DVB S2

Incospec Seminar

2010-03-09 in Montreal, QC
2010-03-11 in Toronto, ON

Waylon Sun

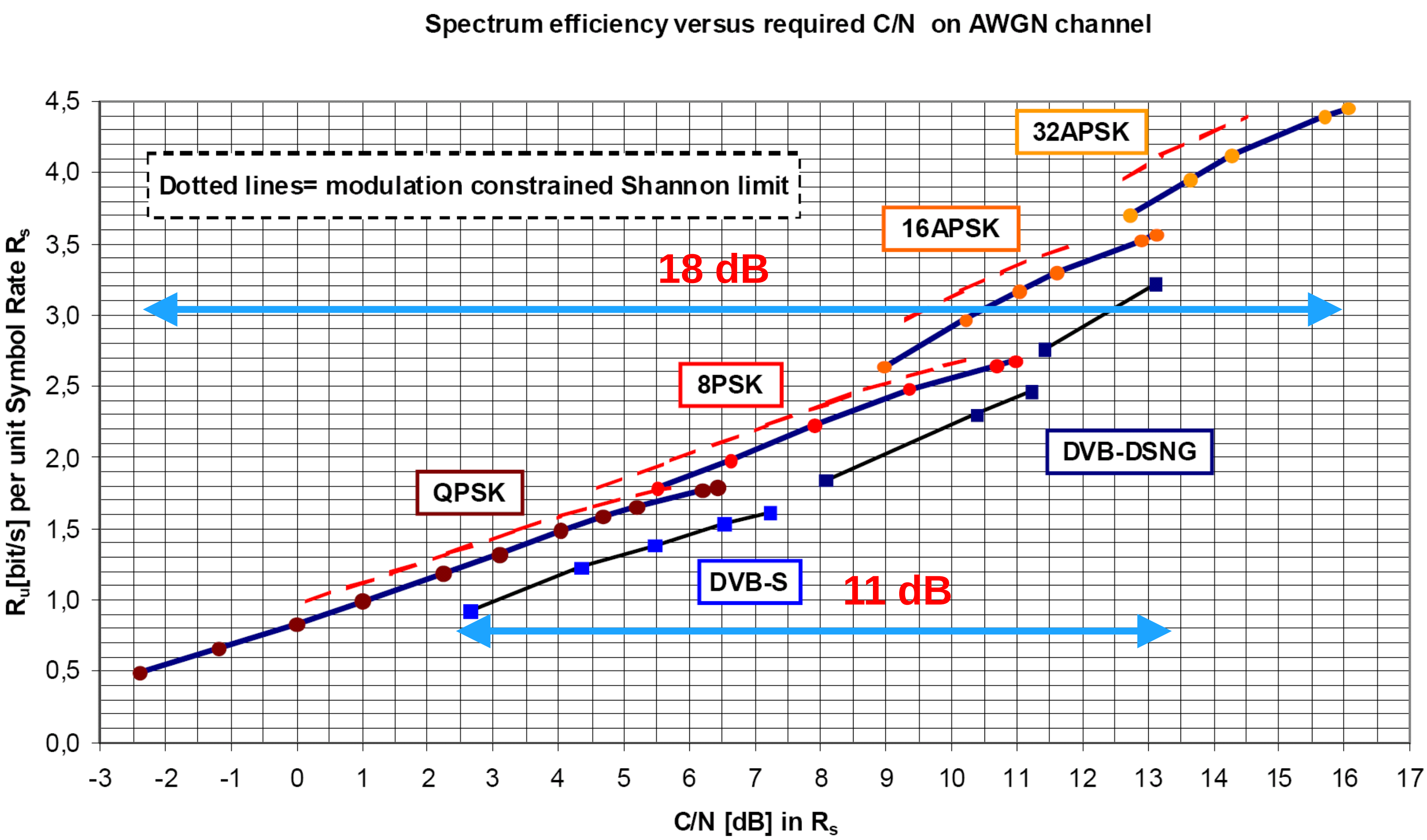
- Broadband Systems
- Professional Equipment
- IP Software

Newtec
SHAPING THE FUTURE OF SATELLITE COMMUNICATIONS

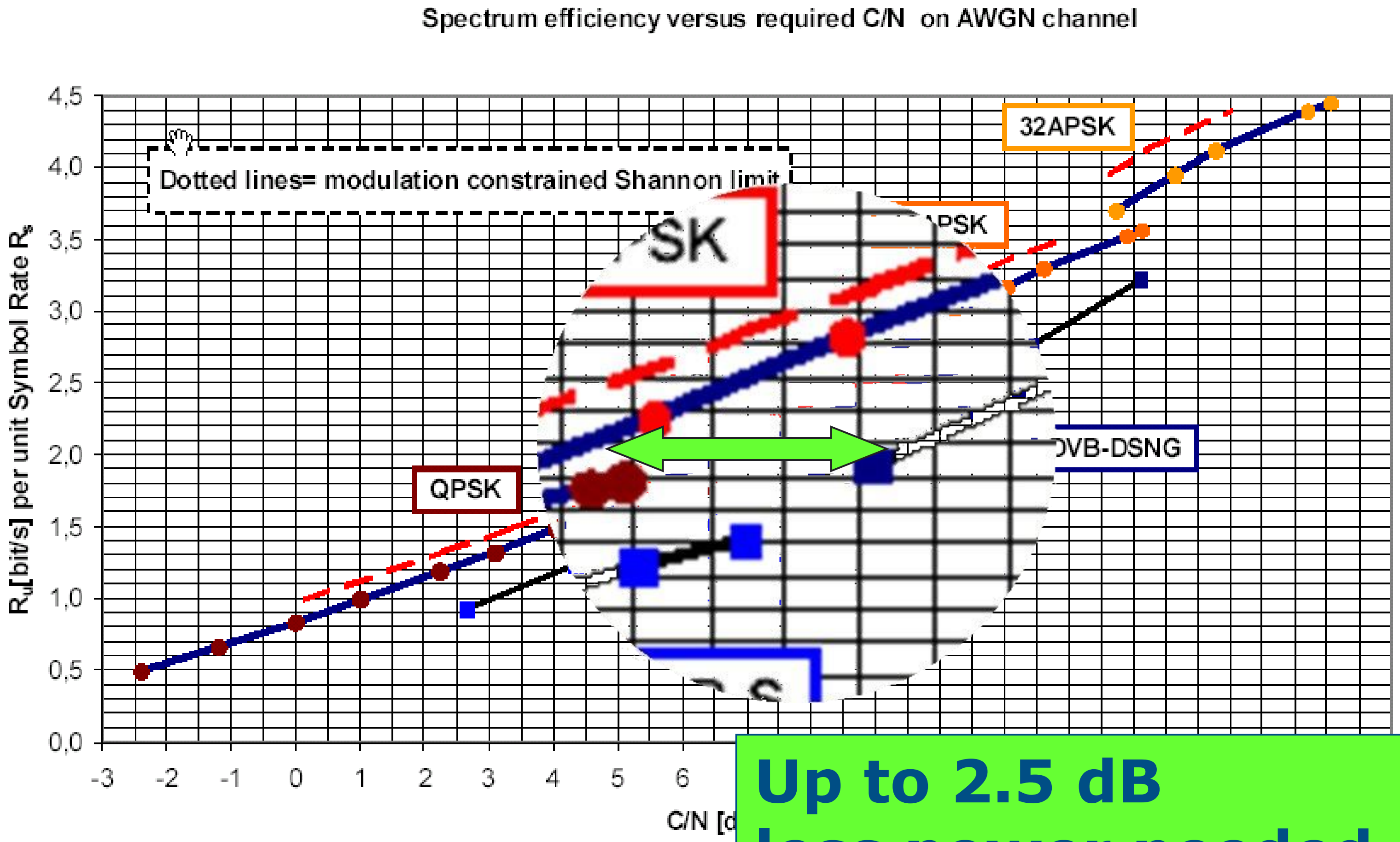
What is DVB-S2

- The second generation DVB standard for digital transmission over satellite to replace DVB-S & DVB-DSNG
- Second generation **framing structure, channel coding and modulation systems** for Broadcasting, Interactive Services, News Gathering and other broadband satellite applications
- Draft released in 2004-01
- EN302307v1.1.1 in 2005-03
- EN302307v1.1.2 in 2006-06
- EN302307v1.2.1 in 2009-08

DVB-S2 Efficiency Compared to DVB-S/DSNG

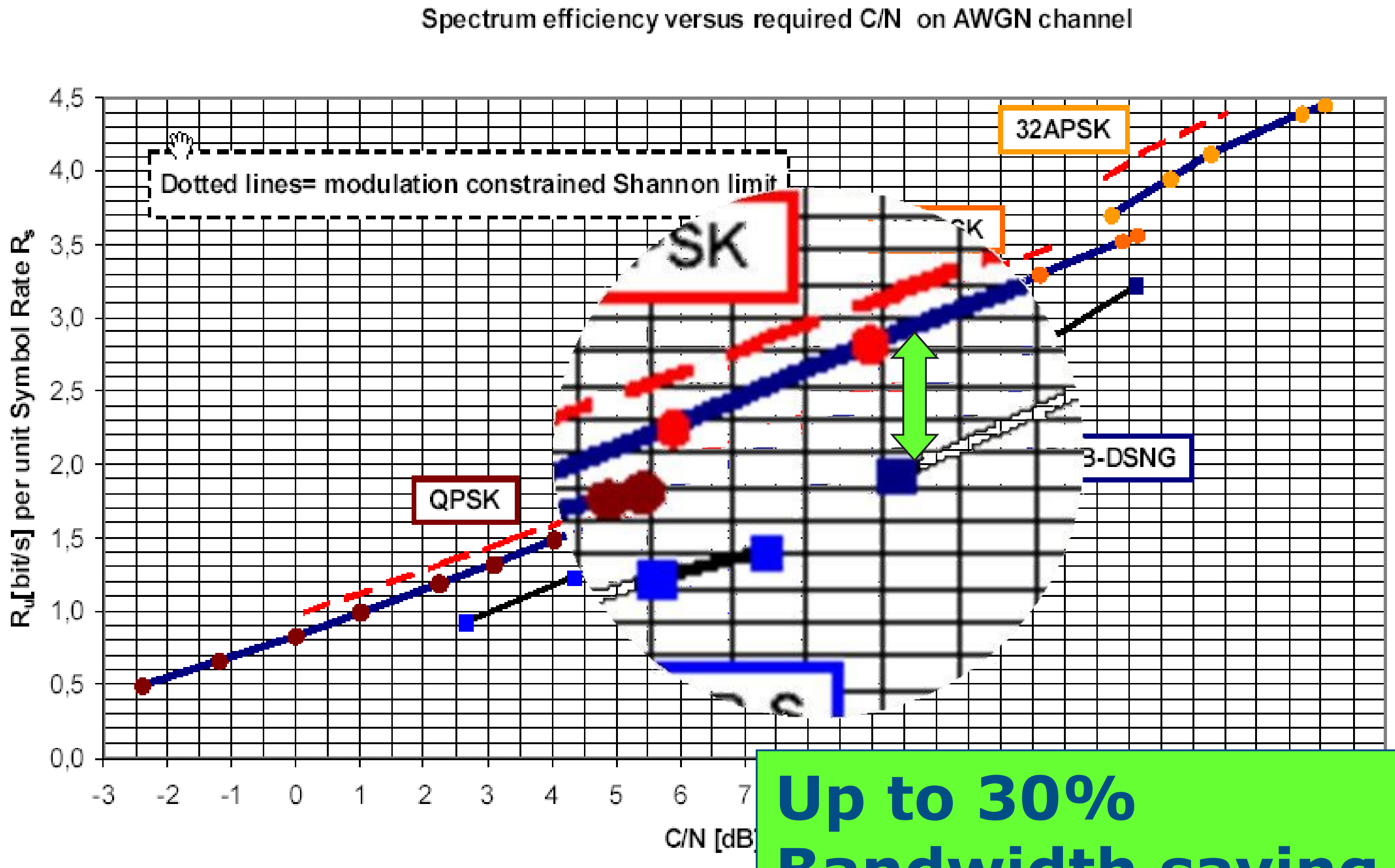


DVB-S2 Outperforming DVB-S



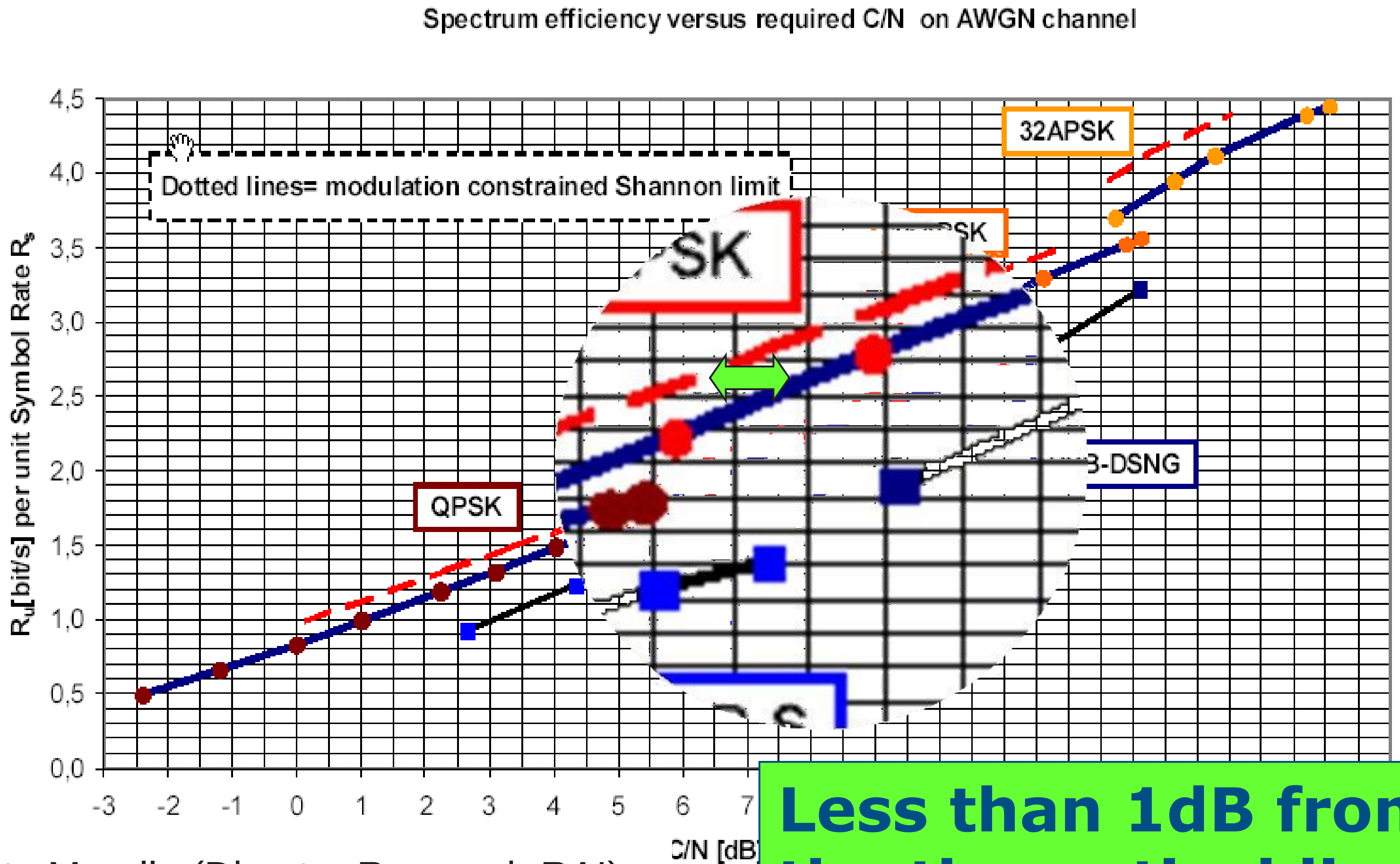
Up to 2.5 dB less power needed

DVB-S2 Outperforming DVB-S



Up to 30% Bandwidth saving

DVB-S2 Outperforming DVB-S



Less than 1dB from the theoretical limit

Alberto Morello (Director Research RAI):
"***DVB-S2 is the last standard***"

The Gain of DVB-S2

- Much better spectral efficiency than DVB-S
  - Up to 40% bandwidth saving (30% from better coding and 10% from smaller roll-off factor) or up to 2.5 dB margin gain
  - Less than 1 dB away from the Shannon limit
- New modulation schemes (16APSK and 32APSK)
- More roll-off factors (20, 25 and 35%)
- New features
  - Support of multiple streams on a single carrier
  - Introduction of variable and adaptive coding and modulation
  - Introduction of generic mode input

The Gain of DVB-S2

- New Forward Error Correction codes
  - LDPC (Low Density Parity Check) replaces Viterbi inner coding
  - BCH (Bose-Chaudhuri-Hocquenghem) replaces Reed Solomon outer coding
  - LDPC codes have resulted in FEC solutions that perform even closer to the Shannon Limit
  - LDPC was invented in 1962 by Dr. Gallager and rediscovered in mid-1990s when working with TCC (Turbo Convolutional Code).
  - Actual implementation of LDPC only became possible with ASIC technology (chip area $<10mm^2$ and $\pm0.09mm$ high precision)

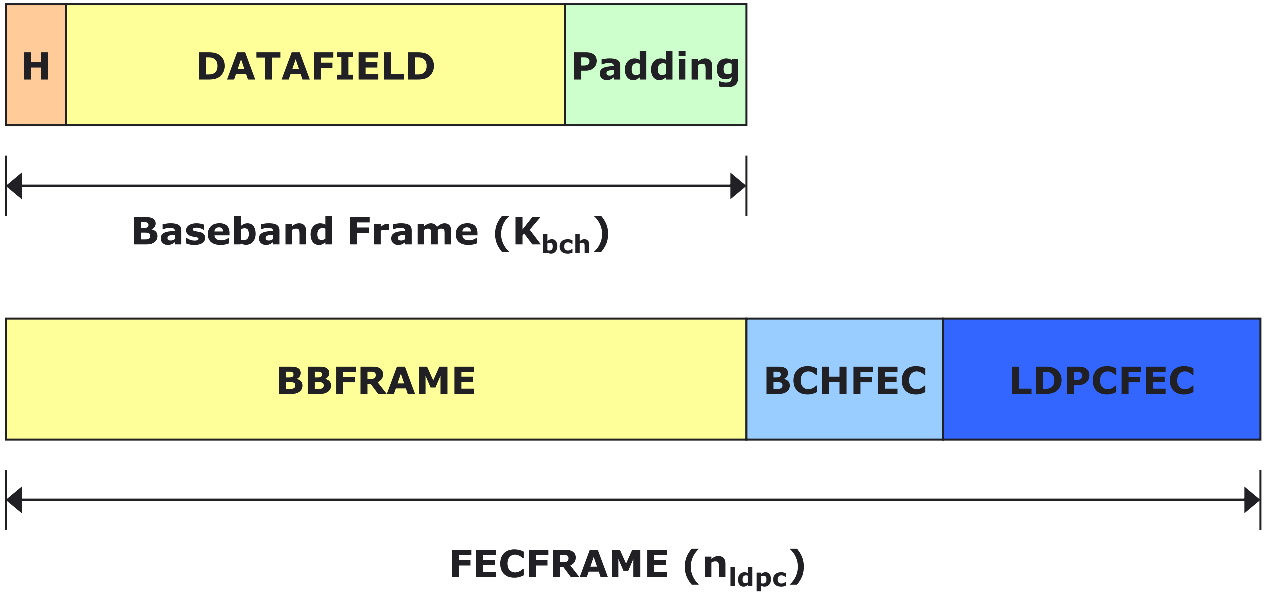
The Gain of DVB-S2

- LDPC uses very big block size (16200 and 64800 bits)
  - less fragmentation and then less overhead
  - large frame size means more delay
  - Short frames is less performing than Normal frames (about 0.3 dB) but with 1/4 of the delay
- More inner code rates: 1/4, 1/3, 2/5, 1/2, 3/5, 2/3, 3/4, 4/5, 5/6, 8/9, 9/10
- APSK allows satellite link operation closer to saturation of the transponder. This is much better than QAM.

DVB-S2 vs. DVB-S

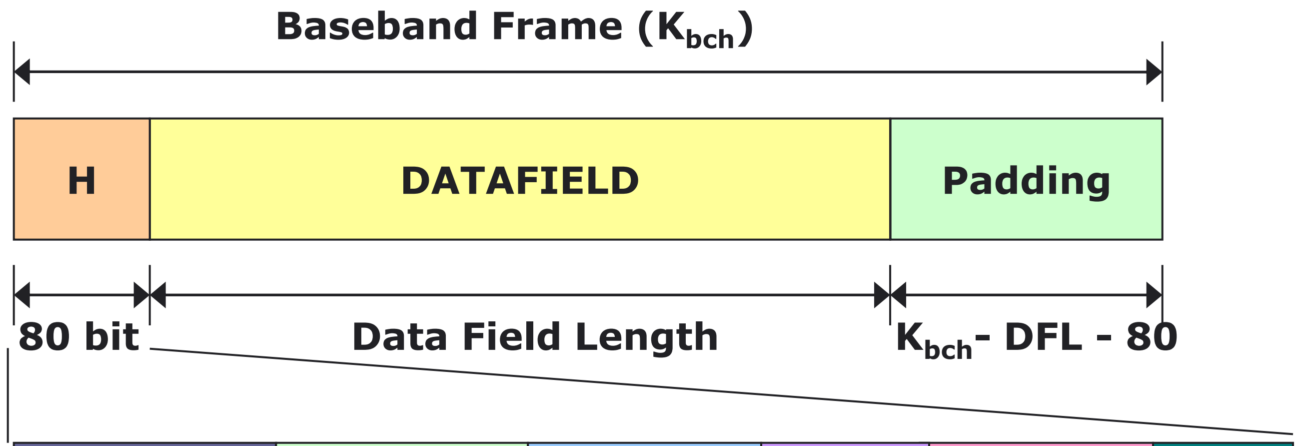
DVB-S	*DVB-S2*
QPSK/8PSK/16QAM	QPSK/8PSK/16APSK/32APSK
ROF: 0,25% & 0,35 %	ROF: 0,20 ; 0,25 ; 0,35 %
Optimized for TS : 188 byte	Generic data format: BB frames (16k or 64k bit)
One single TS / carrier	Multiple streams / carrier
Viterbi & Reed Solomon	LDPC & BCH
Fixed modulation & modcod	CCM / VCM / ACM

Baseband Frame/FECFRAME



- FECFRAME have a fixed length
  - Normal FECFRAME: 64800 bits
  - Short FECFRAME: 16200 bits
- Baseband Frame: Variable length, depening on the FEC

Baseband Frame



MATYPE	UPL	DFL	SYNC	SYNCD	CRC8
MATYPE 1 -TS/GS -SIS/MIS -CCM/ACM -ISSYI -NPD -RO MATYPE 2 -ISI (MIS) -Reserved (SIS)	User Packet Length -Continuous (0x0000) -Packetized (length in bits)	Data Field Length	User Packet Sync byte	Distance to first user packet. Continuous generic streams: 0000	CRC on first 9 bytes of BBH

Mode Adaption Type

Table 3: MATYPE-1 field mapping

TS/GS	SIS/MIS	CCM/ACM	ISSYI	NPD	RO
11 = Transport 00 = Generic Packetized 01 = Generic continuous 10 = reserved	1 = single 0 = multiple	1 = CCM 0 = ACM	1 = active 0 = not-active	1 = active 0 = not-active	00 = 0,35 01 = 0,25 10 = 0,20 11 = reserved

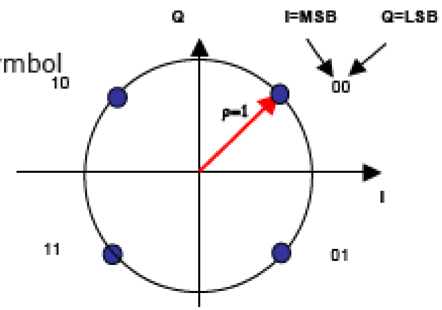
Table 4: BBHeader (Mode Adaptation characteristics) and Slicing Policy for Single Transport Stream Broadcast services

Application area/configuration	MATYPE-1	MATYPE-2	UPL	DFL	SYNC	SYNCD	CRC-8	Slicing policy
Broadcasting services / CCM, single TS	11-1-1-0-0-Y	XXXXXXXX	$188_D x8$	K_{bch} -80_D	47_{HEX}	Y	Y	Break No timeout No Padding No Dummy frame
X= not defined; Y = according to configuration/computation. Break = break packets in subsequent DATAFIELDs; Timeout: maximum delay in merger/slicer buffer.								

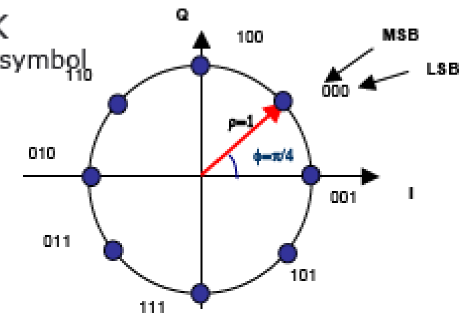
Bit Mapping into Constellation

4 TWTA-friendly modulation schemes:

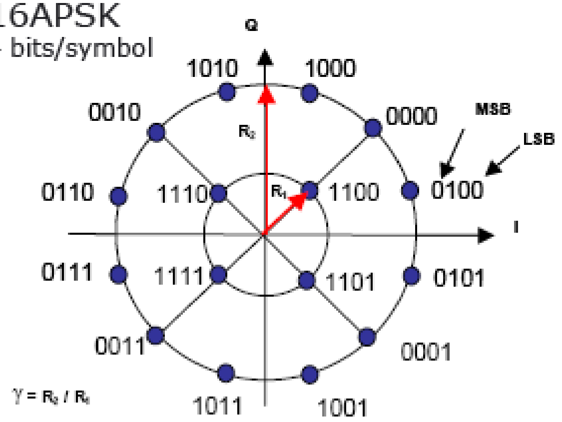
QPSK
2 bits/symbol



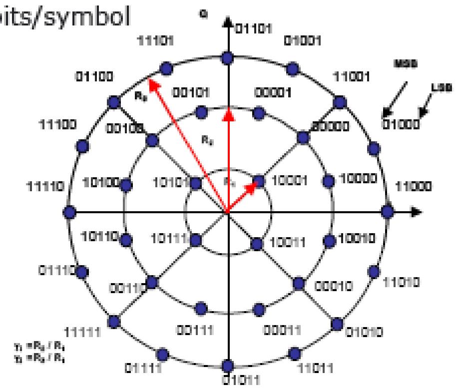
8PSK
3 bits/symbol



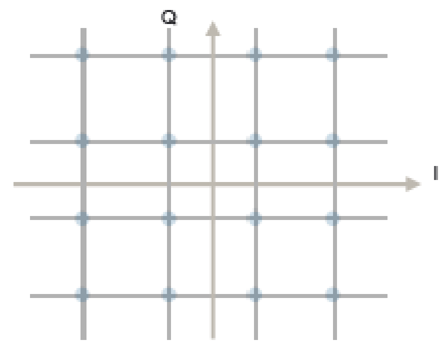
16APSK
4 bits/symbol



32APSK
5 bits/symbol



~~16QAM~~



TWTA Friendly Modulation Schemes

- 16QAM in DVB has limited use in operation
  - High carrier to noise levels required
  - High demands on linearity: large back-off, huge HPAs and antenna sizes
  - High demands on phase noise
- 16APSK in DVB-S2 is fully enabled
  - Lower carrier to noise levels required
  - Easier to decode by demodulator due to less different amplitude and phase levels
  - More resistant to phase noise
  - Availability of pilot

XFECFRAME/PLFRAME

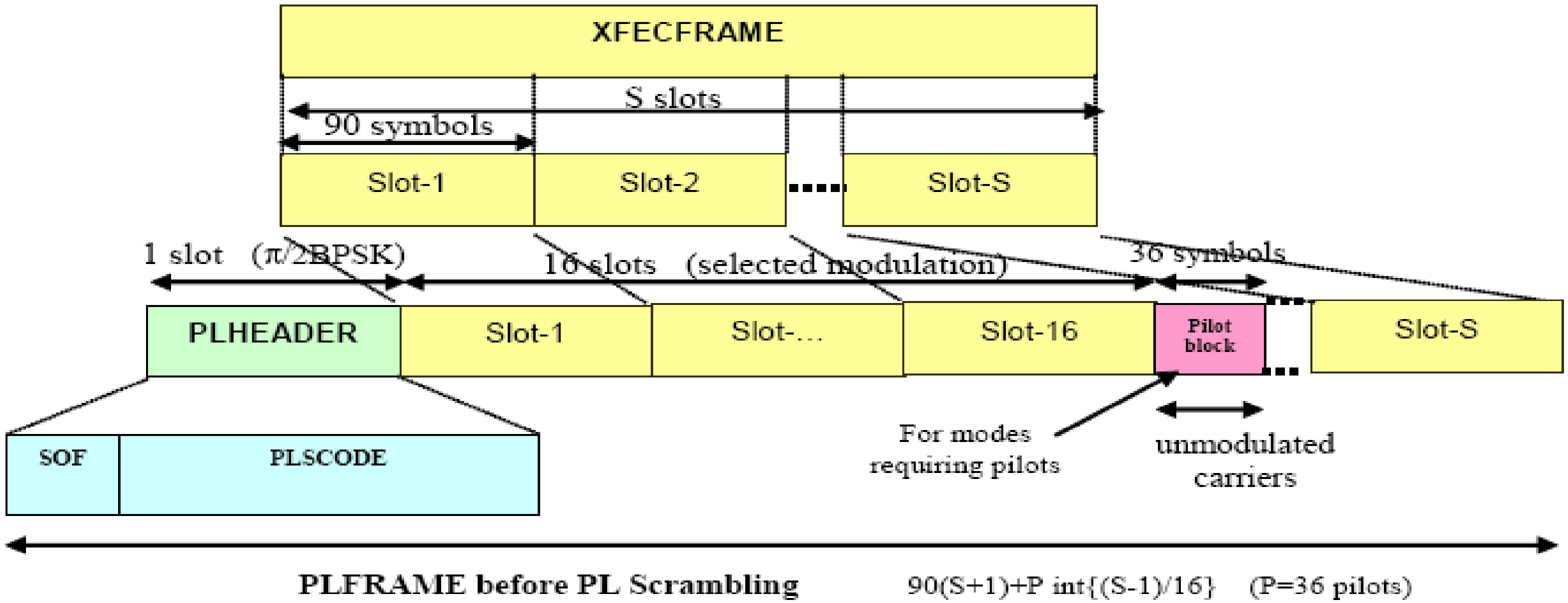
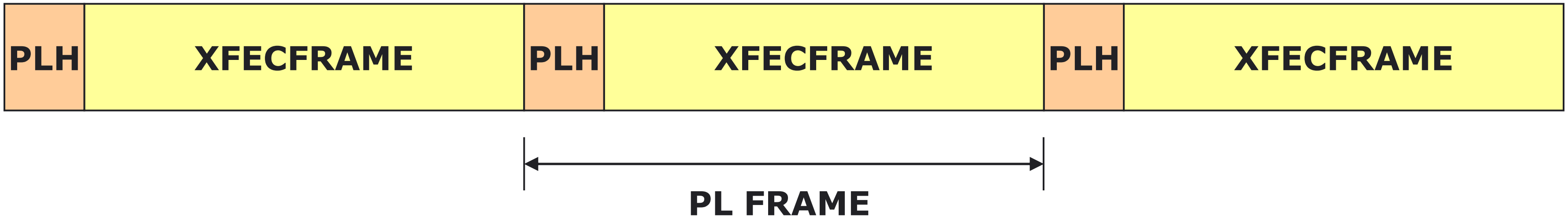


Figure 13: Format of a "Physical Layer Frame" PLFRAME

Table 11: S = number of SLOTs (M = 90 symbols) per XFECFRAME

	n_{ldpc} = 64 800 (normal frame)		n_{ldpc} = 16 200 (short frame)	
η_{MOD} (bit/s/Hz)	S	η % no-pilot	S	η % no-pilot
2	360	99,72	90	98,90
3	240	99,59	60	98,36
4	180	99,45	45	97,83
5	144	99,31	36	97,30

PL Signaling



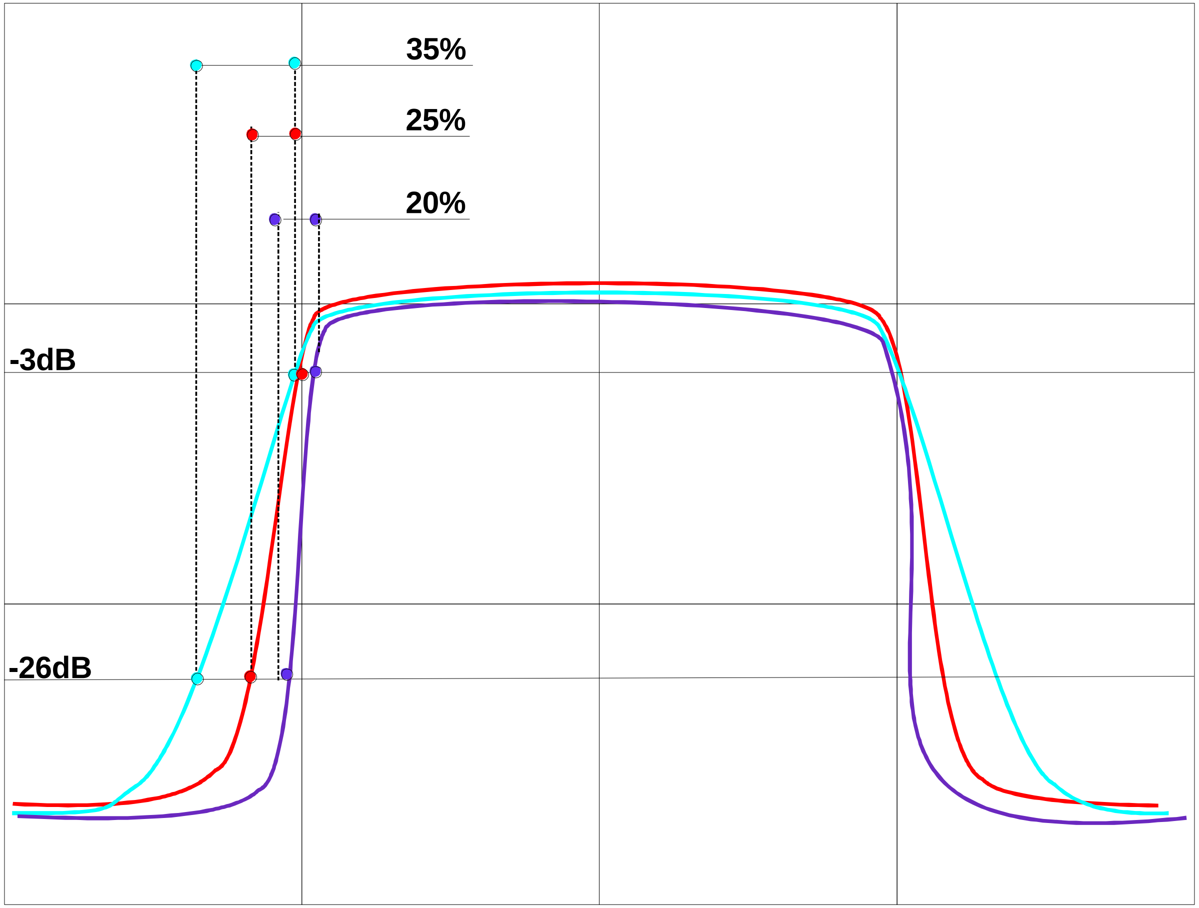
- The PLHEADER is intended for receiver synchronization and physical layer signaling.
- Physical Layer Header
  - SOF Field: Start of the Frame
  - MODCOD Field: Identifying the XFECFRAME modulation and FEC rate
  - TYPE Field: Identifying the FECFRAME length (normal/short) and the presence/absence of pilots (on/off)

MODCOD Table

Mode	MOD COD	Mode	MOD COD	Mode	MOD COD	Mode	MOD COD
QPSK 1/4	1_D	QPSK 5/6	9_D	8PSK 9/10	17_D	32APSK 4/5	25_D
QPSK 1/3	2_D	QPSK 8/9	10_D	16APSK 2/3	18_D	32APSK 5/6	26_D
QPSK 2/5	3_D	QPSK 9/10	11_D	16APSK 3/4	19_D	32APSK 8/9	27_D
QPSK 1/2	4_D	8PSK 3/5	12_D	16APSK 4/5	20_D	32APSK 9/10	28_D
QPSK 3/5	5_D	8PSK 2/3	13_D	16APSK 5/6	21_D	Reserved	29_D
QPSK 2/3	6_D	8PSK 3/4	14_D	16APSK 8/9	22_D	Reserved	30_D
QPSK 3/4	7_D	8PSK 5/6	15_D	16APSK 9/10	23_D	Reserved	31_D
QPSK 4/5	8_D	8PSK 8/9	16_D	32APSK 3/4	24_D	DUMMY PLFRAME	0_D

More Choice of Roll-off Factors

- New roll-off factor
- Occupied BW of the modulated signal = symbolrate x (1 + α)



α = roll-off factor

DVB-S

α = 35 %

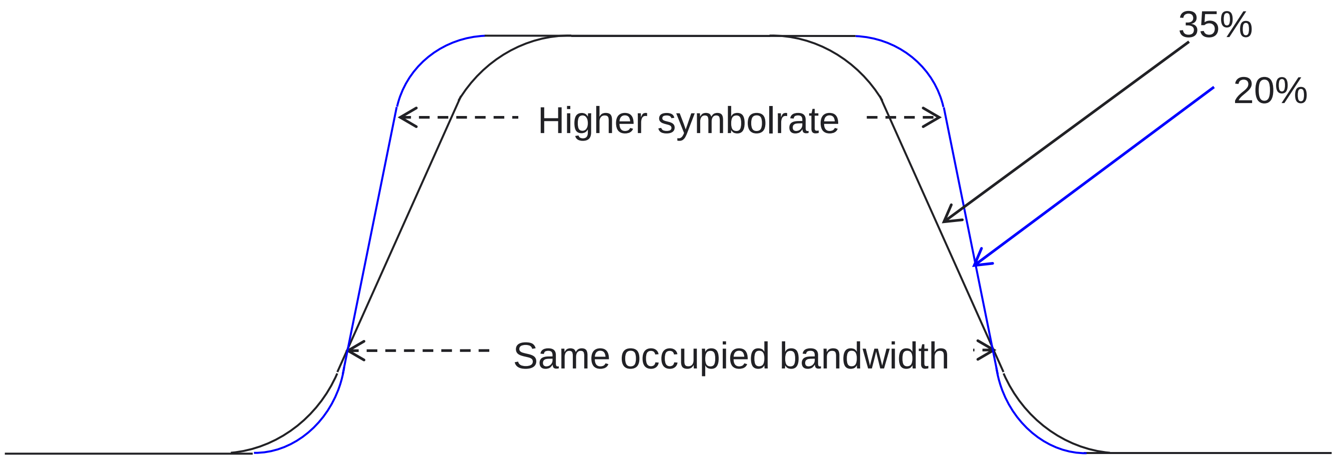
DVB-DSNG:

α = 25 or 35 % (professional)

DVB-S2:

α = 20, 25 or 35%

Increase of the Throughput by Reducing the Roll-off



- DVB-S2 roll-off allows for a higher symbol rate in the same leased bandwidth
- Example for a 36 MHz transponder
  - DVB (35%) 26.7 Mbaud
  - DVB-DSNG (25%) 28.8 Mbaud
  - DVB-S2 (20%) 30.0 Mbaud

Modulator Functional Diagram

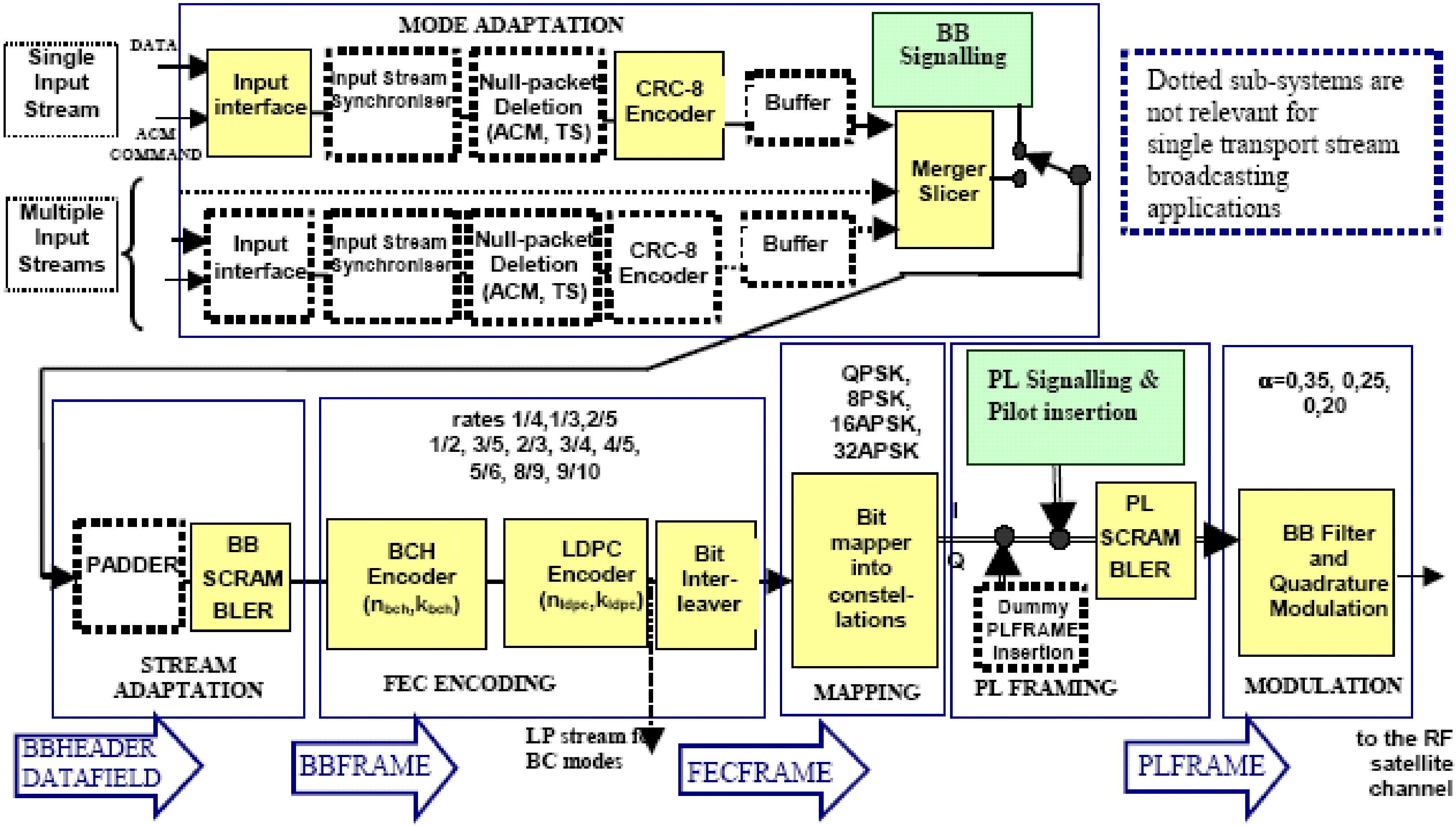


Figure 1: Functional block diagram of the DVB-S.2 System

CCM, VCM and ACM

- In DVB-S2 each BB frame can be encoded and modulated with its own set of parameters - on the same carrier!

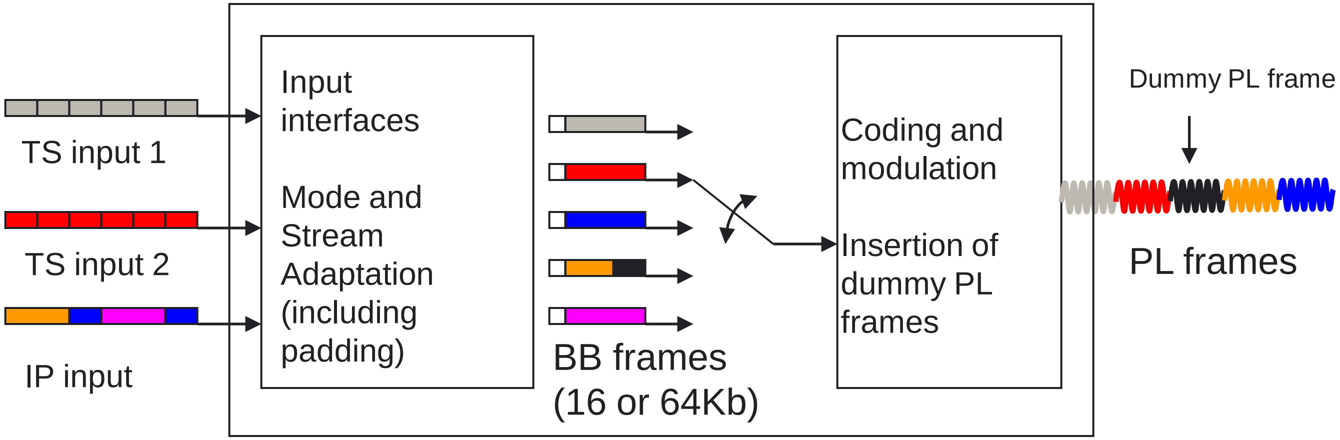
- CCM Constant Coding and Modulation
  - All frames use the same parameters
  - Mainly used in video broadcasting (simple, cheap demod ASIC chips)

- VCM Variable Coding and Modulation
  - Different streams/services are coded with different parameters
  - IP trunking, primary video distribution

- ACM Adaptive Coding and Modulation
  - Each frame in a stream is coded with its own set of parameters. Parameters are modified dynamically according to the reception conditions for each receiver
  - Will be the killer application if shaping is made dynamical

DVB-S2 Multi-Streams

- A DVB-S2 modulator can have several physical or logical inputs:



- The data of each input is processed in separated BB frames.
- The BB frames are time-multiplexed at the Physical Layer on the same carrier (allows for a big forward carrier)
- Demodulators can decode individual streams based on ISI independently from the other streams
- Each stream can be modulated with its own set of parameters (VCM and ACM)
- No need for TS multiplexer with significant saving of overhead.

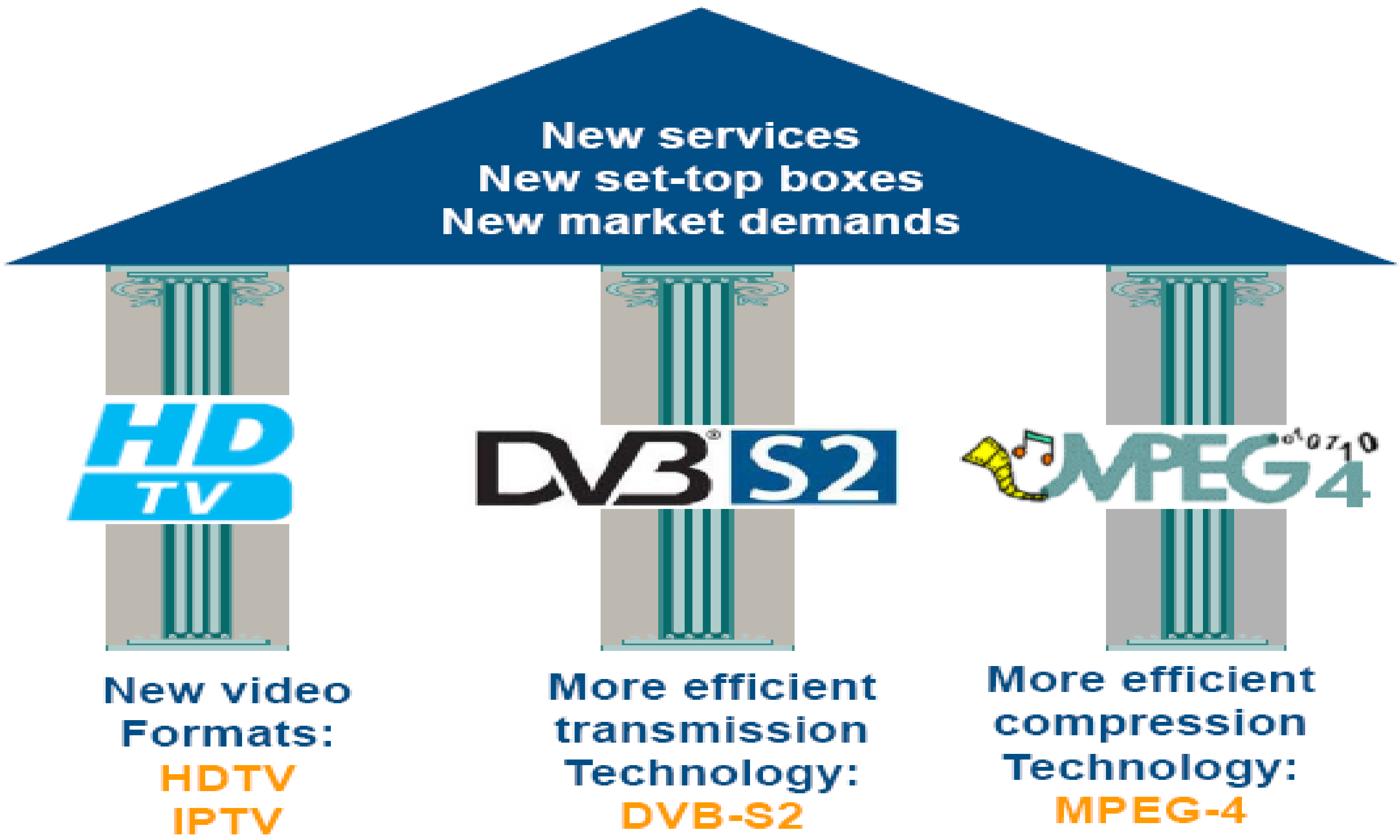
Eb/No vs. Es/No

- In DVB-S, the performance of a demodulator for a certain modcod is expressed in Eb/No (energy per bit over the normalised noise).
- In DVB-S2, Es/No is used (Energy per symbol over the normalised noise)
- In case of VCM/ACM operation, there is no constant bits per symbol over DVB-S2 carrier
- In case of CCM, Es/No = Eb/No + 10 log (η)
  - where the η is the spectral efficiency for the selected modcod.
  - Spectral efficiency is the number of bits per symbol
  - Spectral efficiency is based the MODCOD, Frame Size, Pilot On/Off, and Padding On/Off

Spectral Efficiency_MPEG (No Encapsulation)

MODCOD	64800 Efficiency no pilot	64800 Efficiency pilot	16200 Efficiency no pilot	16200 Efficiency pilot
QPSK 1/4	0.49024315	0.47857701	0.36532357	0.35746714
QPSK 1/3	0.65644814	0.64082687	0.62905983	0.61553166
QSPK 2/5	0.78941213	0.77062677	0.76092796	0.74456392
QPSK 1/2	0.98885811	0.96532660	0.84884005	0.83058542
QPSK 3/5	1.18830409	1.16002644	1.15653236	1.13166069
QPSK 2/3	1.32225300	1.29078781	1.28840049	1.26069295
QSPK 3/4	1.48747307	1.45207620	1.42026862	1.38972521
QPSK 4/5	1.58719606	1.54942612	1.50818071	1.47574671
QPSK 5/6	1.65466297	1.61528754	1.59609280	1.56176822
QPSK 8/9	1.76645122	1.72441560	1.72796093	1.69080048
QPSK 9/10	1.78861188	1.74604892		
8PSK 3/5	1.77999078	1.73956925	1.72531876	1.69203287
8PSK 2/3	1.98063624	1.93565829	1.92204007	1.88495891
8PSK 3/4	2.22812356	2.17752546	2.11876138	2.07788496
8PSK 5/6	2.47856155	2.42227629	2.38105647	2.33511969
8PSK 8/9	2.64601199	2.58592412	2.57777778	2.52804573
8PSK 9/10	2.67920701	2.61836532		
16APSK 2/3	2.63720074	2.57461345	2.54879227	2.50522317
16APSK 3/4	2.96672805	2.89632027	2.80966184	2.76163343
16APSK 4/5	3.16562308	3.09049503	2.98357488	2.93257360
16APSK 5/6	3.30018416	3.22186264	3.15748792	3.10351377
16APSK 8/9	3.52314303	3.43953015	3.41835749	3.35992403
16APSK 9/10	3.56734193	3.48268009		
32APSK 3/4	3.70329502	3.62333183	3.49309309	3.41916520
32APSK 4/5	3.95157088	3.86624681	3.70930931	3.63080541
32APSK 5/6	4.11954023	4.03058929	3.92552553	3.84244562
32APSK 8/9	4.39785441	4.30289399	4.24984985	4.15990594
32APSK 9/10	4.45302682	4.35687509		

DVB-S2 Application Drivers



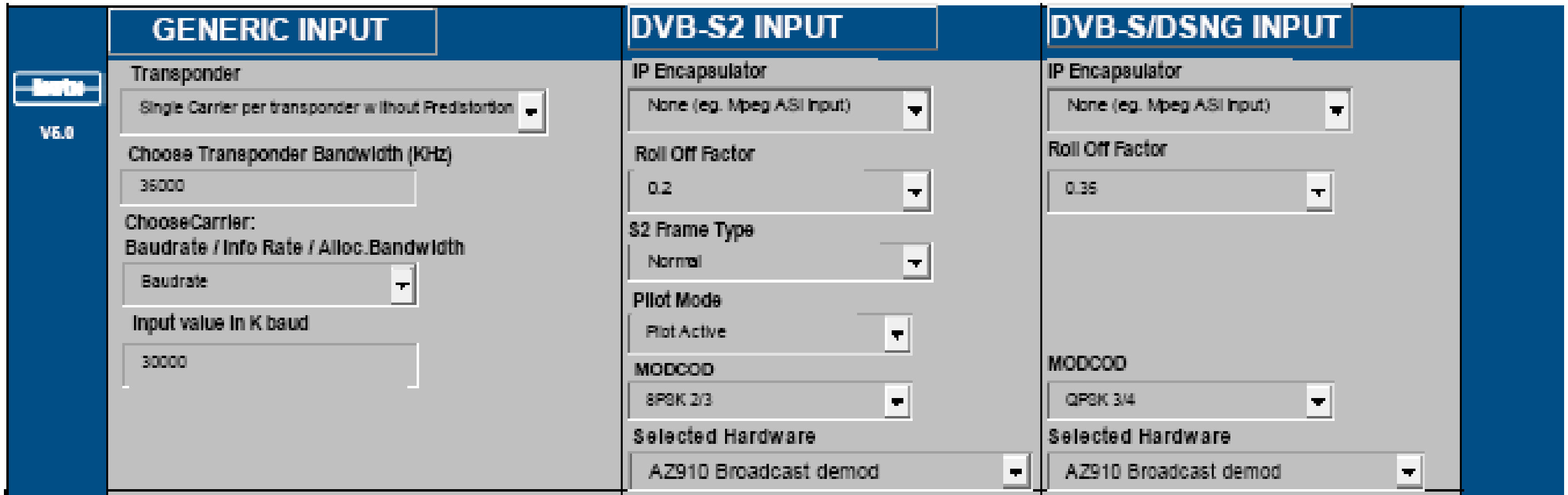
DVB-S2 8PSK 2/3 vs. DVB-S QPSK 3/4

- DVB-S: QPSK 3/4, 29.27 Msps, 35%
- DVB-S2: 8PSK 2/3, 30.0 Msps, 20%, pilot present

- We can fully push the DVB-S2 MODCOD to 8PSK 2/3 to maximize throughput.
- The data rate is increased by 18.4199 Mbps, that is 45.54% comparing with DVB-S.

DVB-S QPSK 3/4	DVB-S2 8PSK 2/3
Es/No=7.26 dB	Es/No=7.10 dB
C/No=82.03 dB-Hz	C/No=81.87 dB-Hz
OB=39.514 MHz	OB=36.000 MHz
Data Rate=40.4511 Mbps	Data Rate=58.0710 Mbps

Newtec DVB-S2 Calculator



	DVB-S2	DVB-S/DSNG
a) Generic Outputs		
Baudrate (Kbaud)	30000.0	30000.0
Required Es/No (dB) (=Co/No) (for BER: 1E-7)	7.10	7.26
C/No (dBHz)	81.87	82.03
Channel Bandwidth (KHz)	36000.0	40500.0 above max (36000)
Frame Length (msec)	0.7398	
b) Output to be entered on SATMASTER - "Carrier" - page		
Required Eb/No (dB) (for BER: 1-7)	4.23	5.85
Info Rate (Kbps)	58071.0	41460.0
Overhead % Info Rate (assuming IP packet size of 600By)	0.00	0.00
FEC Code Rate	0.6452	0.7500
Spreading Factor (dB)	0	0
R/S code (n/k)	1	1.085
1 + Roll Off Factor	1.00	1.00
Carrier Spacing Factor	1.20	1.35
Modulation M-PSK	8	4
c) Output to be entered on SATMASTER-Satellite- page		
GIBO (dB) (Satellite dependent)	1.10	0.00
GOBO (dB)	0.60	0.33
C/IM (dB) (adjust Sat-C/IMo to obtain target C/IM)	18.01	
Alternatively:Non-linear Degradation(dB) equiv. to C/IM effect	0.37	

Generic Mode

- In DVB-S the data format was exclusively the MPEG Transport Stream (TS)
- The size of the MPEG transport stream packet (188 bytes) was optimised for the Reed Solomon error correction code, which is no longer used by DVB-S2

DVB-S2 introduces a new Generic Mode for

- Generic Continuous Stream and Packetized Stream

For the Generic Mode

- It is compatible with any type of data (IP, ATM,…)
- It doesn’t need transport stream overhead (2%)
- The efficiency gain for IP could be more than 4%

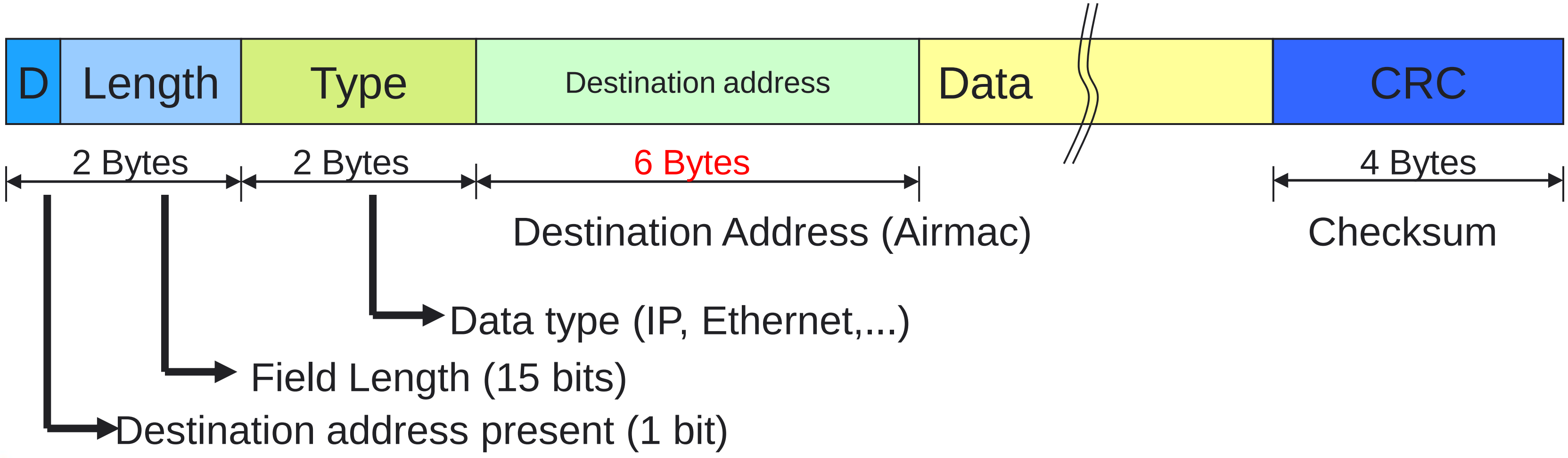
Generic Stream Encapsulation (GSE)

- DVB-S2 does not define an encapsulation mechanism for IP data such as MPE as in DVB-S.
- It is being studied by the standardization group (TM-GBS)
- 2 proposals were presented: EDGE (ESA) and GULE (IETF)
- They were merged and enhanced to create the GSE for the Generic Mode
- The GSE protocol has been devised as an adaptation layer to provide network layer packet encapsulation and fragmentation functions over the generic stream of the DVB-S2 standard.
- ETSI TS102606V1.1.1 in 2007-10_protocol
- ETSI TS102717V1.1.1 in 2009-06_implementation guidelines

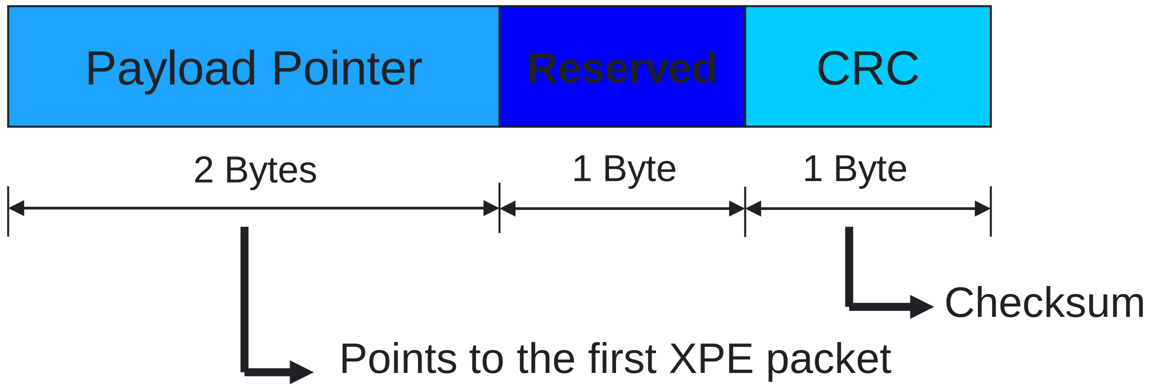
eXtended Performance Encapsulation (Newtec Proprietary)

- Propriety protocol based on GULE
  - Data packets are encapsulated with a 4 or 10 byte header
    - 4 Byte header: Single Destination Mode
    - 10 Byte header: Multi-destination Mode
  - Optional CRC (4 bytes)

XPE Packet: Sub-Network Data Unit (SNDU)

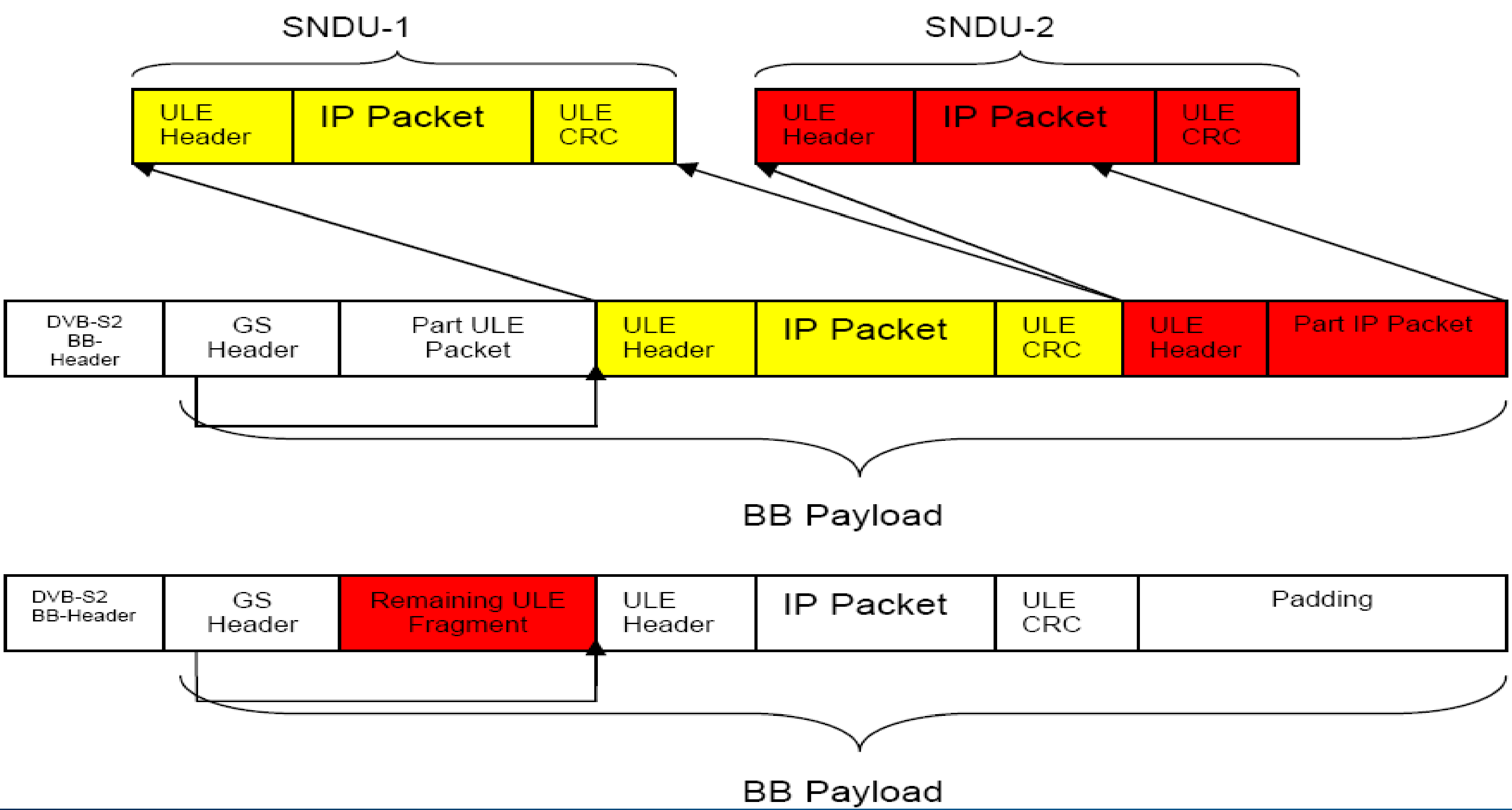


- Generic Stream Header



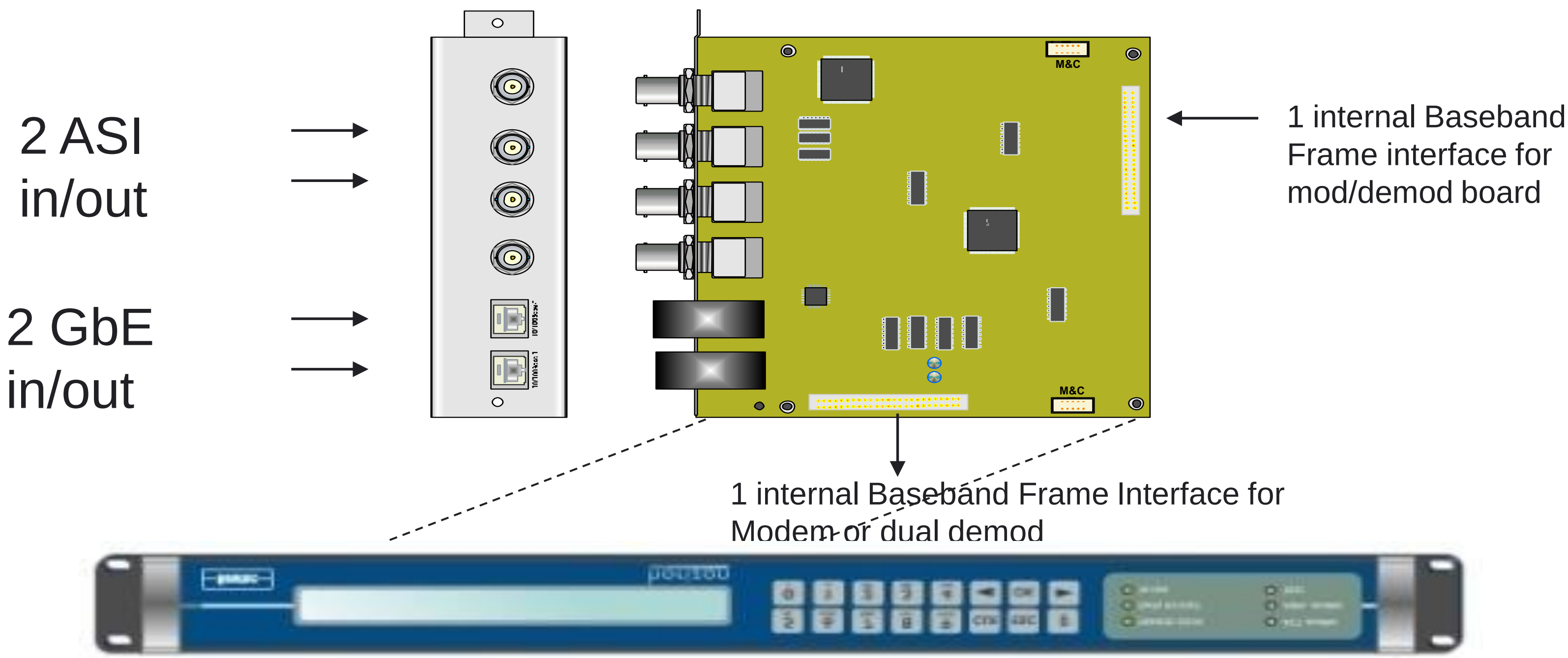
eXtended Performance Encapsulation (Newtec Proprietary)

- Generic Stream
  - XPE packets are put directly into Baseband frame



Gigabit Ethernet Interface: NTC/7015

- DVB-S2 is optimized for both video and IP
- Newtec offers a unique GbE interface that takes full advantage of all the feature that DVB-S2 has to offer



DVB-S2 modulator or demodulator or modem

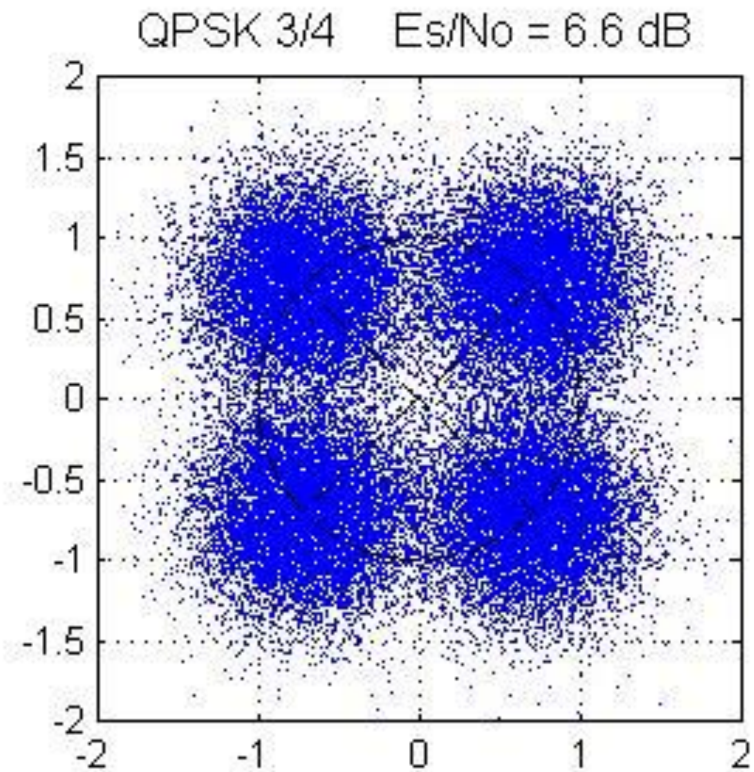
GbE Processing Modes

Interface	Interface data type	Over air	DVB-S	DVB-S2	Ethernet / ASI mode
ETHERNET	IP	ULE / MPE	✓	✓	L2 Ethernet bridge L3 IP bridge or router
		XPE	✗	✓	L2 Ethernet bridge L3 IP bridge or router
	TS over IP	TS	✓	✓	✗
	S2BBF	S2BBF	✗	✓	✗
ETHERNET + ASI	IP + TS	XPE + TS	✗	✓	L2 Ethernet bridge L3 IP bridge or router
ASI	TS	TS	✓	✓	ASI normal ASI Multi-stream ASI Fixed delay
	S2BBF	S2BBF	✗	✓	✗
	PRBS generator	TS	✓	✓	All modes

Pilots

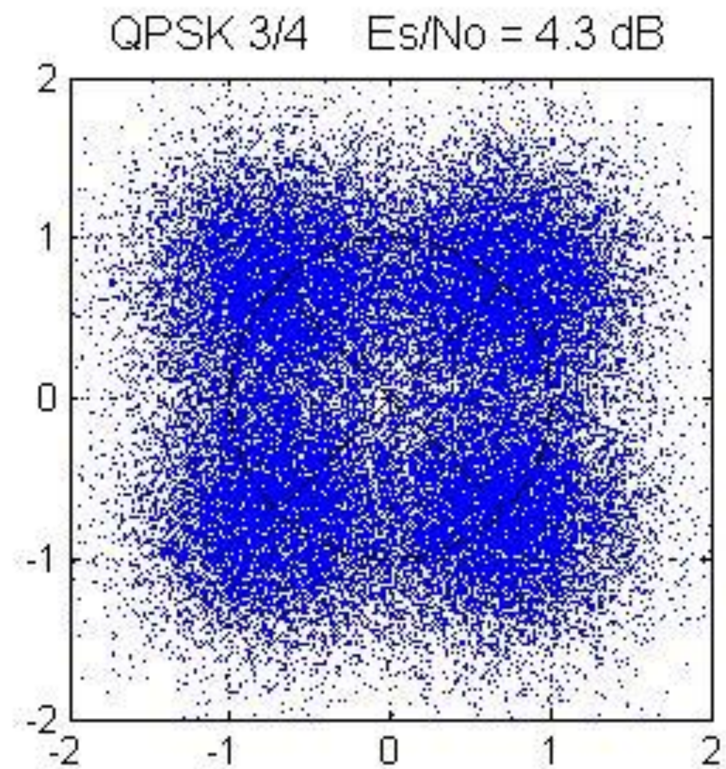
Comparing DVB-S to DVB-S2

DVB-S



- BER 1E-7 after R/S (< 20 MBaud)
- 1.3824 bit/Hz

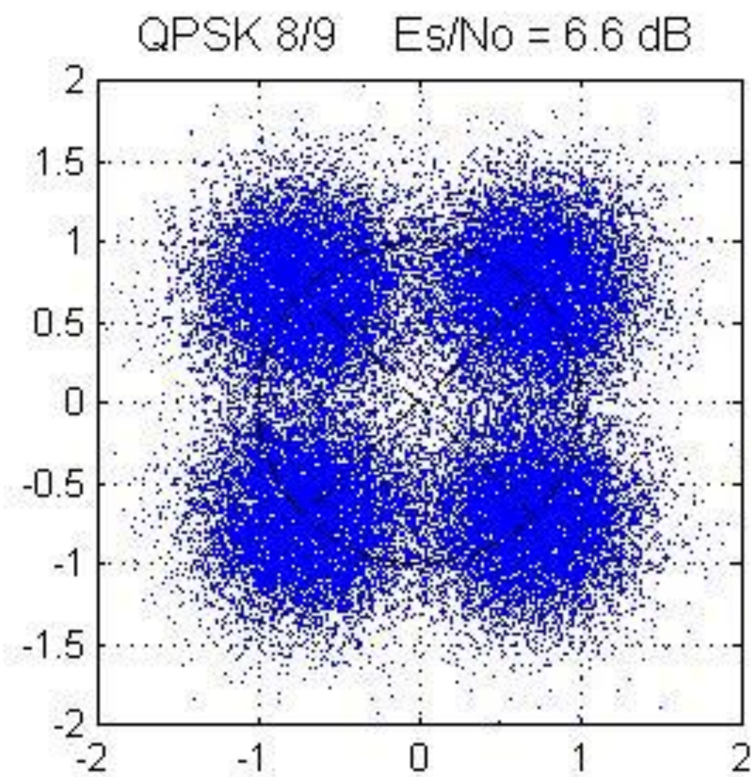
DVB-S2



- PER 1E-5 188-byte (~BER 5E-8)
- 1.4875 bit/Hz

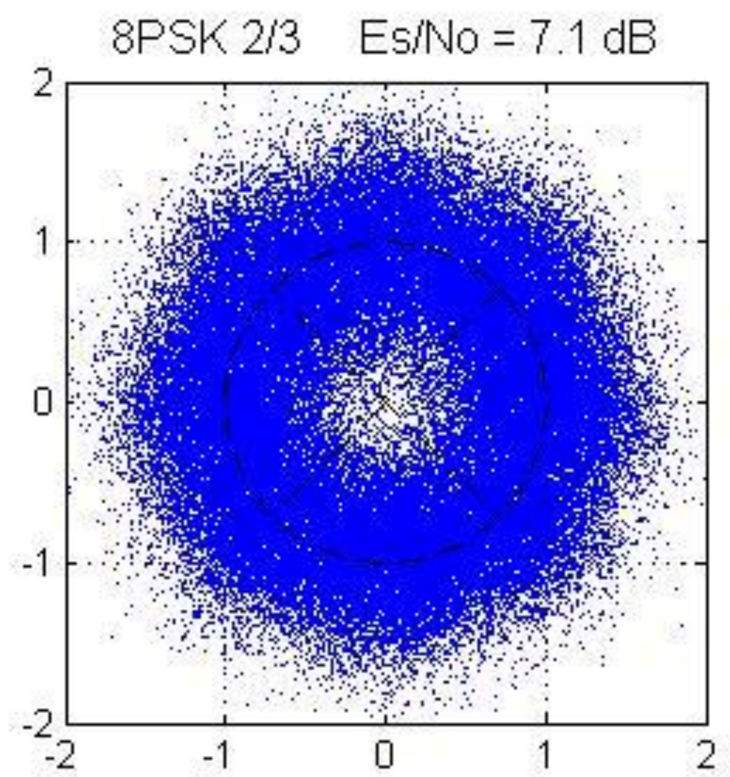
Comparing DVB-S to DVB-S2

DVB-S2



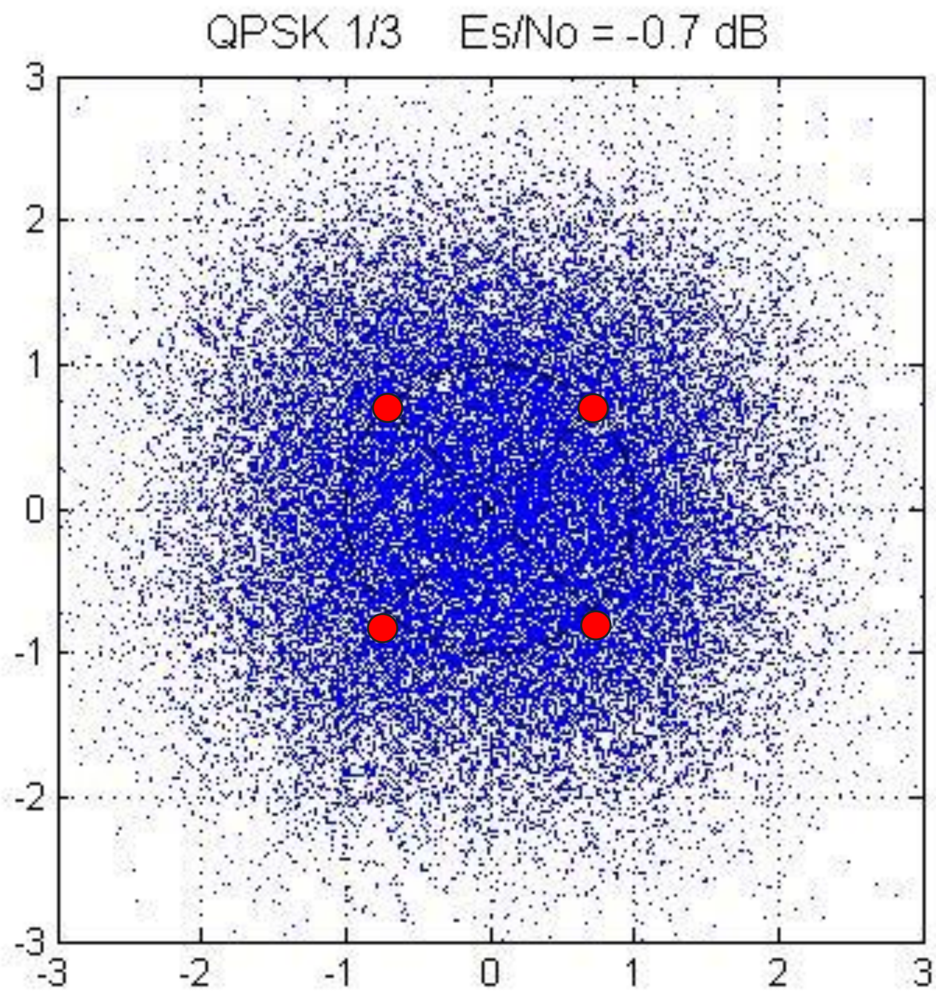
- PER 1E-5 188-byte (~BER 5E-8)
- 1.7665 bit/Hz

DVB-S2



- PER 1E-5 188-byte (~BER 5E-8)
- 1.9806 bit/Hz

A New Parameter: Pilot



DVB-S2 Challenge:

- Near Shannon performance
- Maintain carrier recovery under phase noise of LNB and tuner

DVB Requirement:

- Customers with existing antena/LNB should **only** change their set-top box to migrate from DVB-S to DVB-S2

Pilot:

- Each pilot shall be an un-modulated symbol, identified by I = (1/√2), Q = (1/√2).
- Subject to the same thermal/phase noise as any other symbols, it helps the demodulator in carrier recovery and receiver synchronization

When to Use Pilots: Newtec Demodulator AZ910

- Newtec AZ910 demodulator

type A (PL-DRO)	type B (free running DRO)
	< -35dBc/Hz at 10 Hz
< -70dBc/Hz at 100 Hz	< -63dBc/Hz at 100 Hz
< -75dBc/Hz at 1kHz	< -73dBc/Hz at 1kHz
< -80dBc/Hz at 10 kHz	< -85dBc/Hz at 10 kHz
< -85dBc/Hz at 10 0kHz	< -90dBc/Hz at 100 kHz
	< -96dBc/Hz at 1 MHz
	< -108dBc/Hz at >10 MHz

  - Type A: Can be used for all baud rates
  - Type B: Baudrates >5 MBaud for QPSK and 8PSK

- Performance figures under QPSK 1/3, 8PSK 3/5 2/3, and 16APSK 2/3 3/4 or symbol rates below 3 MBaud are measured with pilots on

Pilots: Generic Recommendations

- Need for Pilots increases with:
  - Higher modulation schemes: 16APSK and 32APSK
  - Low code rates: 1/4, 1/3, 2/5, 1/2 and 3/5 for QPSK; 3/5, 2/3, 3/4 and 5/6 for 8PSK
  - Low symbol rates: <5 Mbaud for Type B LNB or <3 Mbaud for Type A LNB.

- DVB-S2 ACM/VCM : **Pilots on**

- Pilots do not degrade performance when used but not needed

- Use of pilot introduce around 2% overhead

Short and Normal Frame

Short Frames – Normal Frames (Comparative)

	Short Frame	Normal Frames
Performance	-	+ (average 0.3 dB better)
Spectral Efficiency	-	+
Delay (modulation - demodulation)	+ (only 25% of Normal Frames)	-
Broadcast	Not supported	Mandatory

- Recommendations:
  - Short frames: Only for time critical data applications
  - Broadcast: Normal Frames are mandatory
  - ACM/VCM: **Do not mix** short and normal frames

Short Frames – Normal Frames (Delay Estimation)

- Modulator delay:
  - 2 frames
- Demodulator
  - 3 frames
- Modulation–Demodulation Delay Calculation
  - Delay=(#frames x [frame-size] x spectral efficiency)/(mxbitrate)
    - Example: 256kbit/s, 8PSK 2/3, Pilots on, Short frames

      # frames: 5

      Frame-size: 16200 bits

      Spectral efficiency: 1.880672 bit/Hz

      m = 3 (8PSK)

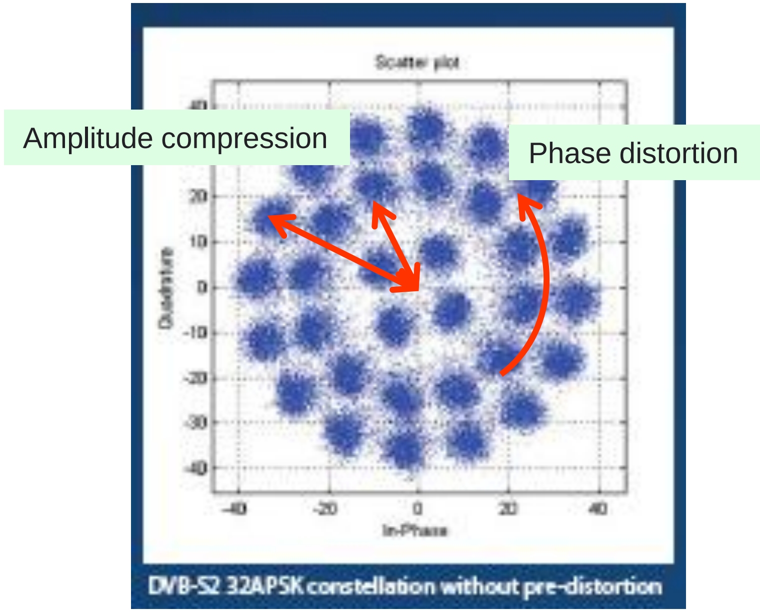
      bitrate: 256000 bit/s

      ➔ Delay = 0.198s = **198 ms**

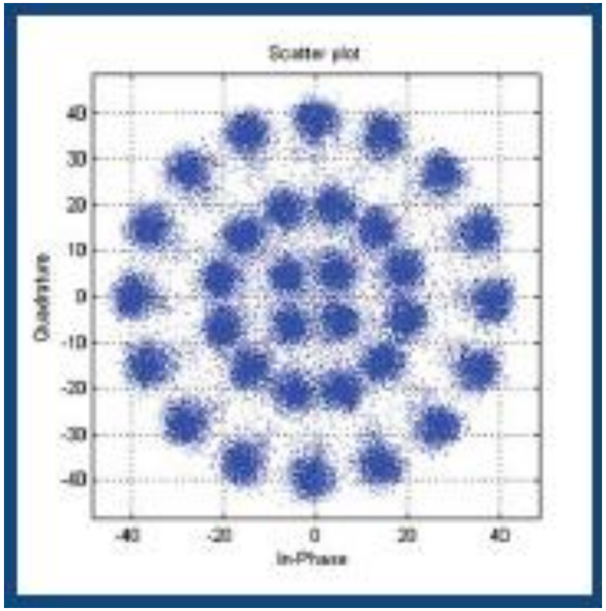
Pre-Distortion
&
Equalization

Equalink™ : an enabler for 32APSK

- Due to the lower carrier-to-noise levels required in DVB-S2, higher modulation schemes such as 32APSK become possible
- Newtec's unique Equalink™ is an embedded solution for predistortion in the modulator



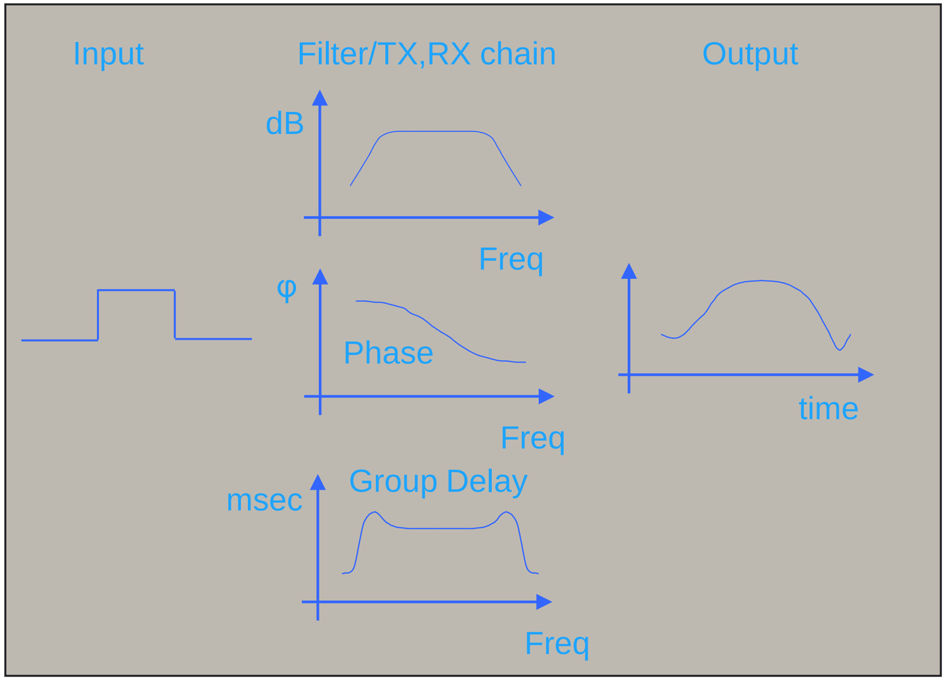
Decoded signal without predistortion



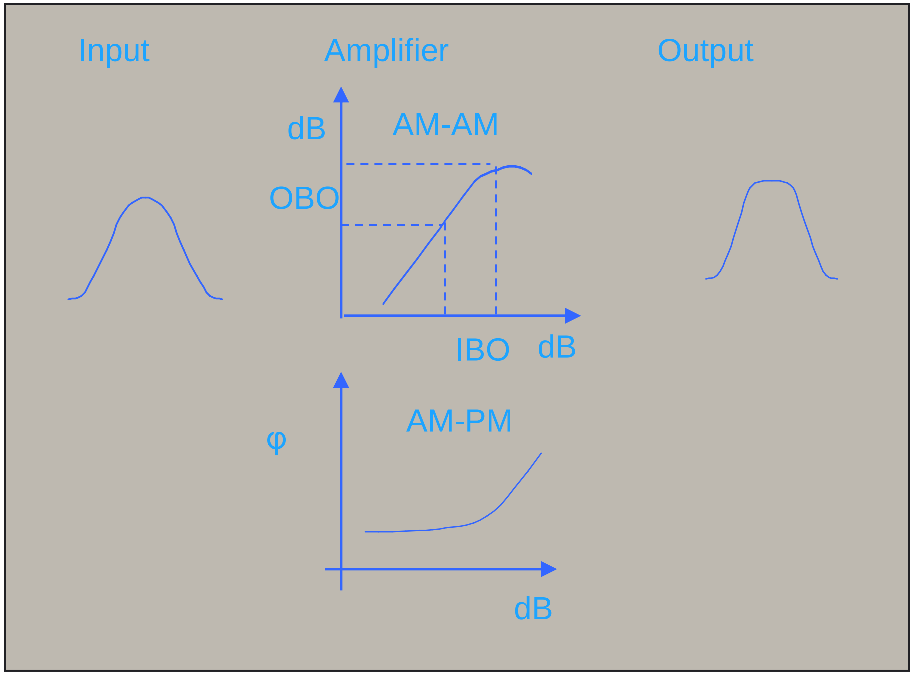
Decoded signal after enabling Equalink in the modulator

Pre-Distortion and Equalization: The origin

Linear Distortion – IMUX Filters



Non-Linear Distortion: Amplifiers



Impact: Received signals are distorted - degradation of the bit error rate

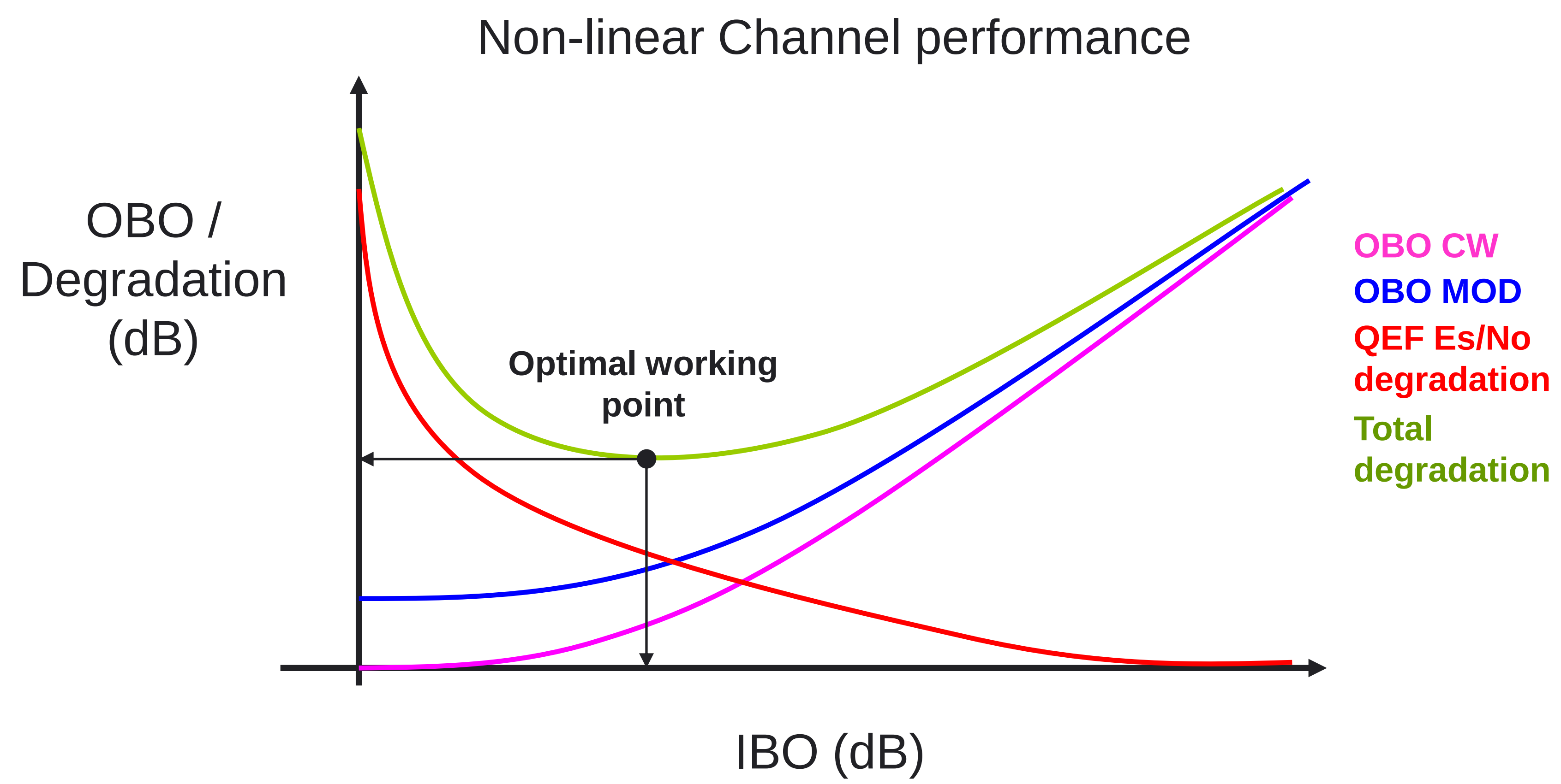
Linear : Superposition principle holds – Characteristics are independent of the applied amplitude (Filters)

Non-Linear : Characteristics are changing with the input amplitude (amplifier working close to saturation)

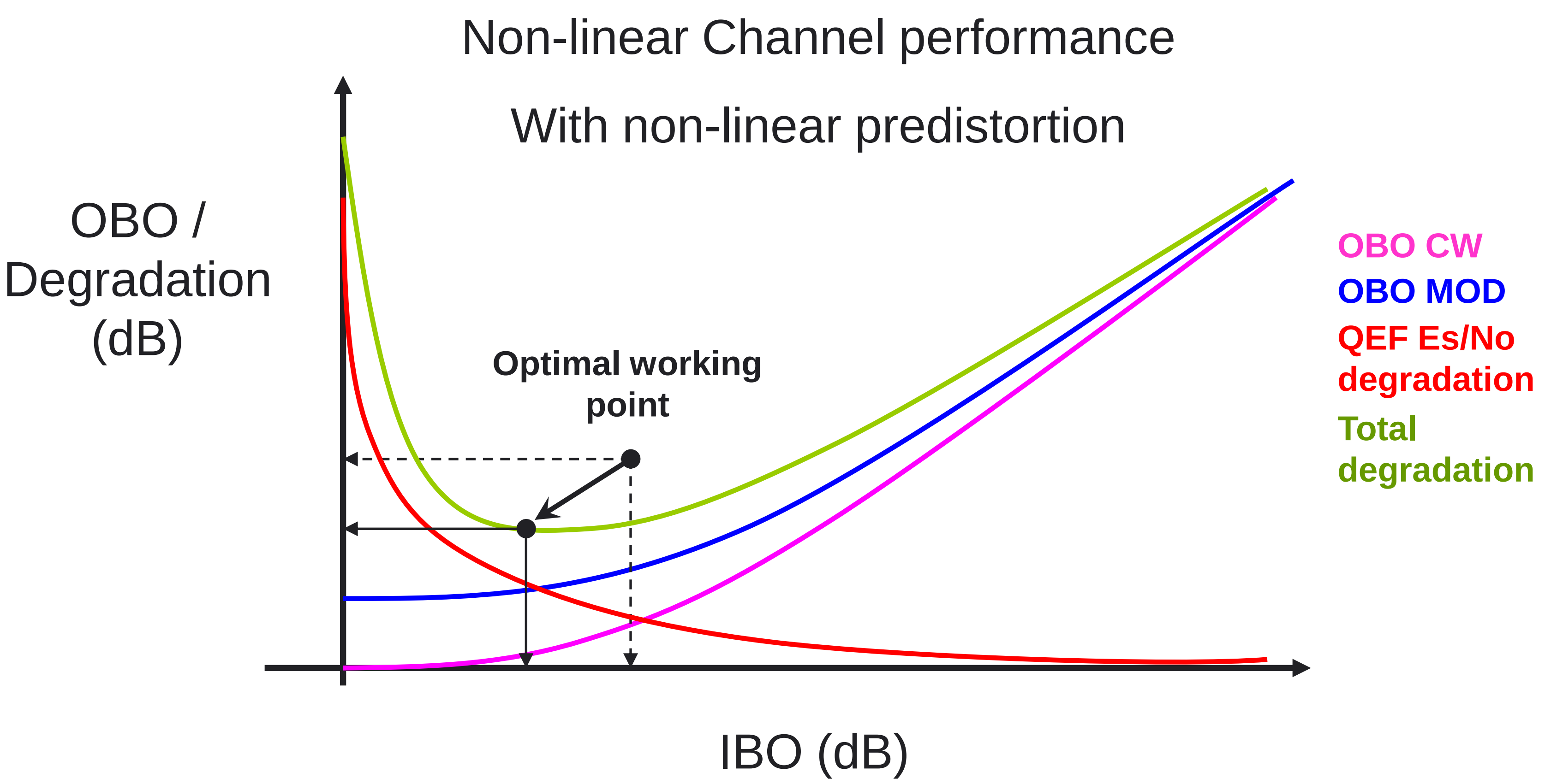
Pre-Distortion and Equalization

- Linear predistortion and Equalization
  - What: Compensates for amplitude and group-delay impairments in the transmission channel
  - Where:
    - Modulator: Linear predistortion (requires knowledge of amplitude and group delay characteristics of the transmission channel, operating parameters)
    - Demodulator: Adaptive Equalization (embedded. The operator just needs to enable/disable)
- Non linear predistortion
  - What: Compensates for compression and phase rotation caused by non-linearity of amplifiers and clustering caused by filters.
  - Where:
    - Modulator: Non-linear predistortion (requires knowlegde of transponder AM-AM and AM-PM characteristics)

Performance Degradation due to Non-Linearity (1)

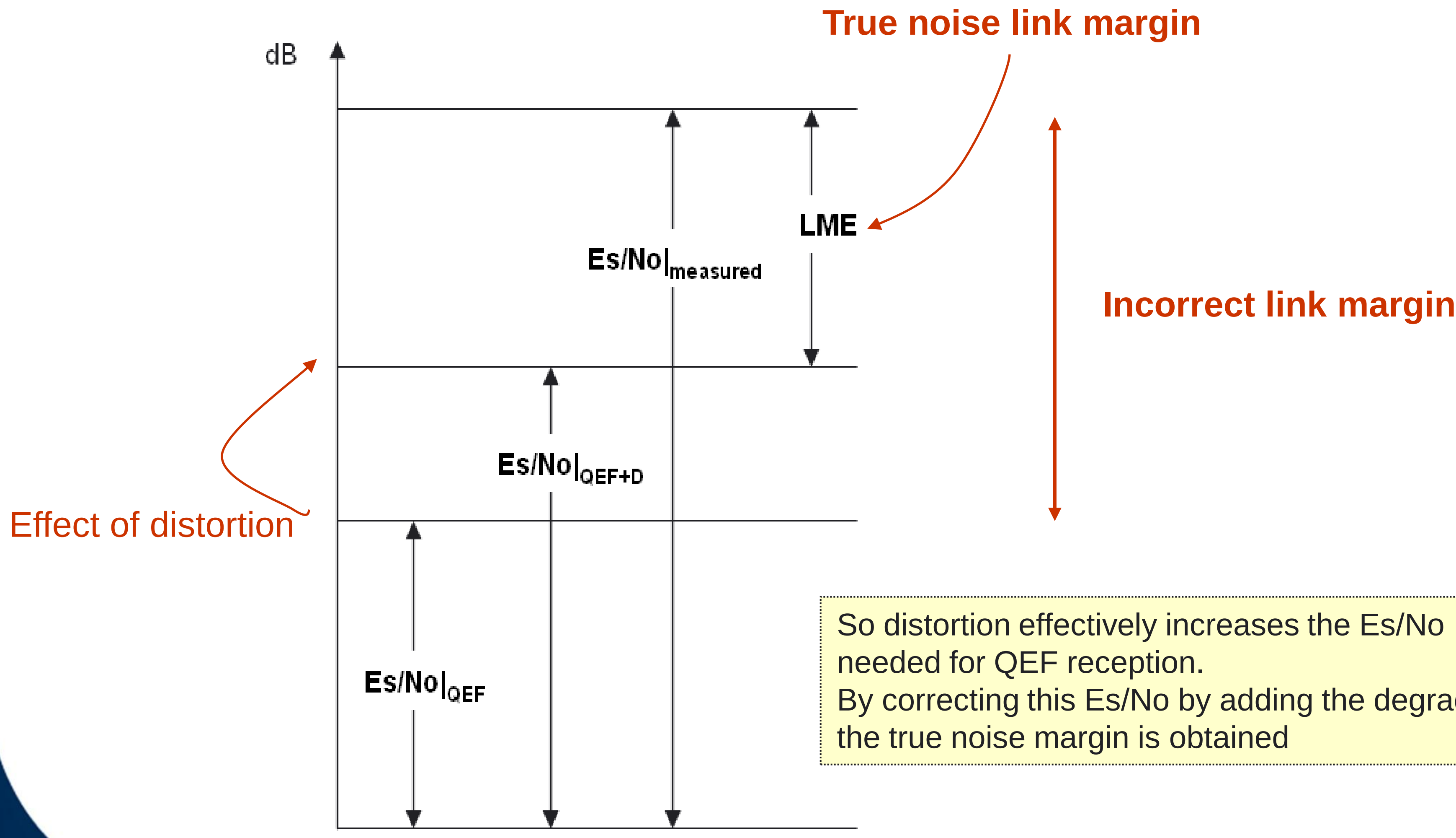


Performance Degradation due to Non-Linearity (2)



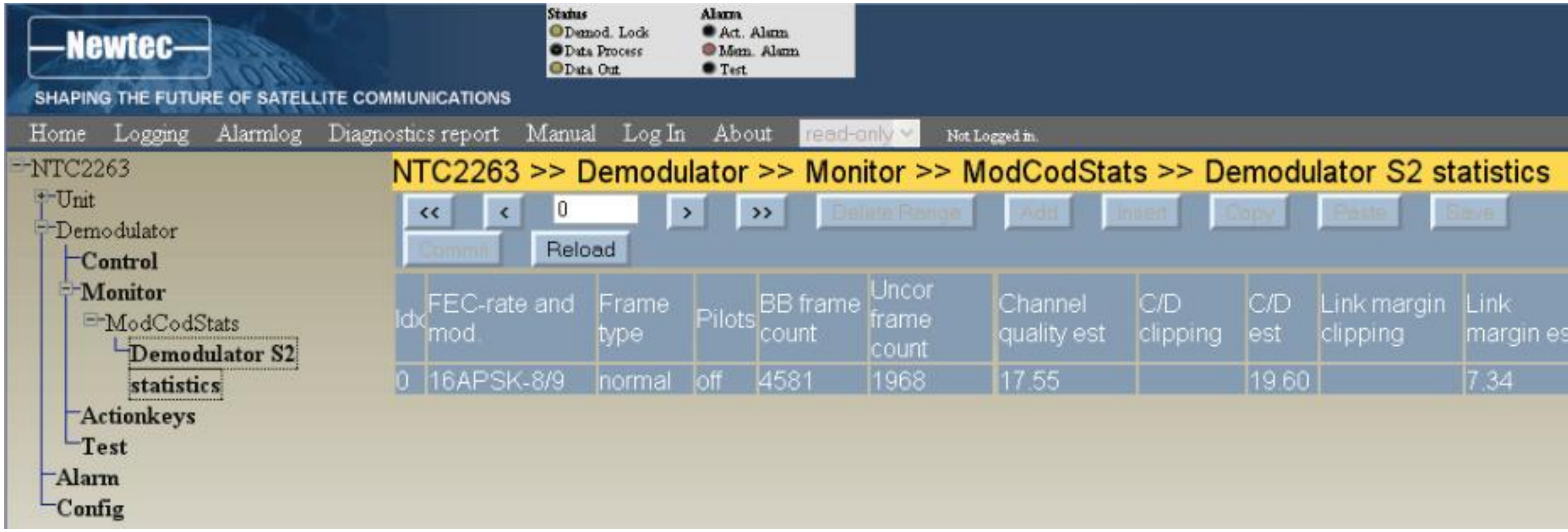
Noise and Distortion Estimator NoDE

NoDE: Noise and Distortion Estimator



So distortion effectively increases the Es/No needed for QEF reception.
By correcting this Es/No by adding the degradation the true noise margin is obtained

NoDE: Finding the Optimum Operating Point



../Demodulator/Monitor/ModCodStats/Demodulator S2 statistics

- Modulation and FEC
- Frame type (normal/short)
- Pilots (on/off)
- BB frame count (number of decoded baseband frames)
- Uncor frame count (number of uncorrected frames)
- Channel Quality Estimation
- C/D Estimation
- Link Margin Estimation (LME)

Thank you for your attention

waylon.sun@newtec.eu

Broadband Systems

Professional Equipment

IP Software

SHAPING THE FUTURE OF SATELLITE COMMUNICATIONS