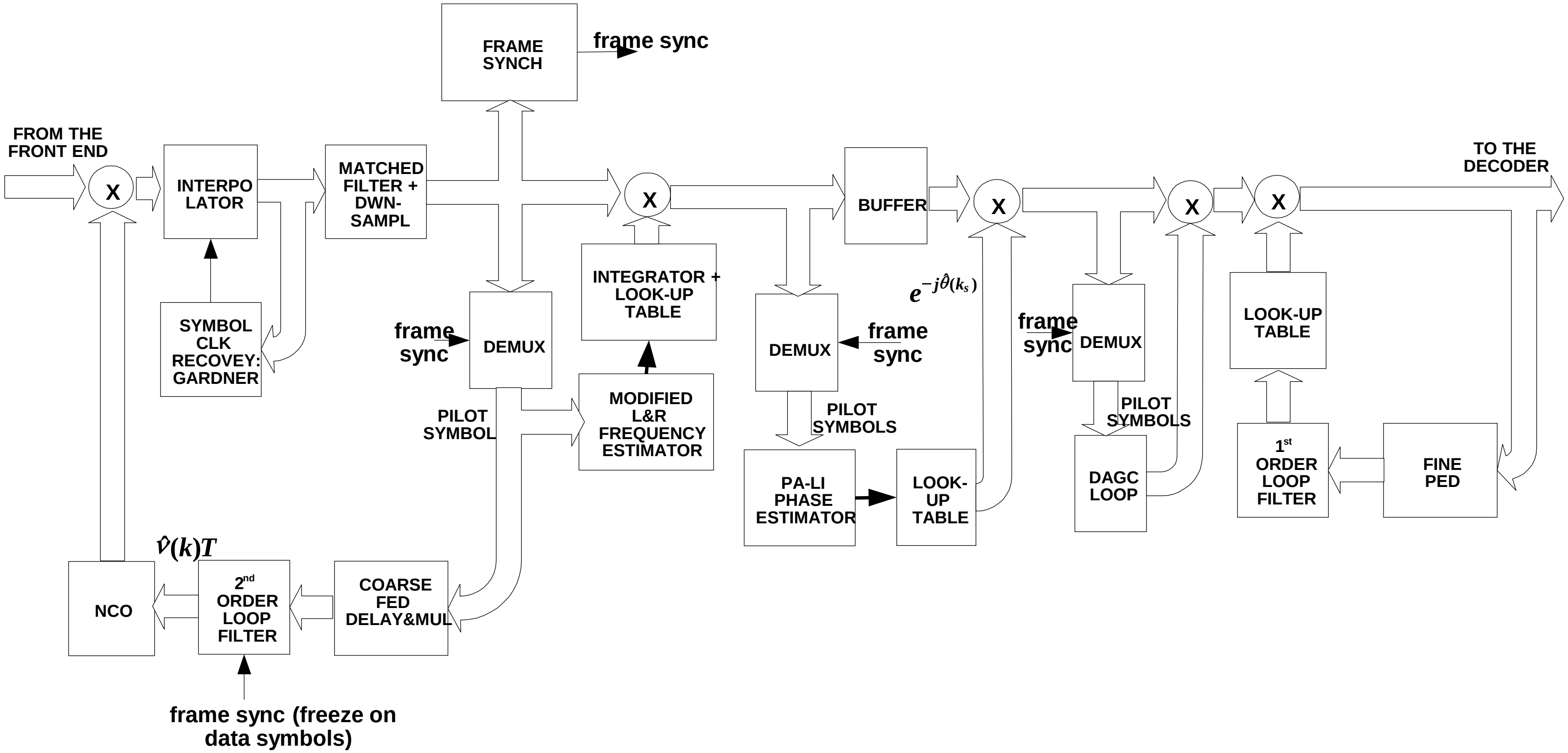
- Optimization of Total Degradation (OBO+Distortion Loss)
- Reduction of the IBO operating point
- Improvement in the HPA DC to RF conversion efficiency

$$D_{\mathrm{TOT}}(s)[\mathrm{dB}] = \left[\frac{E_s}{N_0}\right]^{\mathrm{NL}}_{\mathrm{req}}(s)[\mathrm{dB}] - \left[\frac{E_s}{N_0}\right]^{\mathrm{AWGN}}_{\mathrm{req}}(s)[\mathrm{dB}] + \mathrm{OBO}(s)[\mathrm{dB}]$$



Satellite Standards - DVB-S2X: Physical Layer

DVB-S2 demodulator block diagram



Satellite Standards - DVB-S2X: Physical Layer

DVB-S2 mass-market chipset

STV6110A

8PSK/QPSK low-power 3.3 V satellite tuner IC

Data Brief

Features

- RF to baseband 8PSK/QPSK direct conversion
- Single 3.3 V DC supply
- Input frequency range 950 MHz to 2150 MHz
- Supports 1 to 45 Msymbol/s
- On-chip RF loop-through
- Fully integrated PLL frequency synthesizer for DVB-S2 (including loop filter)
- Extremely low phase noise compliant with DVB-S2 requirements
- Low external component count
- Low power consumption
- Flexible crystal frequency output to drive the demodulator IC
- Continuously variable gain: 0 to 65 dB
- Additional and programmable gain on baseband amplifier: 0 to 16 dB
- Programmable 5- to 36-MHz cut-off frequency (butterworth 5th-order baseband filters)
- Compatible with 5-V and 3.3 V I^2C bus

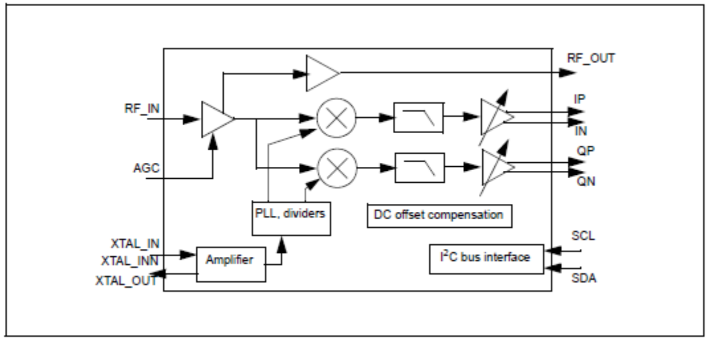
Description

The STV6110A satellite tuner is a direct-conversion (zero IF) receiver dedicated to digital TV broadcasting.

On the RF input is a low noise amplifier (LNA), with buffer to supply the RF output for loop-through, and a continuously variable gain LNA to ensure an optimal signal level for the two mixers. Each mixer, which down-converts the signal to baseband, is followed by a low-pass filter and amplifier. The baseband gain can be varied by programming a register via the I^2C bus.

The LO signals are provided by an integrated PLL which contains an on-chip voltage controlled oscillator (VCO) meeting stringent phase noise requirements. The PLL loop filter is integrated. The LO frequencies are programmable.

The comparison frequency for the phase-frequency detector (PFD) is generated by dividing the crystal oscillator reference frequency. The crystal frequency can be from 16 MHz to 32 MHz depending on application.



STV0910

Multi-standard advanced dual demodulator for satellite digital TV broadcast set-top boxes

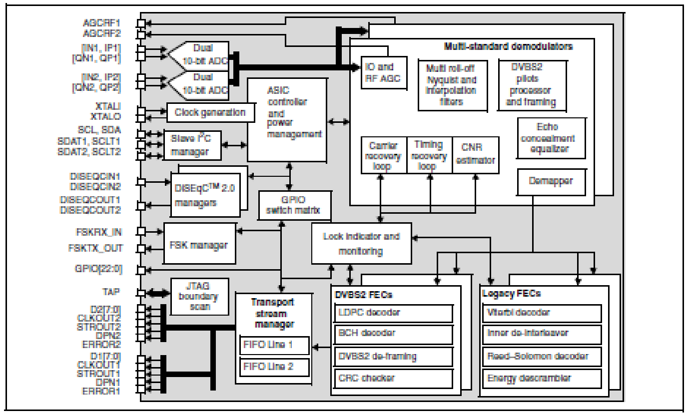
Data brief

Features

- Dual multi-standard demodulation for broadcast applications
  - DVBS2 QPSK, 8PSK, CCM, VCM
  - Legacy DVBS and DirecTV™ QPSK with SuperFEC™ for enhanced reception
  - Multi-tap equalizer for RF reflection removal
  - Wide range carrier frequency tracking loop for offset recovery
- Advanced version for DVBS2 16APSK, 32APSK, low QPSK code rates and ACM
- Dual multi-standard decoding
  - DVBS2 FEC and framing
  - Up to 270 Mbit/s channel bit rate
  - DVBS or DirecTV™ legacy
- Interfaces
  - Dual data to MPEG decoder
  - DVB common interface compliant
  - I^2C serial bus interface, including two private repeaters for tuners
  - JTAG interface for boundary scan
  - 2 DiSEqC 2.x 22-kHz interfaces
  - FSK interface
  - Flexible GPIOs and interrupts
  - Bit error rate monitoring and reporting
- Technology
  - Multi supply: 1.1-V core, 2.5-V analog, 3.3-V digital interfaces
  - Fine-grained power management
  - LFBGA-168 12x12 mm^2 package, RoHS

Description

The STV0910 is a cost effective, high-performance dual demodulator/decoder for advanced DVB satellite reception.



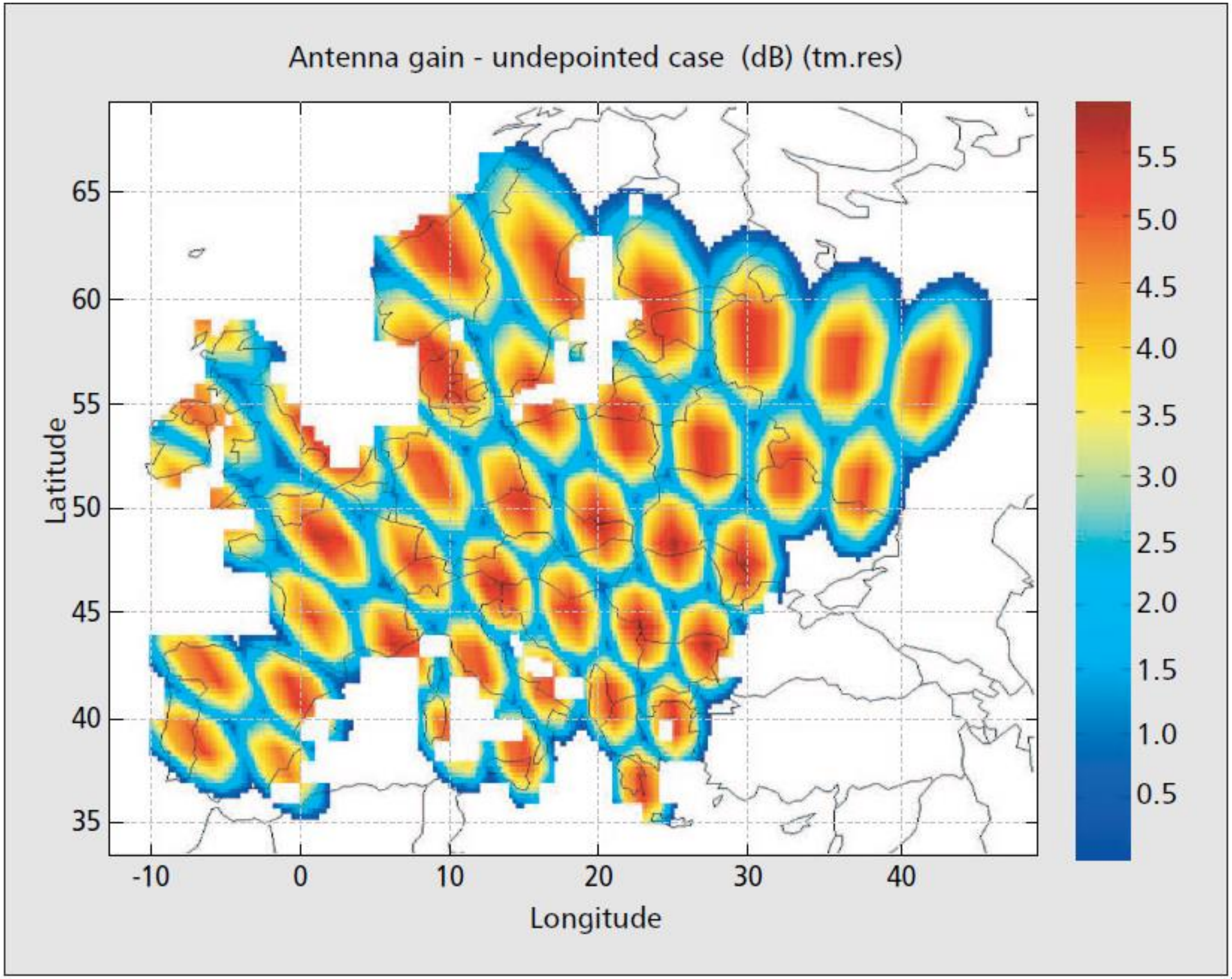
December 2012 Doc ID 024009 Rev 1 1/4

For further information contact your local STMicroelectronics sales office. www.st.com

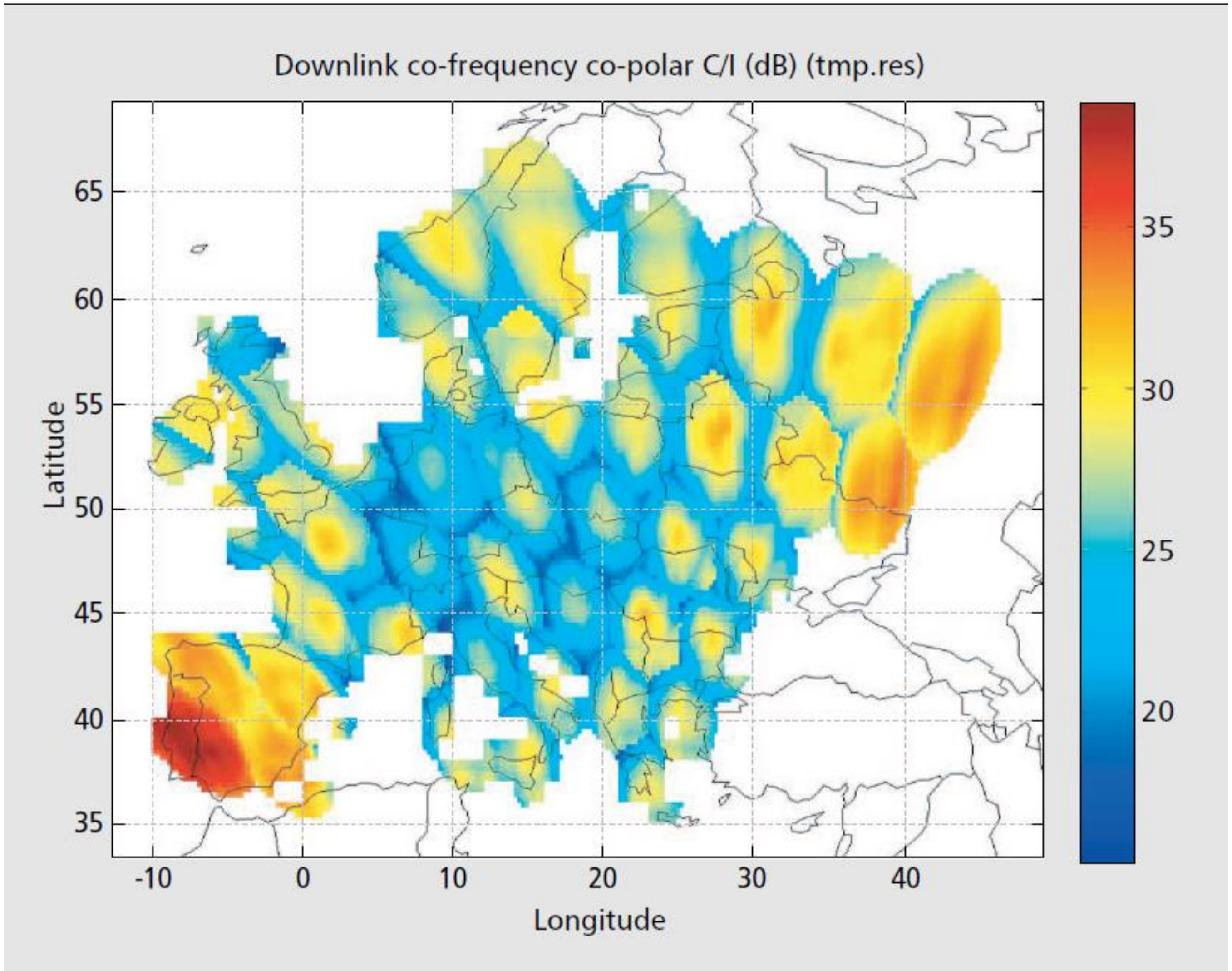
Why Adaptive Coding and Modulation in Satellite Broadband Networks?

- Broadband applications are one-to-one service (not one-to-many as broadcasting)
- The user SNIR (FWD example) is dependent on the satellite antenna gain and path losses (location dependent), the atmospheric losses (weather thus time dependent) and the co-channel and adjacent channel interference
- The physical layer configuration (MODCOD = FEC code rate and modulation) can be locally optimized to get the maximum throughput for each user considering the current SNIR

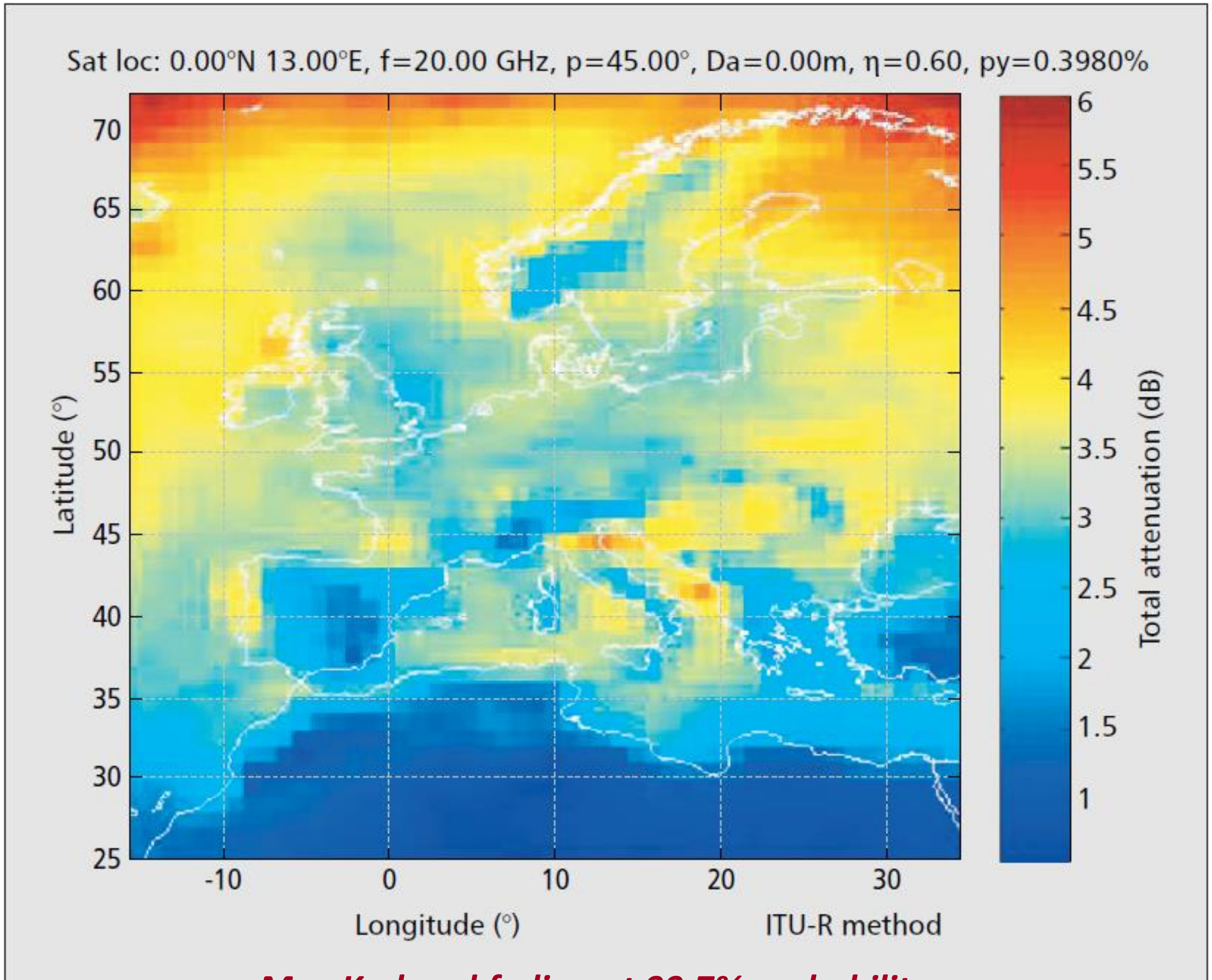
Satellite Standards - DVB-S2X: Physical Layer



Satellite Standards - DVB-S2X: Physical Layer



Satellite Standards - DVB-S2X: Physical Layer

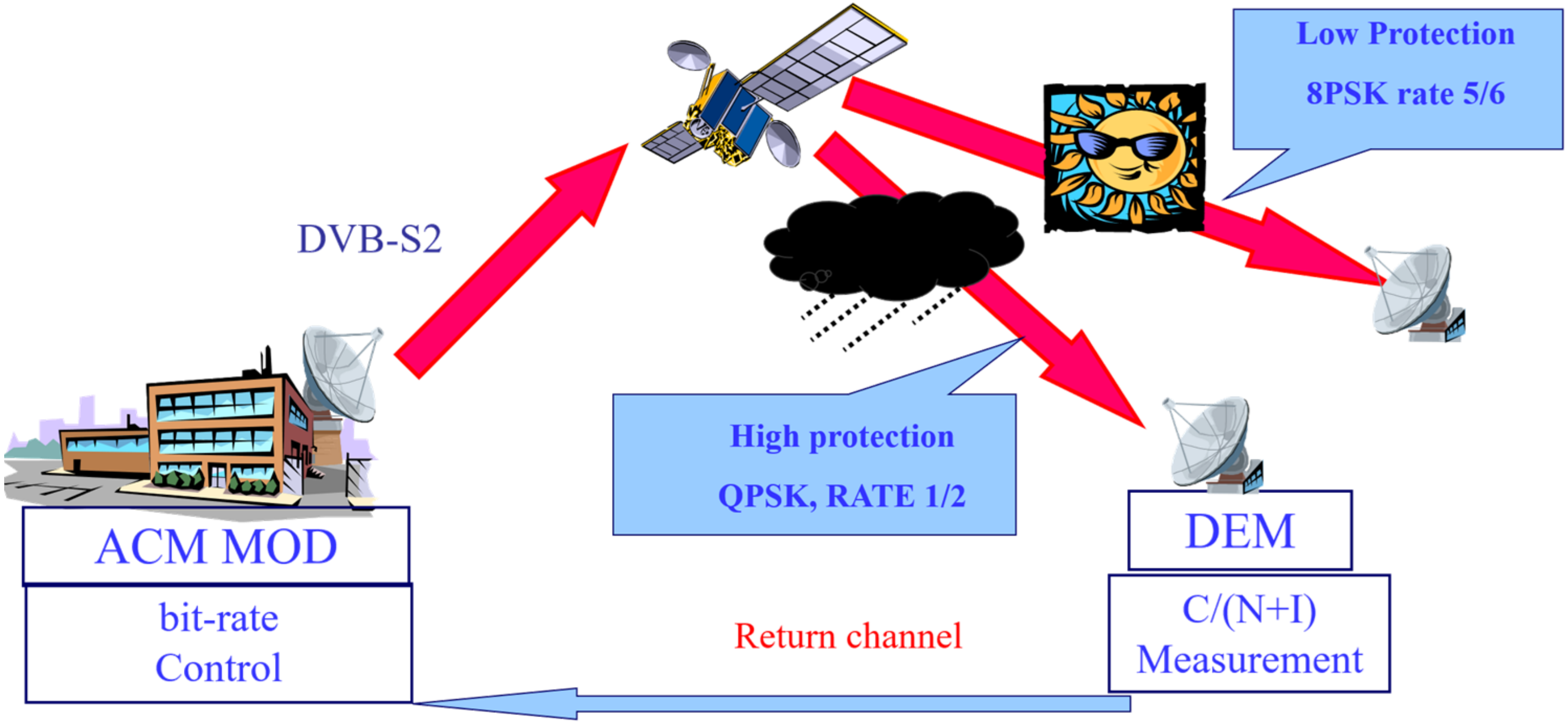


Max Ka-band fading at 99.7% probability

Satellite Standards - DVB-S2X: Physical Layer

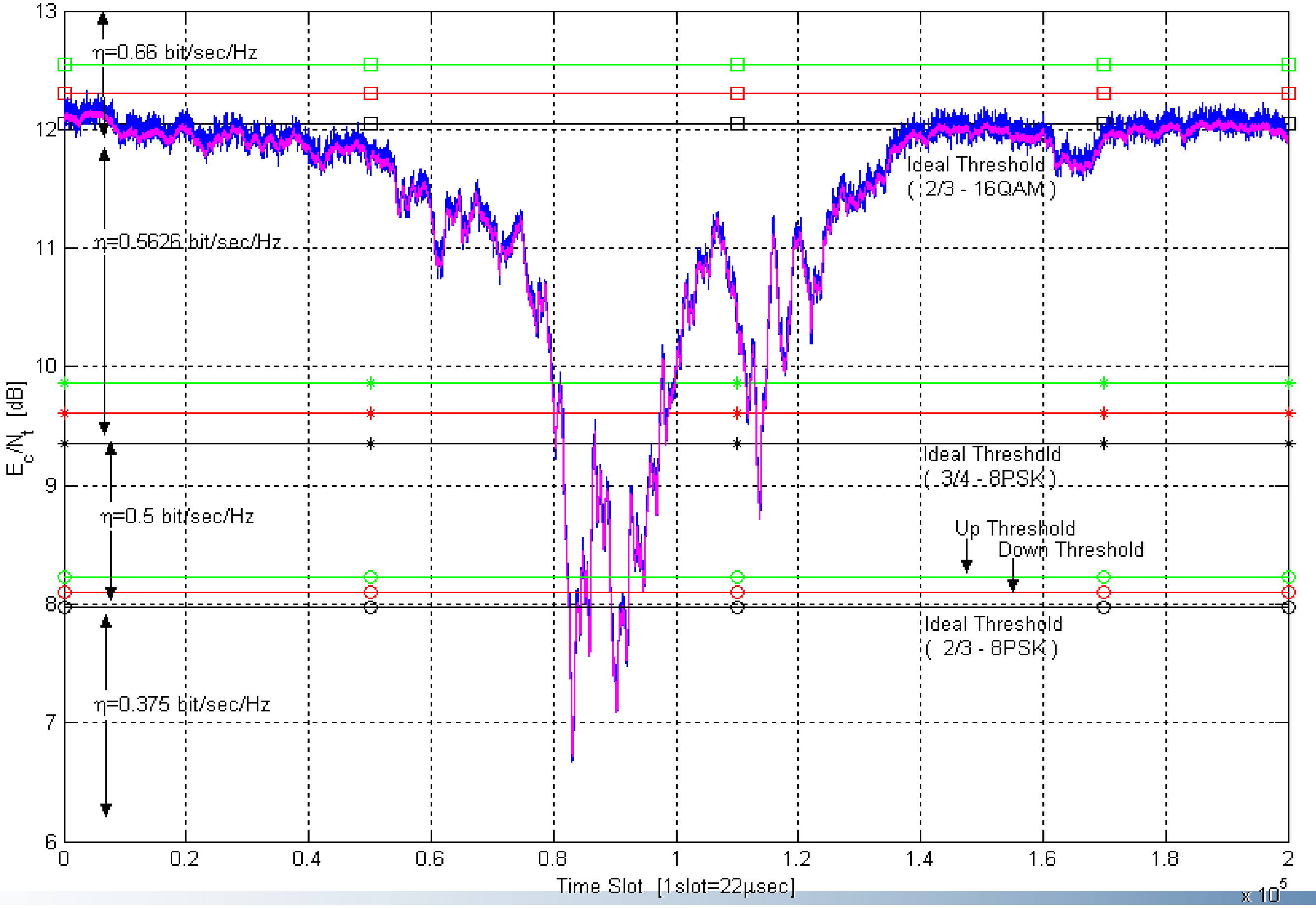
How does ACM work in DVB-S2(X)?

- Quasi-real-time adaptation based on the C/(N+I) estimation at the user terminal
- Minimization of link margins required for a given link availability
- User throughput reduction (instantaneous bit rate) can be compensated by RRM



Satellite Standards - DVB-S2X: Physical Layer

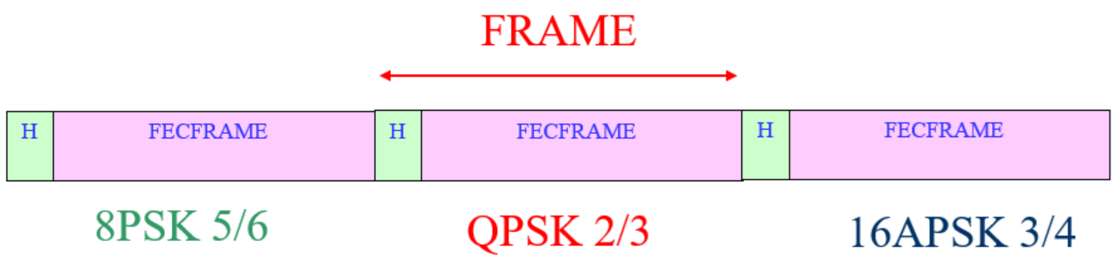
- ACM based on real-time SNIR estimate by each user terminal
- Hysteresis required to avoid MODCODs ping-pong effects



Dip. Ingegneria dell'Informazione
University of Pisa, Italy

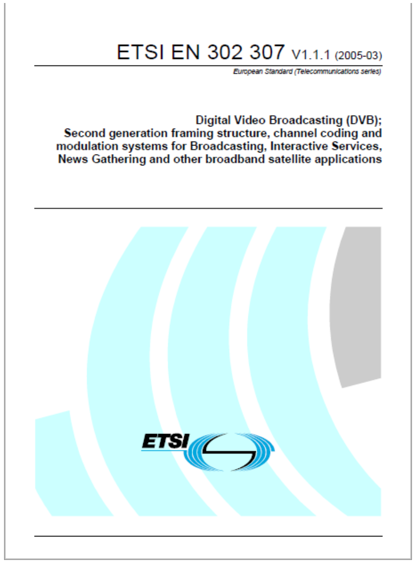
RESULTS

- Ka-band multibeam forward link example using DVB-S2 and ACM
- The majority of users are adopting 8PSK or 16APSK depending on their location and/or channel conditions
- More protected MODCODs (QPSK) used with limited probability
- The impact on the throughput corresponds to **190% increase** compared to a classical CCM approach!
- The TDM frame allows to mix different MODCODs on the same carrier



- Deep fading is rare and limited in the coverage area => negligible impact on the system throughput!

DVB-S2 in the Commercial Market



ETSI EN 302 307 V1.1.1 (2005-03)
European Standard (Telecommunications series)

Digital Video Broadcasting (DVB);
Second generation framing structure, channel coding and modulation systems for Broadcasting, Interactive Services, News Gathering and other broadband satellite applications

ETSI