DVB and DVB-H Systems

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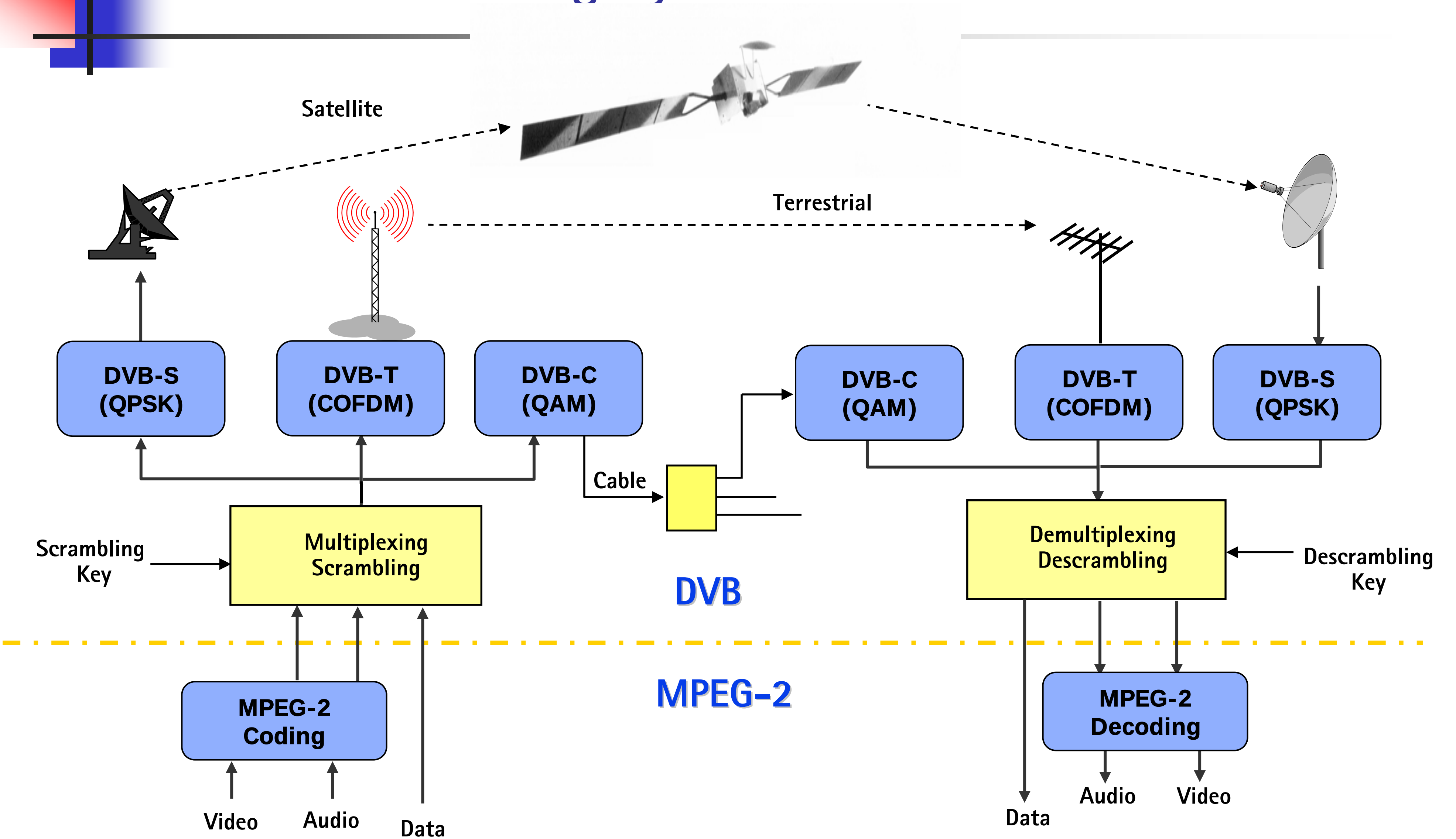
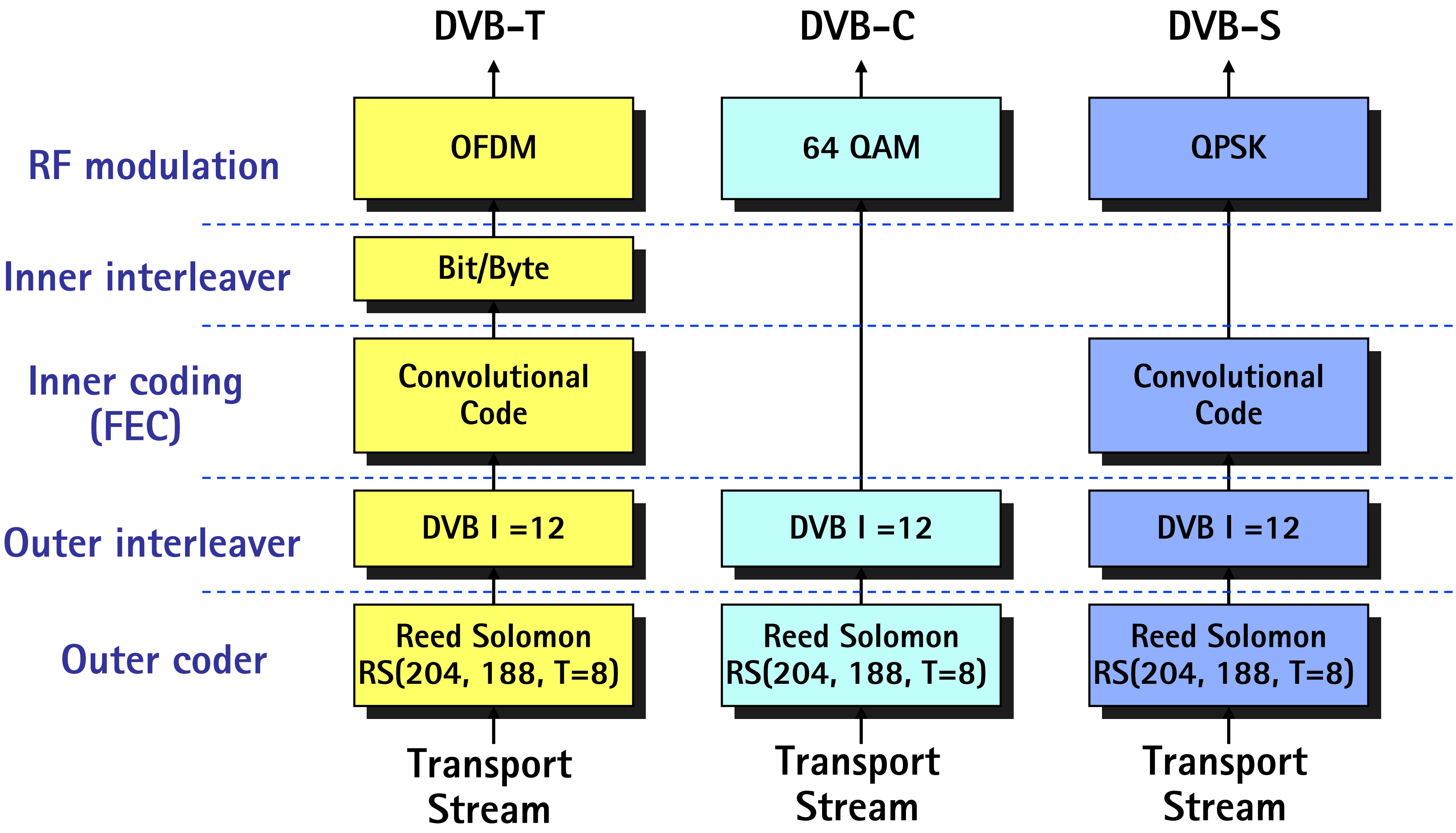
DVB Broadcasting System



DVB Broadcasting Standards

- Transmission
  - EN 300 421 DVB Framing structure, channel coding and modulation for 11/12 MHz satellite service (DVB-S)
  - EN 300 429 DVB Framing structure, channel coding and modulation for cable (DVB-C)
  - EN 300 744 DVB Framing structure, channel coding and modulation for digital terrestrial television (DVB-T)
- Audio-Video Coding
  - MPEG-2: ISO 13818 Generic coding of moving pictures and associated audio information: Systems, video, audio, compliance testing, DSM-CC, etc.
    - Part1 Systems: Transport Stream, Program Specific Information (PSI), Part2 Video, Part3 Audio, Part6 DSM-CC Data Broadcasting on MPEG2
  - MPEG-4: ISO 14496 Coding of audio-visual objects
    - Part1 System, Part2 Visual, Part3 Audio, etc.
  - MPEG-4 AVC: ISO 14496 Coding of audio-visual object Part10 (ITU.T H.264)
  - ITU.T H.263 Coding of moving video
- Data Broadcasting
  - EN 301 192 DVB specification for data broadcasting
    - MPE, INT, Time Slicing
  - EN 301 468 (DVB-SI) DVB service information
    - NIT, Service Information

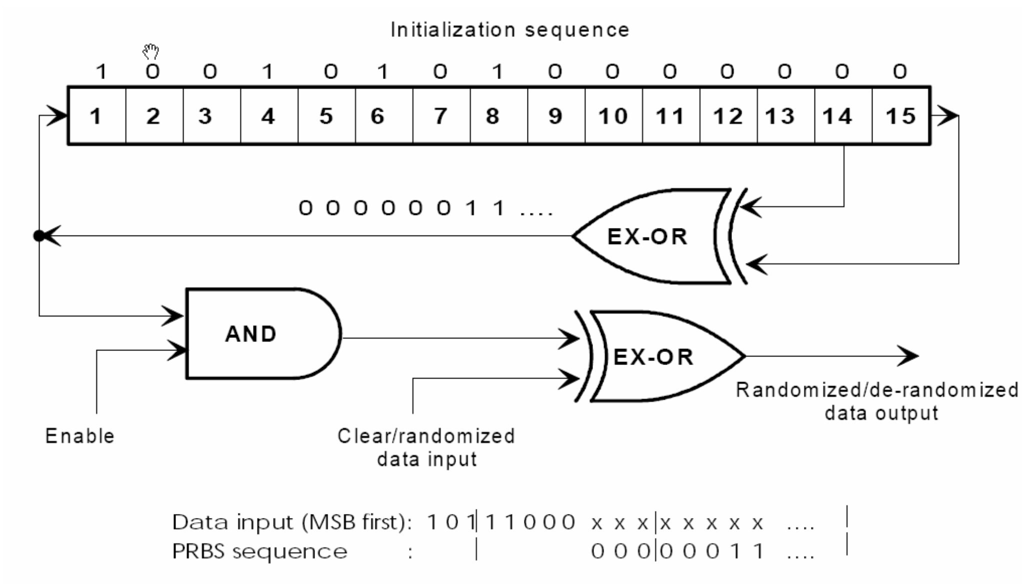
Error Correction in DVB System (Transmitter)



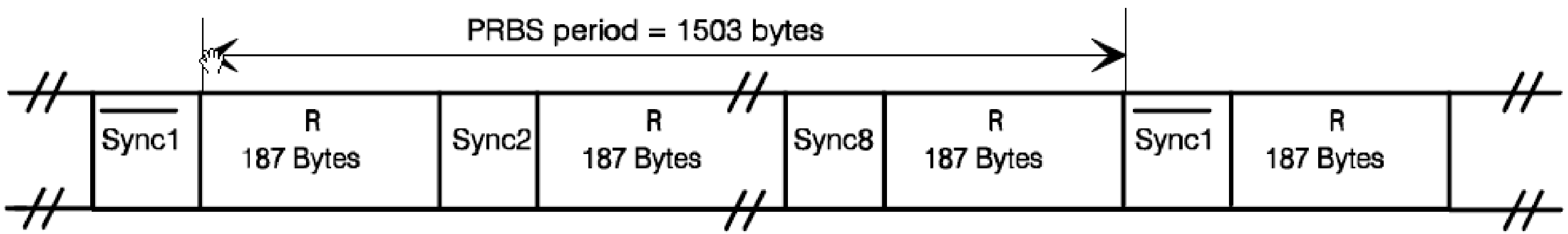
Requirements for Modulation in DVB Systems

- **Satellite reception (QPSK, Phase modulation)**
  - Carrier to noise ratio C/N can be very small (10 dB or less)
  - No reflections, but nonlinear transmission chain (C-class amplifiers in the satellites) leading to amplitude distortions
  - => constant amplitude modulation should be used (QPSK)
- **Cable reception (QAM, Amplitude and Phase modulation)**
  - C/N is quite high, generally over 30 dB
  - The signal can be effected by echoes due to impedance mismatches in the network
  - Amplitude modulation can be used, but echo cancellation is necessary
- **Terrestrial reception (COFDM, Coded Orthogonal Frequency Division Multiplex)**
  - Propagation conditions for signal are difficult, especially if mobile reception is required with simple antennas => variable echoes due to multipaths and signal level variations
  - => COFDM right choice

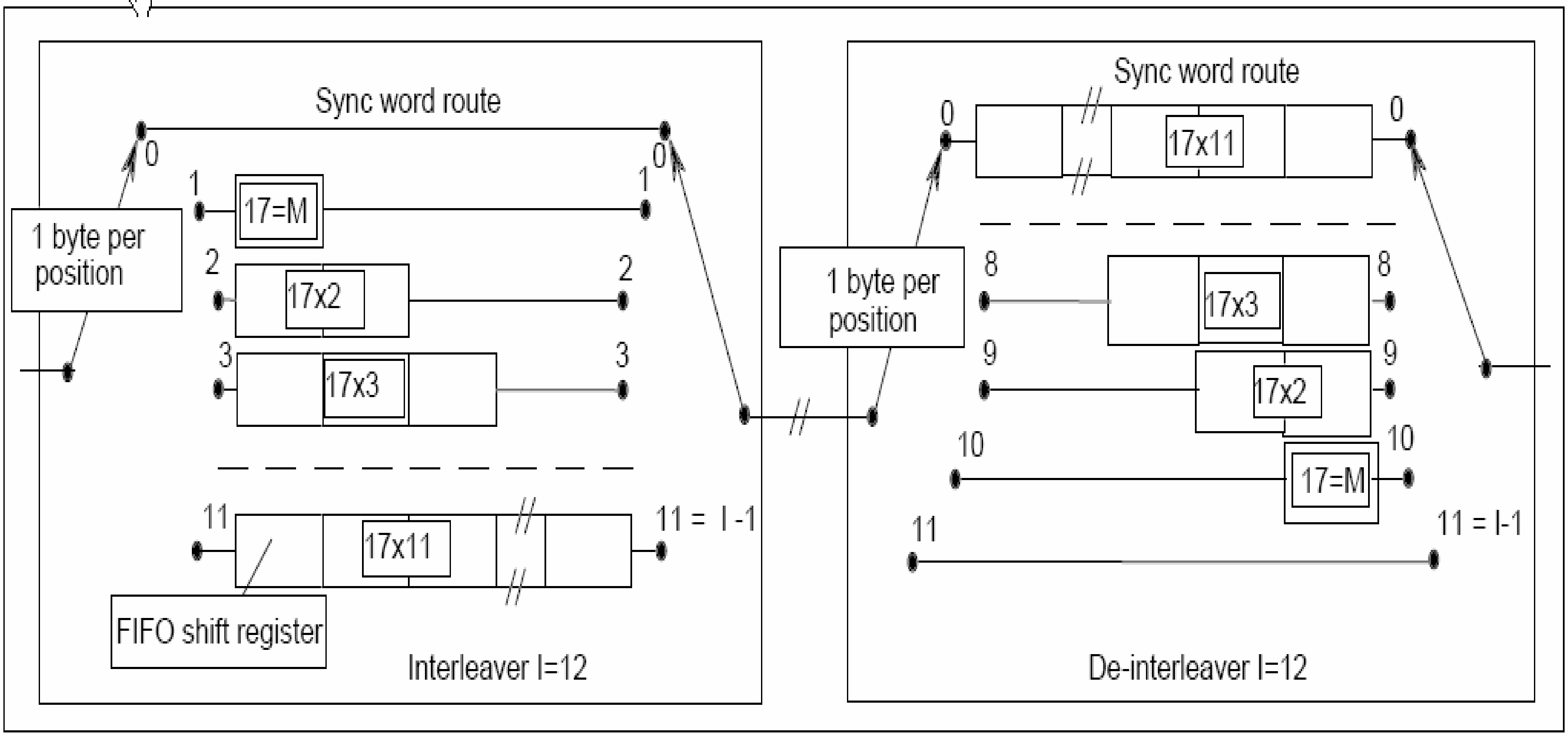
DVB Channel Coding: Randomization, energy dispersal



- All data in DVB channel is transmitted in fixed length packets; at this stage sync+187 data bytes
- Sync byte = 0x47
- Ever 8th sync byte= 0xB8
- Bytes between sync bytes are randomized for energy dispersal



DVB Channel Coding: Interleaver



DVB Channel Coding: Outer coding (RS), interleaving, framing

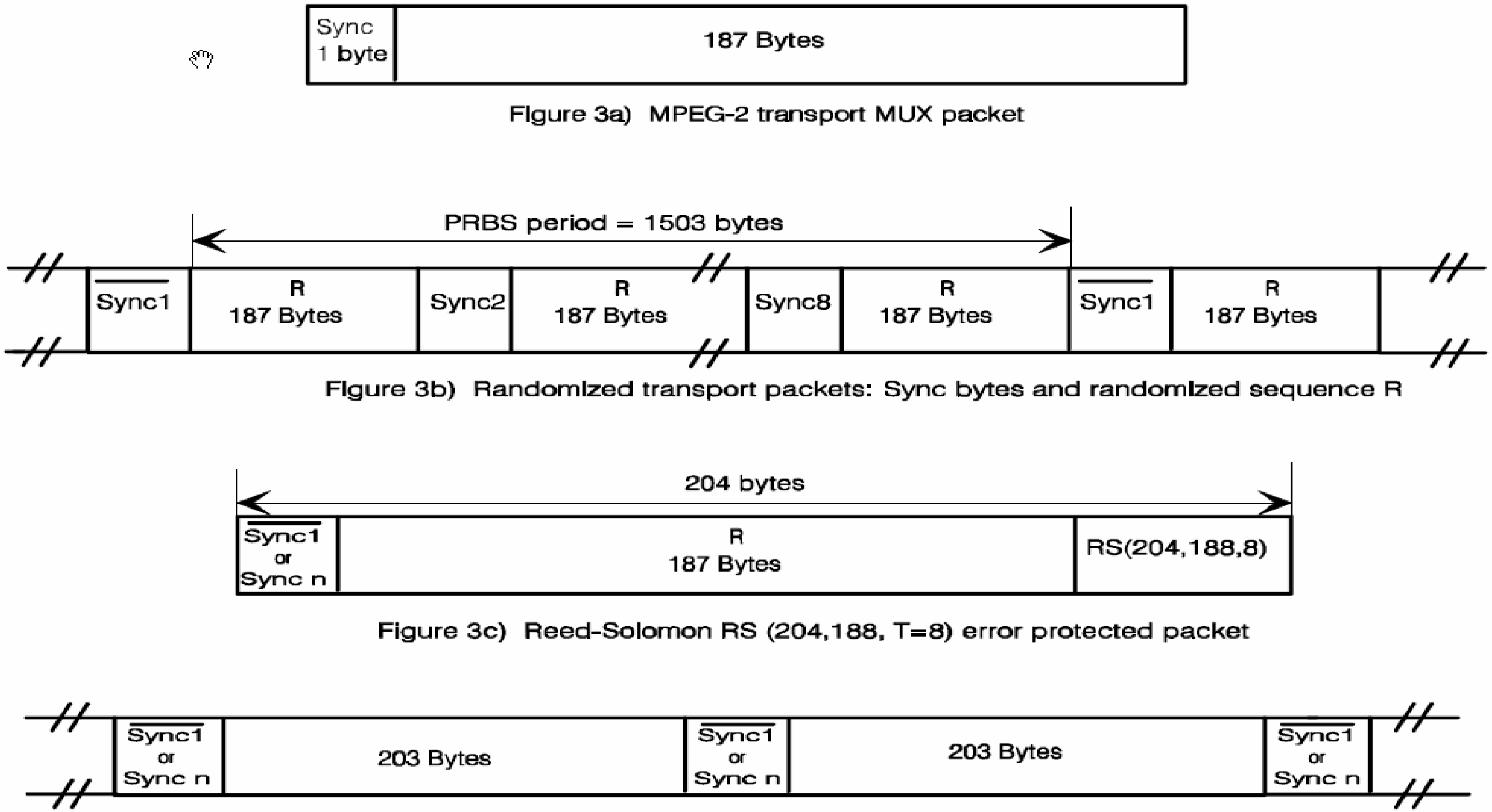


Figure 3a) MPEG-2 transport MUX packet

Figure 3b) Randomized transport packets: Sync bytes and randomized sequence R

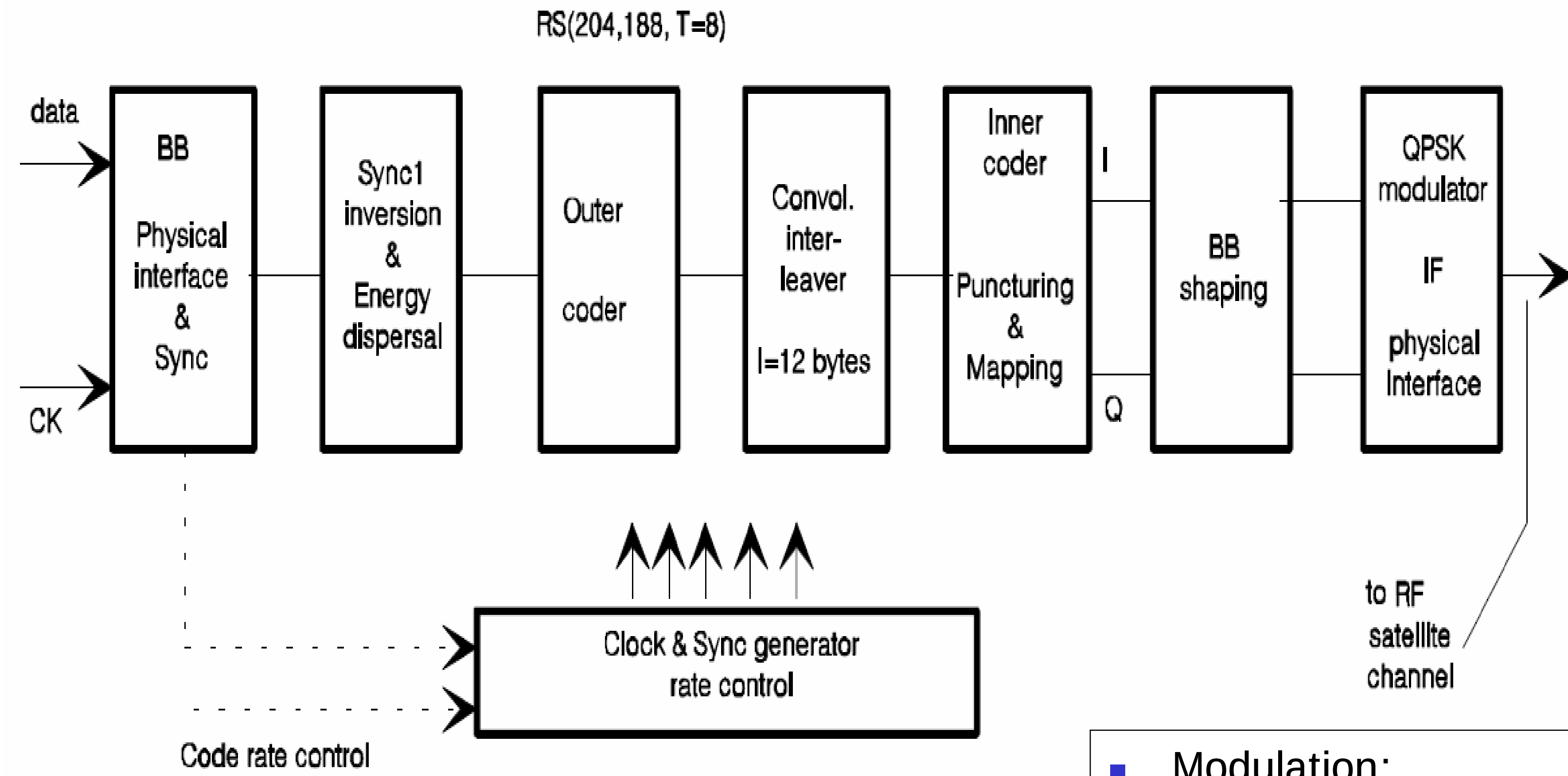
Figure 3c) Reed-Solomon RS (204,188, T=8) error protected packet

Figure 3d) Interleaved frames; interleaving depth I=12 bytes

$\overline{\text{Sync1}}$ = not randomized complemented sync byte

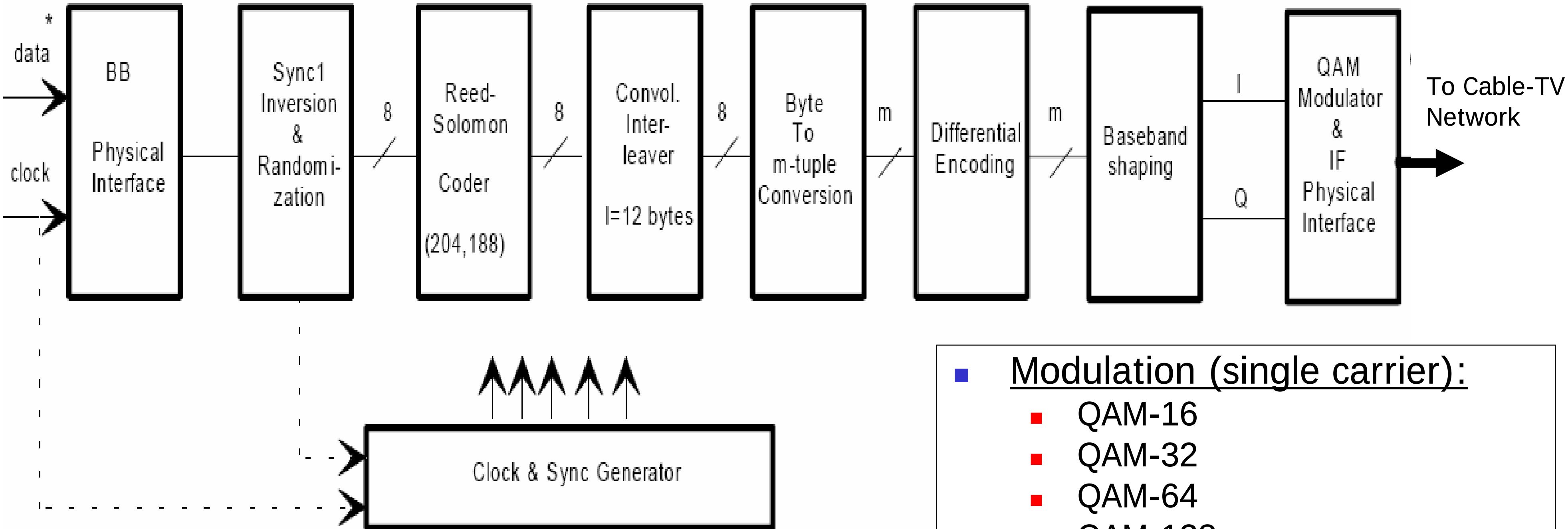
Sync n = not randomized sync byte, n = 2, 3, ..., 8

DVB-S Satellite Broadcasting (Transmitter Site Processing)



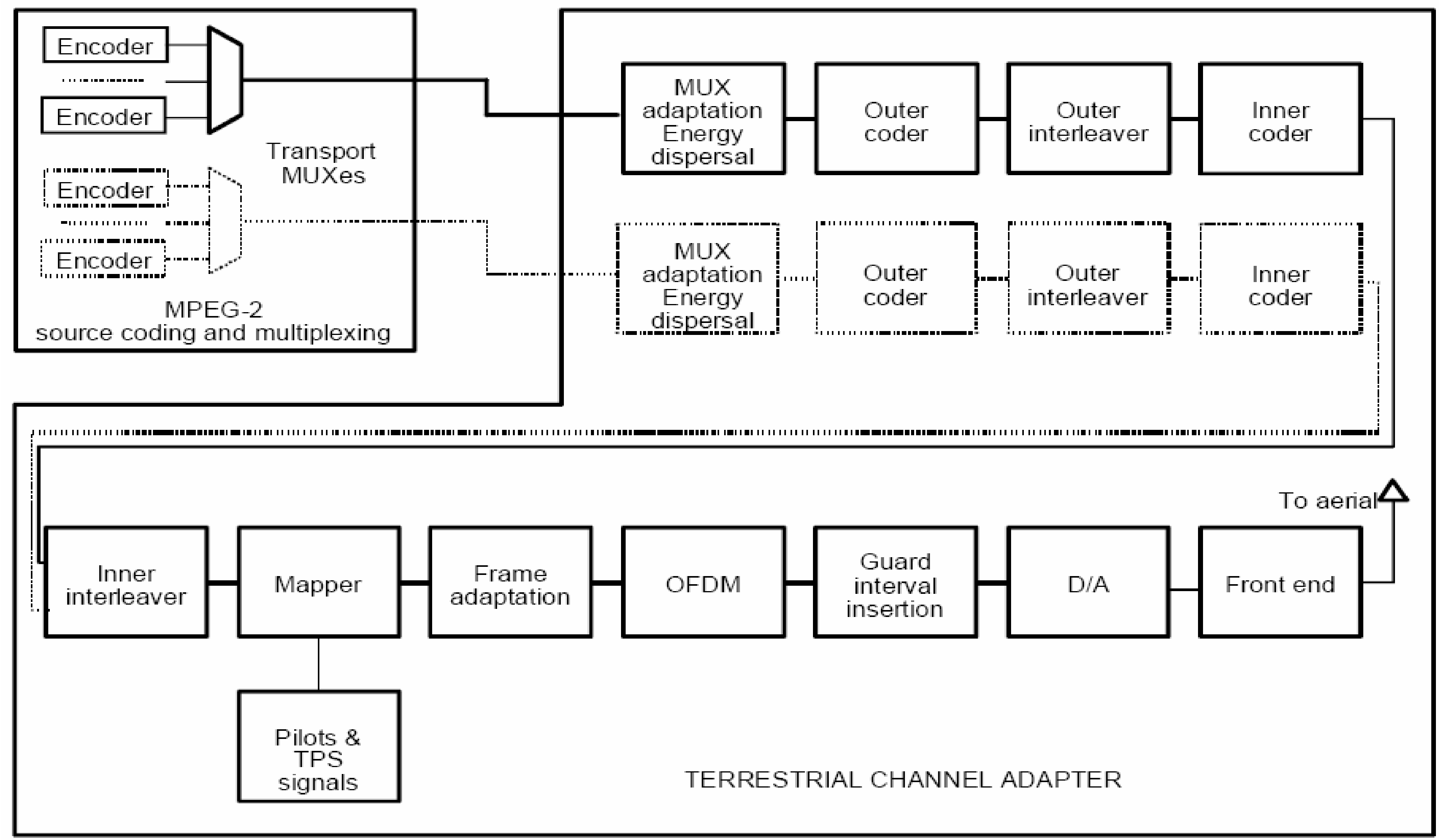
- <u>Modulation:</u>
  - QPSK (single carrier)
- <u>Convolutional code rates:</u>
  - ½, 2/3, ¾, 5/6, 7/8

DVB-C Cable Broadcasting (Transmitter Site Processing)



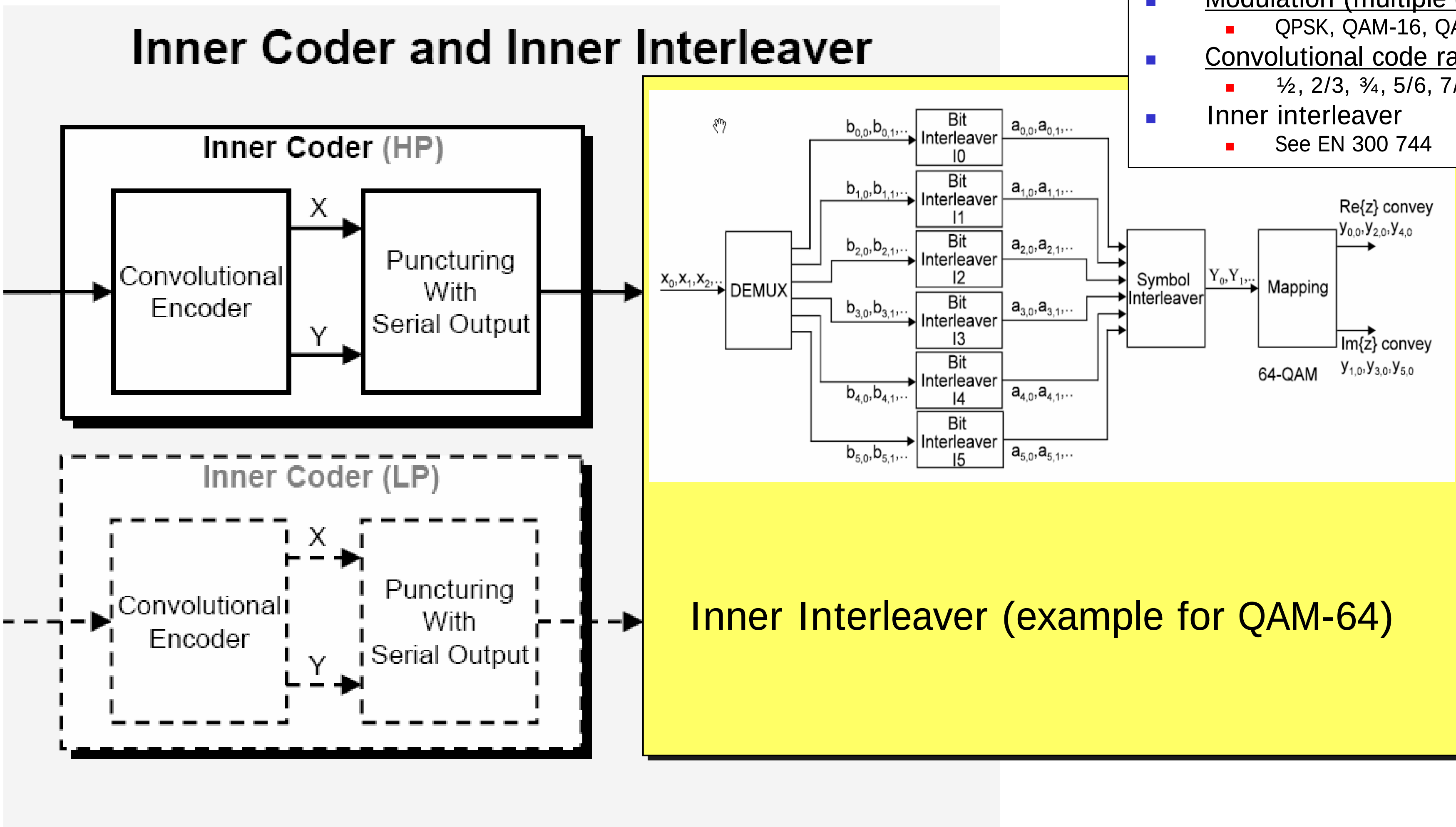
- Modulation (single carrier):
  - QAM-16
  - QAM-32
  - QAM-64
  - QAM-128 or
  - QAM-256
- Inner Coder:
  - Byte to m-tuple conversion

DVB-T Terrestrial Broadcasting

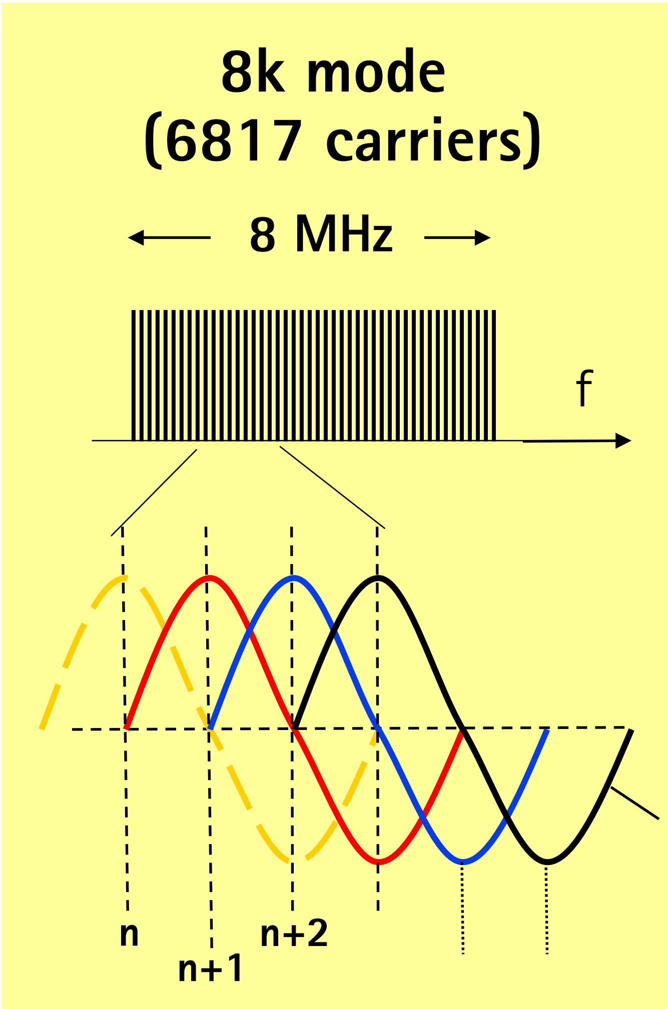


DVB-T Channel Coding: Inner Interleaver

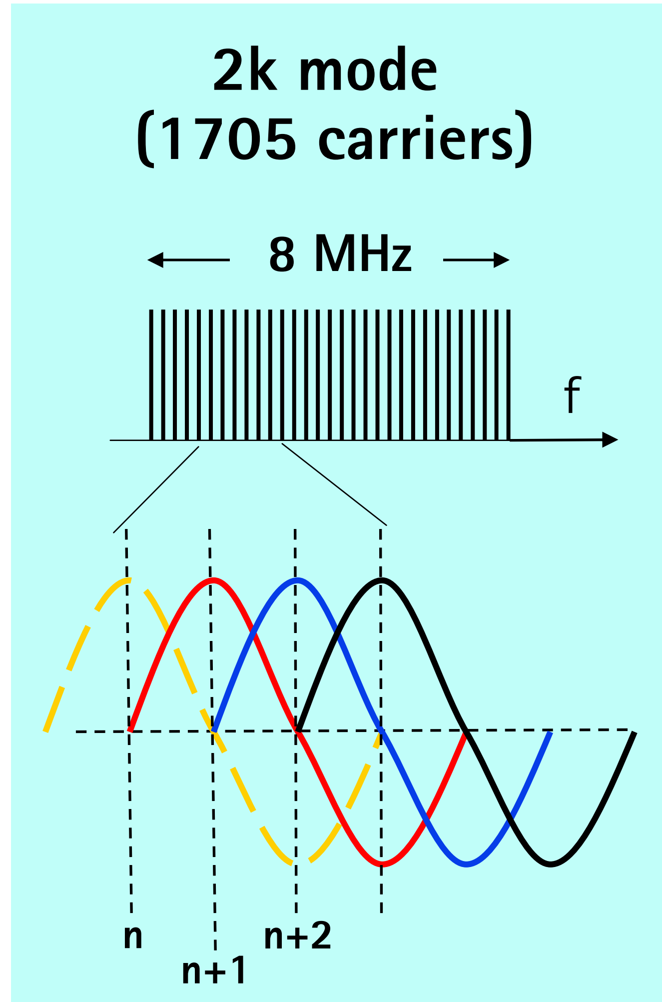
- Modulation (multiple carriers):
  - QPSK, QAM-16, QAM-64
- Convolutional code rates:
  - ½, 2/3, ¾, 5/6, 7/8
- Inner interleaver
  - See EN 300 744



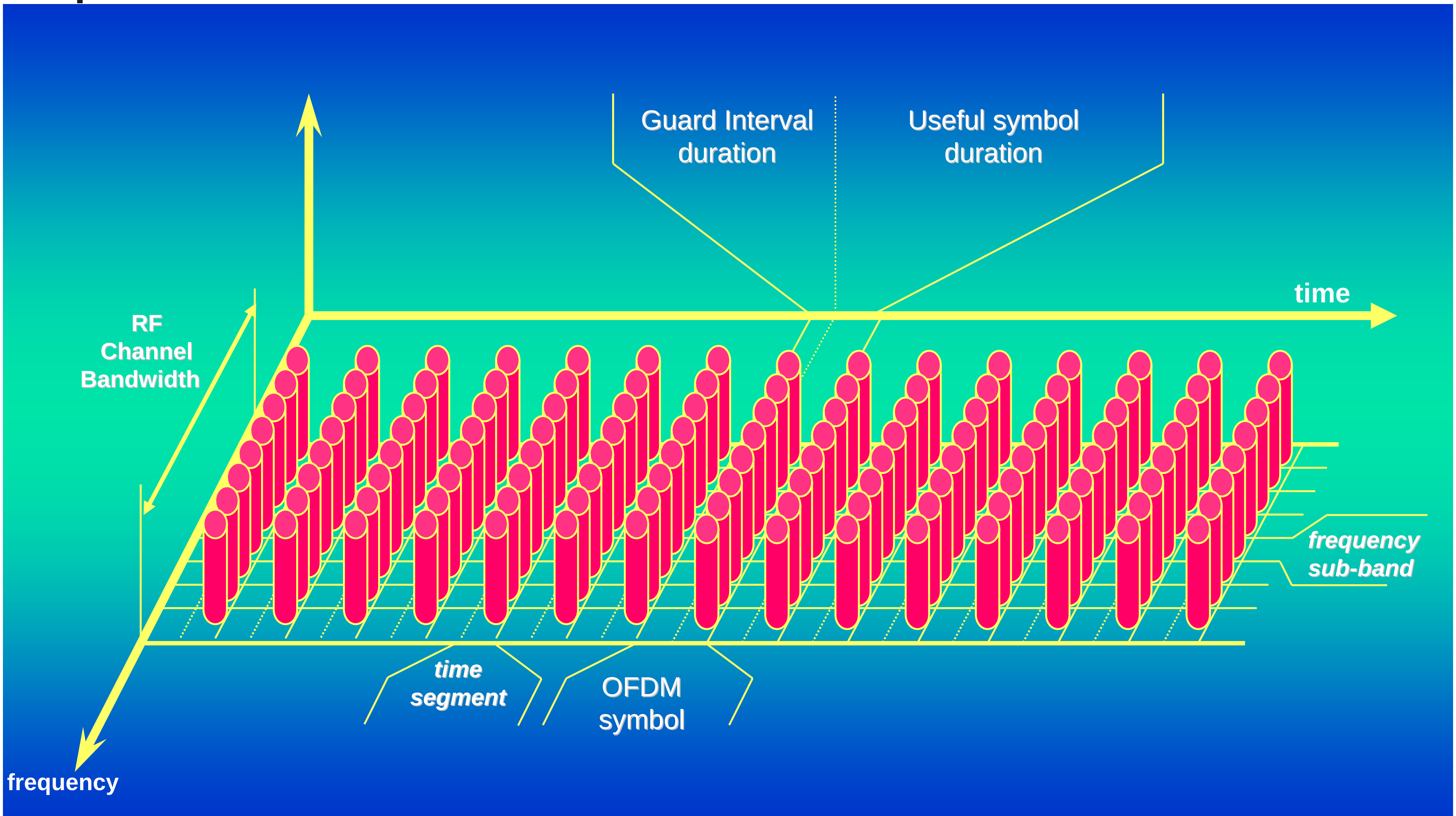
DVB-T Modulation Method: COFDM (Coded Orthogonal Frequency Division Multiplexing)



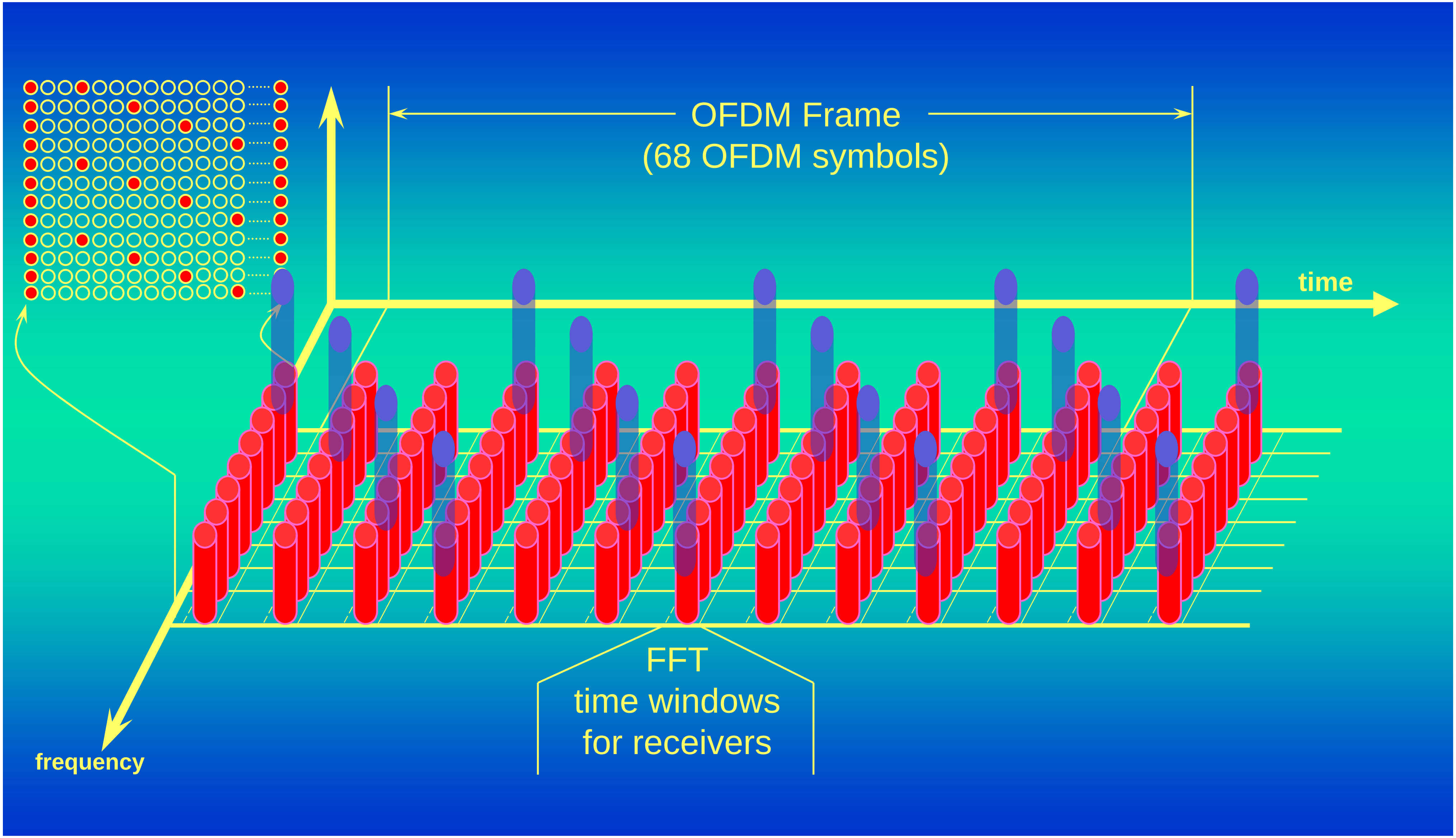
Each carrier QPSK, 16 QAM, or 64 QAM modulated



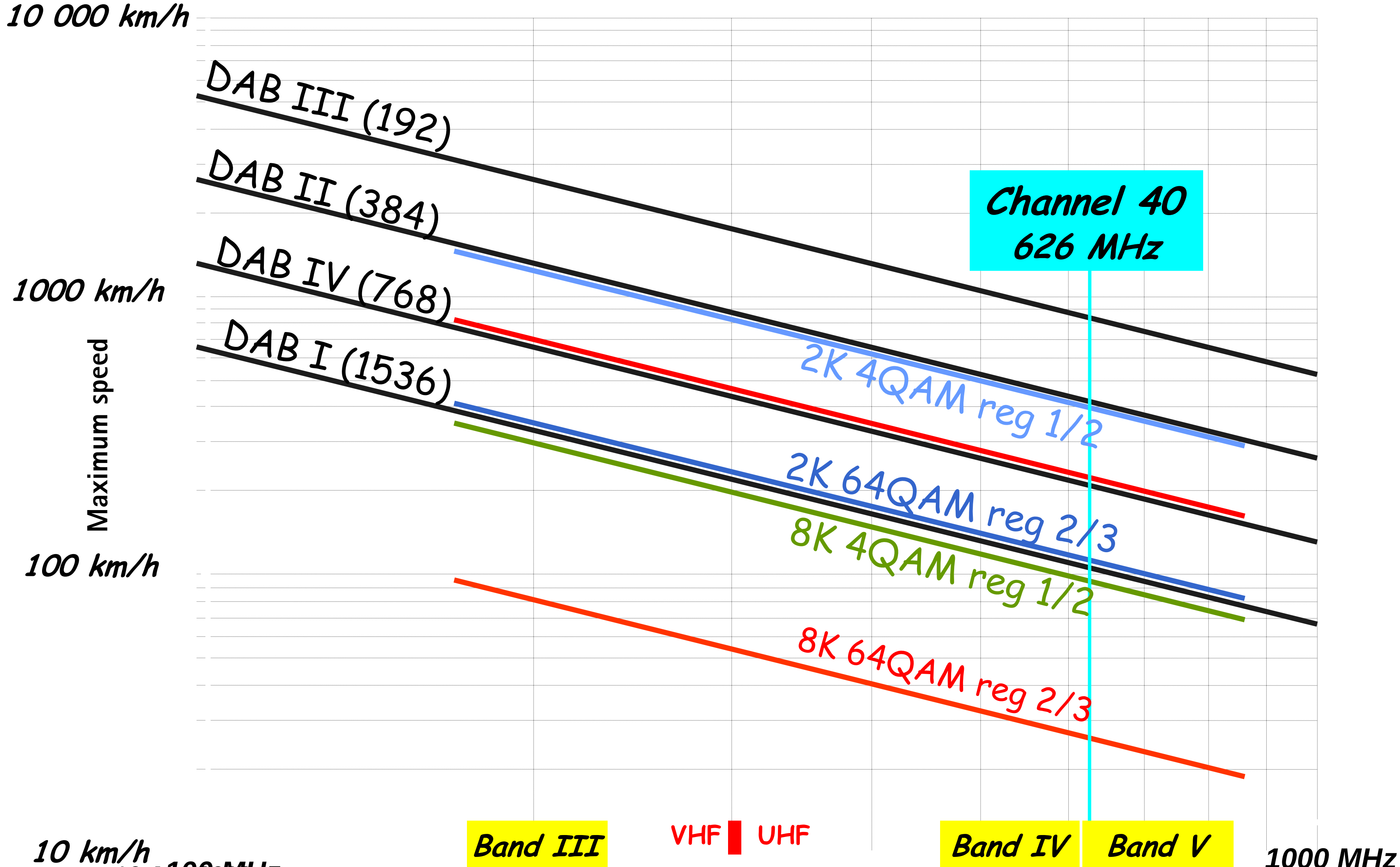
DVB-T COFDM Carrier Arrangement



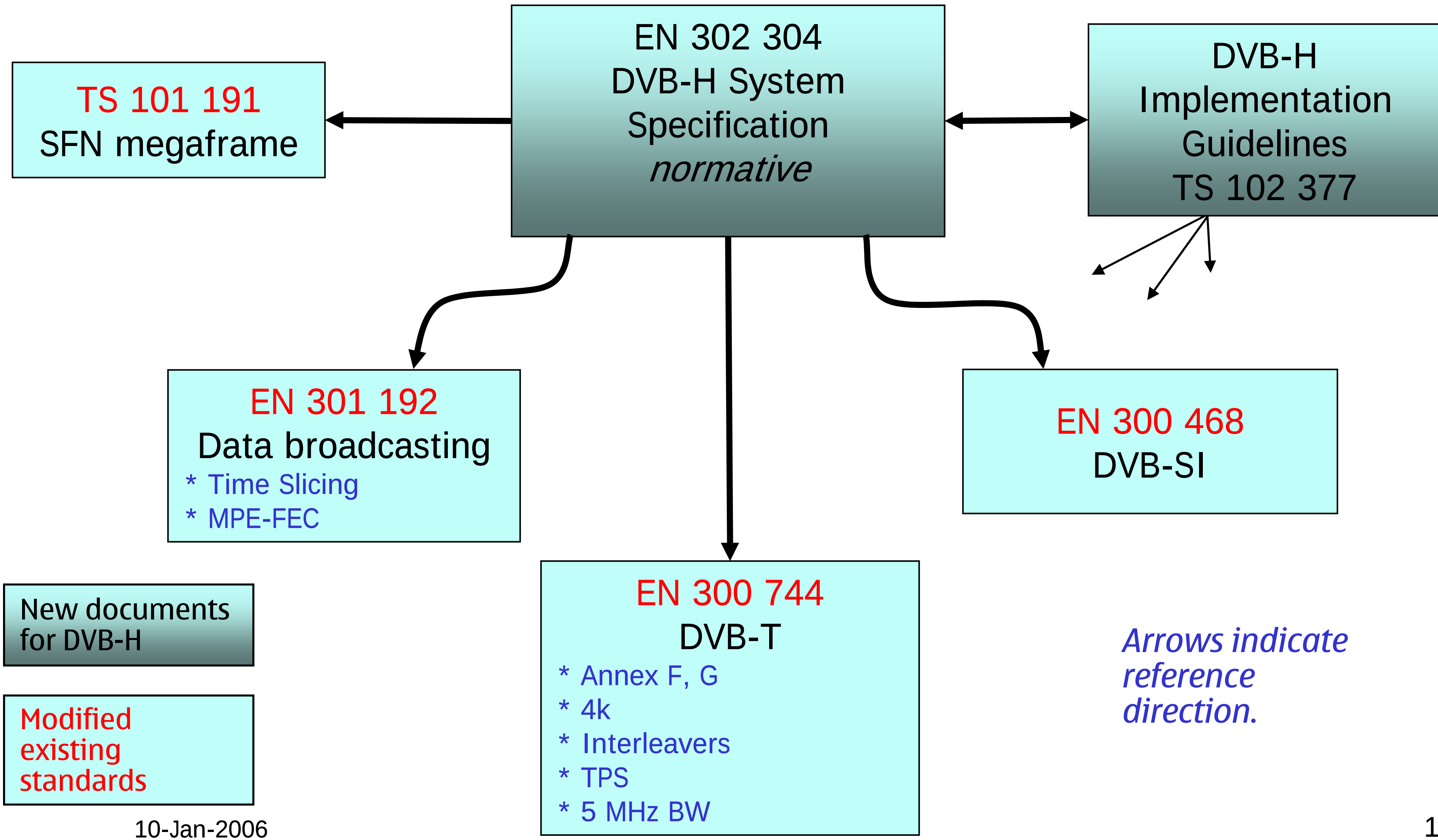
Synchronization Pilots for Receiver Locking



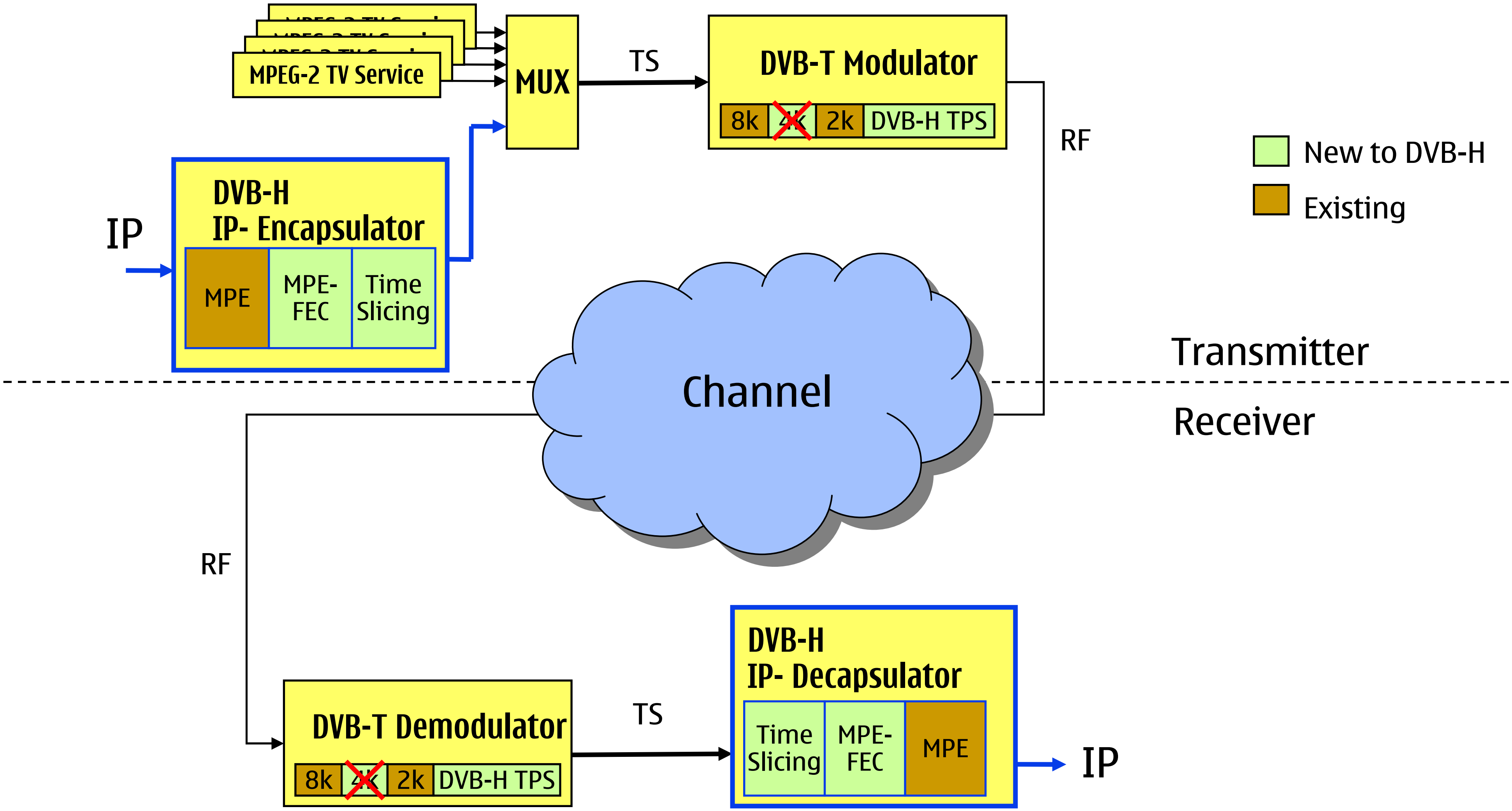
Maximum Speed vs. Frequency (DVB-T 2K & 8K and DAB)



DVB-H Standards



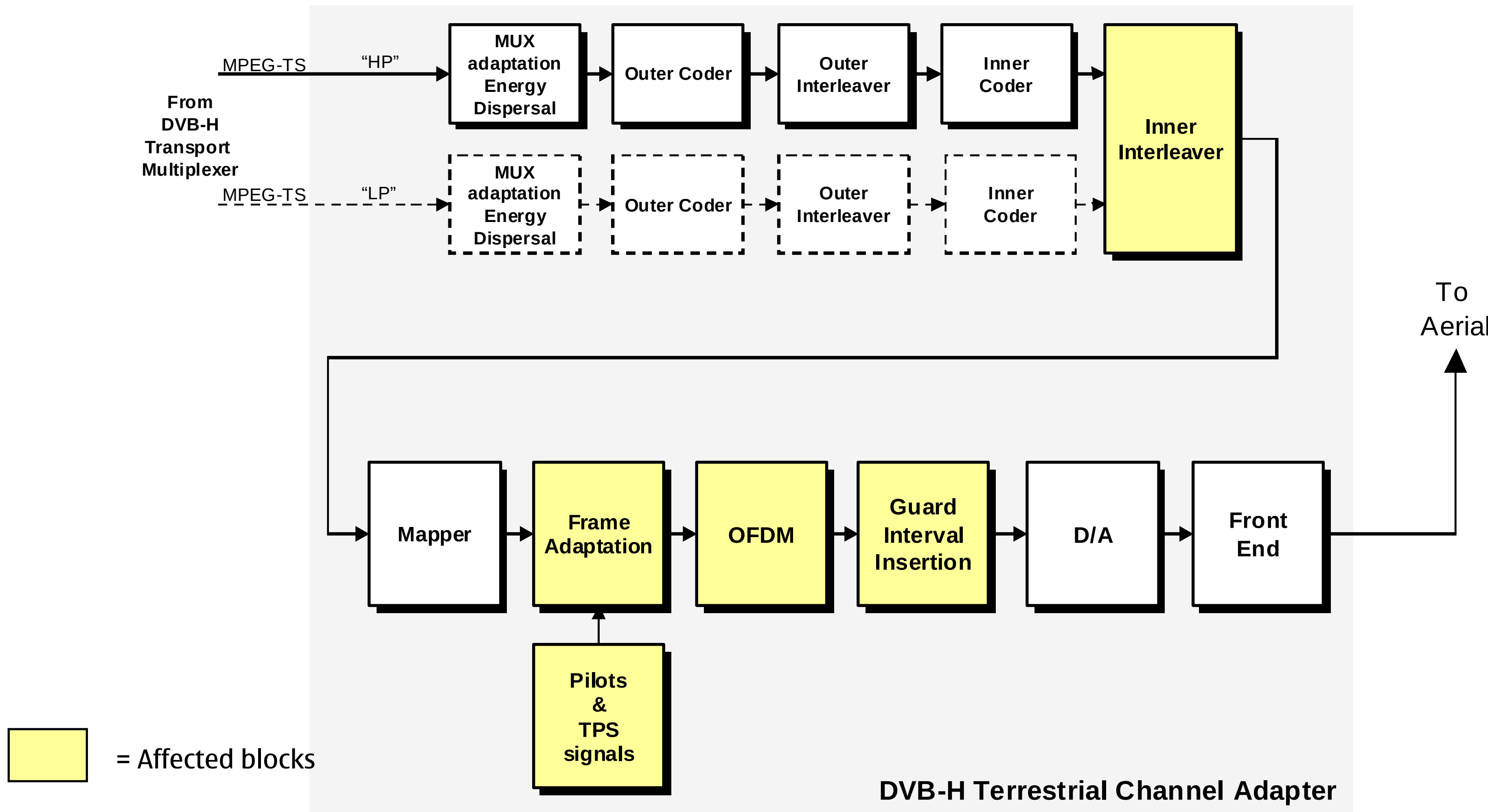
DVB-H System (see EN 302 304!)



From DVB-T to DVB-H

- DVB-T as a physical transfer layer has been specified in ETS 300 744.
- With the introduction of DVB-H some new features have been added to the specification.
  - 4K mode, in-depth interleavers, DVB-H signalling, parameters for 5 MHz operation in non-broadcast bands.
  - Additions have been done in Annexes F and G.
  - Some references from the main text to new annexes.
  - Some editorial corrections in the main text.
  - Additions are not intended for fixed broadcasting.
- New DVB-H documents have been created
  - EN 302 304 Transmission System for Handheld Terminals
    - In just a short document referring to EN 300 744 and some other documents which have been updated during the process
  - TS 102 377 DVB-H Implementation Guidelines
    - 4K-mode and physical layer aspects
    - Time slicing principle explained
    - MPE-FEC functionality explained
    - DVB-H/DVB-T compatibility issues
    - DVB-H services
    - Hierarchical modulation
    - Handover
    - Etc.

DVB-H System Blocks Modified from DVB-T System

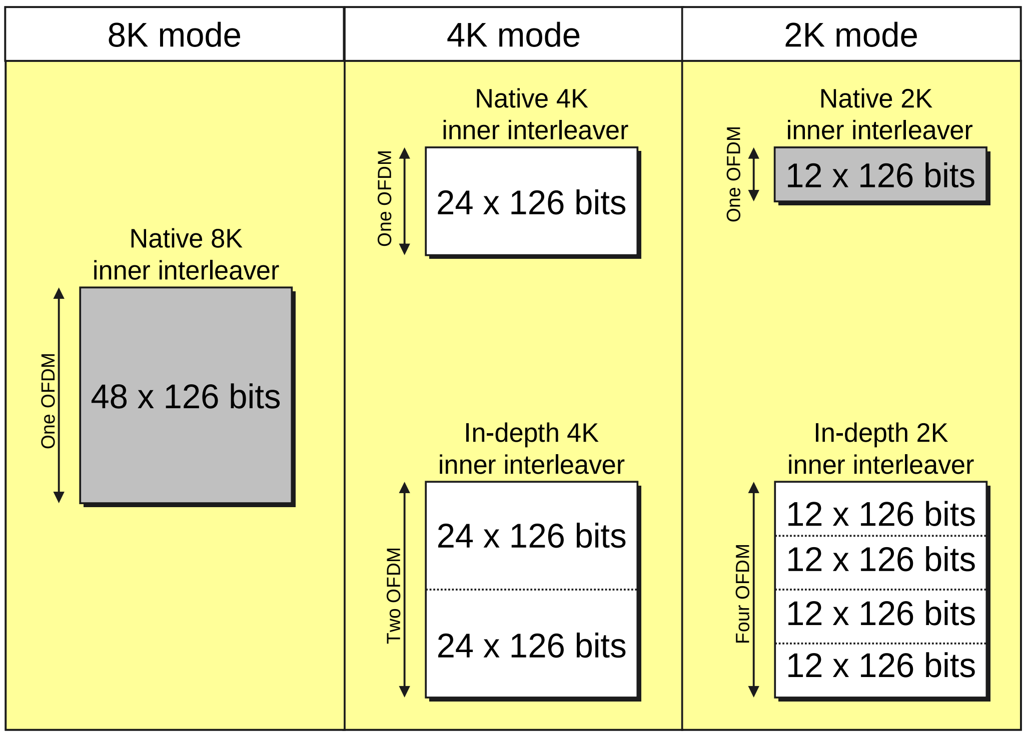


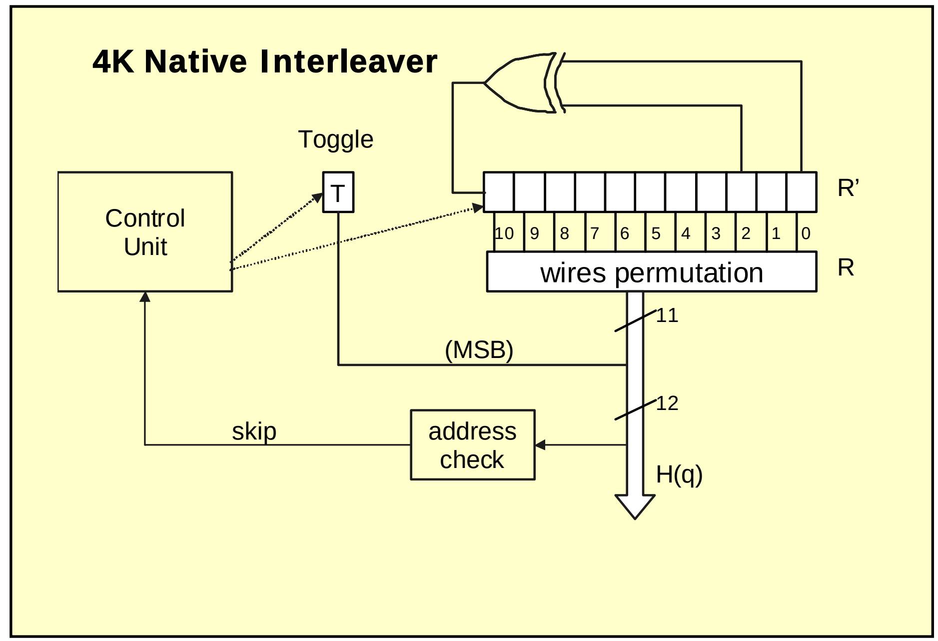
4K-Mode is an Interpolation Between 2K- and 8K-Mode

- The additional 4K DVB terrestrial transmission mode is an interpolation of the parameters defined for the 2K and 8K transmission modes.
- It aims to offer an additional trade-off between transmission cell size and mobile reception capabilities, providing an additional degree of flexibility for network planning.
- Features of 8K, 4K and 2K transmission modes:
  - 8K transmission mode
    - can be used both for single transmitter operation:
    - suitable for small, medium and large SFNs
    - allows high-speed reception
  - 4K transmission mode
    - can be used both for single transmitter operation
    - Suitable for small and medium SFNs
    - allowing very high speed reception
  - 2K transmission mode
    - can be used for single transmitter operation
    - suitable and for small SFNs with limited transmitter distances
    - allows extremely high speed reception

4K Native Interleaver and In-depth Interleaver

- Bit interleaving block size is 126 bits and 24 blocks are needed to cover one OFDM symbol in 4K mode
- In-depth interleaver goes over two symbol times so that impulse noise immunity is quasi-similar to 8K mode
- The native 4K interleaver uses the same general structure as the 2K/ 8K interleavers; a new permutation table has been developed





DVB-H: Continual and TPS Pilots in 4K Mode

- 4K mode uses 89 continual pilots
  - 8K: 177, 2K: 45
- 4K mode uses 34 TPS pilots
  - 8K: 68, 2K: 17
- 4K mode uses 3024 data carriers
  - 8K: 6048, 2K: 1512

Continual pilots carrier positions for 4K mode (index number k)											
0	48	54	87	141	156	192	201	255	279	282	333
432	450	483	525	531	618	636	714	759	765	780	804
873	888	918	939	942	969	984	1 050	1 101	1 107	1 110	1 137
1 140	1 146	1 206	1 269	1 323	1 377	1 491	1 683	1 704	1 752	1 758	1 791
1 845	1 860	1 896	1 905	1 959	1 983	1 986	2 037	2 136	2 154	2 187	2 229
2 235	2 322	2 340	2 418	2 463	2 469	2 484	2 508	2 577	2 592	2 622	2 643
2 646	2 673	2 688	2 754	2 805	2 811	2 814	2 841	2 844	2 850	2 910	2 973
3 027	3 081	3 195	3 387	3 408							

TPS carrier indices for 4K mode											
34	50	209	346	413	569	595	688	790	901	1 073	1 219
1 262	1 286	1 469	1 594	1 687	1 738	1 754	1 913	2 050	2 117	2 273	2 299
2 392	2 494	2 605	2 777	2 923	2 966	2 990	3 173	3 298	3 391		

DVB-H: Transmitter Parameter Signalling (TPS)

- TPS information contains 68 bits; one bit sent in every OFDM symbol
- In 4K mode there are 34 carriers for TPS bits
- TPS is defined over 68 consecutive OFDM symbols, referred as one OFDM frame
- Specially DVB-H related TPS bits are defined in Annex F of EN 300 744

Bit number	Format	Purpose/Content
s_0	see clause 4.6.2.1	Initialization
s_1 to s_{16}	0011010111101110 or 1100101000010001	Synchronization word
s_{17} to s_{22}	see clause 4.6.2.3	Length indicator (see annex F)
s_{23}, s_{24}	see table 10	Frame number
s_{25}, s_{26}	see table 11	Constellation
s_{27}, s_{28}, s_{29}	see table 12	Hierarchy information (see annex F)
s_{30}, s_{31}, s_{32}	see table 13	Code rate, HP stream
s_{33}, s_{34}, s_{35}	see table 13	Code rate, LP stream
s_{36}, s_{37}	see table 14	Guard interval
s_{38}, s_{39}	see table 15	Transmission mode (see annex F)
s_{40} to s_{47}	see clause 4.6.2.10	Cell identifier
s_{48} to s_{53}	all set to "0"	See annex F
s_{54} to s_{67}	BCH code	Error protection

DVB-H Dedicated TPS Bits

Bit number	Format	Purpose/Content
s_{17} - s_{22}	see clause F.4.6.2.3	Length indicator
s_{27}, s_{28}, s_{29}	see clause F.4.6.2.6	Hierarchy information
s_{38}, s_{39}	see clause F.4.6.2.9	Transmission mode
s_{48}, s_{49}	see clause F.4.6.2.11	DVB-H signalling
s_{50} - s_{53}	all set to "0"	Reserved for future use

33 usable bits

Interleavers: bits s27-s29

Transmission modes: bits s38-s39

Time slicing and MPE-FEC usage

Bits s_{27}, s_{28}, s_{29}	α value
000	Non hierarchical
001	$\alpha = 1$
010	$\alpha = 2$
011	$\alpha = 4$
100	see annex F
101	see annex F
110	see annex F
111	see annex F

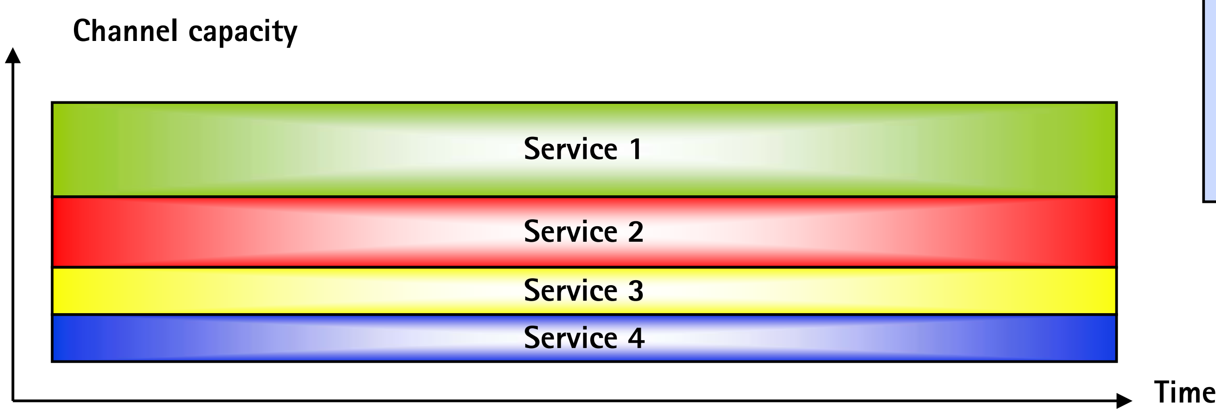
In-depth interleavers in use

Bits s_{38}, s_{39}	Transmission mode
00	2K mode
01	8K mode
10	4K mode
11	reserved

s_{48}	s_{49}	DVB-H signalling
0	x	Time Slicing is not used
1	x	At least one elementary stream uses Time Slicing
x	0	MPE-FEC not used
x	1	At least one elementary stream uses MPE-FEC
NOTE: "x" means whatever bit state.		

Time Slicing Reasoning

- In normal DVB-T MPEG-2 and data transmissions the transport streams from the services are multiplexed together with high frequency on the TS-packet level.
- This means that the services are transmitted practically in parallel, each service having it's share of the TS-packets.



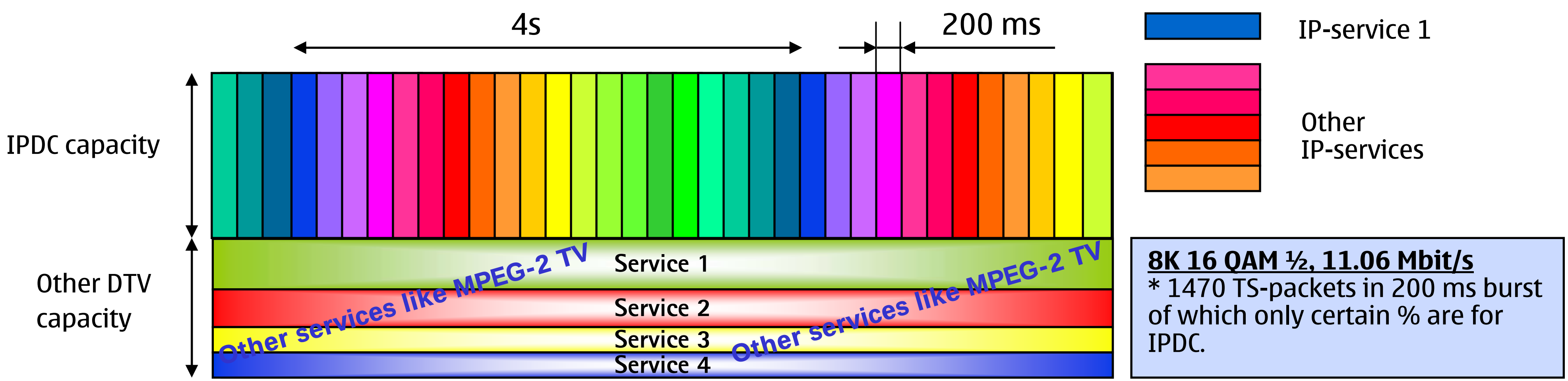
<u>8K 16 QAM ½ 1/8, 11.06 Mbit/s</u>

* 7.412 TS-packets/OFDM-symbol
* 1 Symbol = 1008 us
* 136 us / TS-packet

- For a DVB-T receiver it is impossible to receive only the wanted TS-packets due to the high multiplexing rate.
- All data must be received -> high power consumption.

Time Slicing Principle

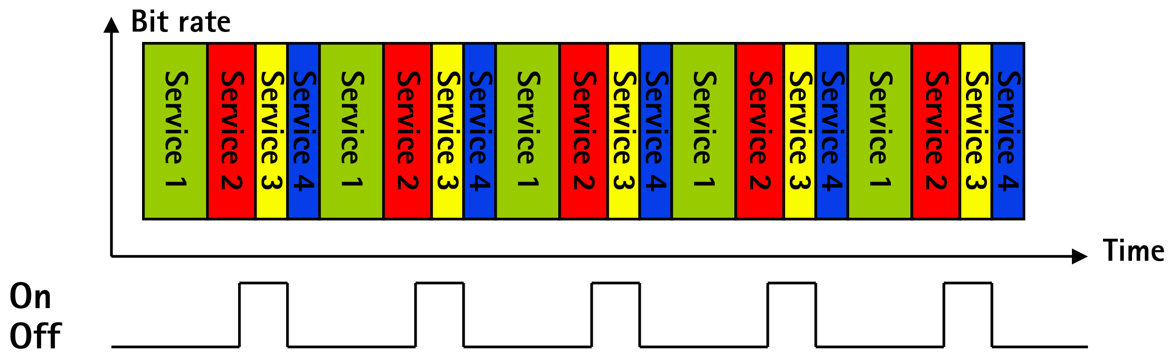
- In time slicing principle the IP-services take certain time slice of the MPE data service when the large portion of the channel capacity is reserved for that service:
  - In this example time slice: 200 ms
  - Full capacity of the MPE data service is reserved for one IP-service at a time
- After longer period, let's say 4 seconds, the first service is again in transmission
- And so on ...
- Timing slicing and transmission times can be configured and signalled dynamically to all receivers in the system



- The IPDC service is just another "MPE-data pipe" for the DVB-system and can be freely multiplexed with other transport streams.

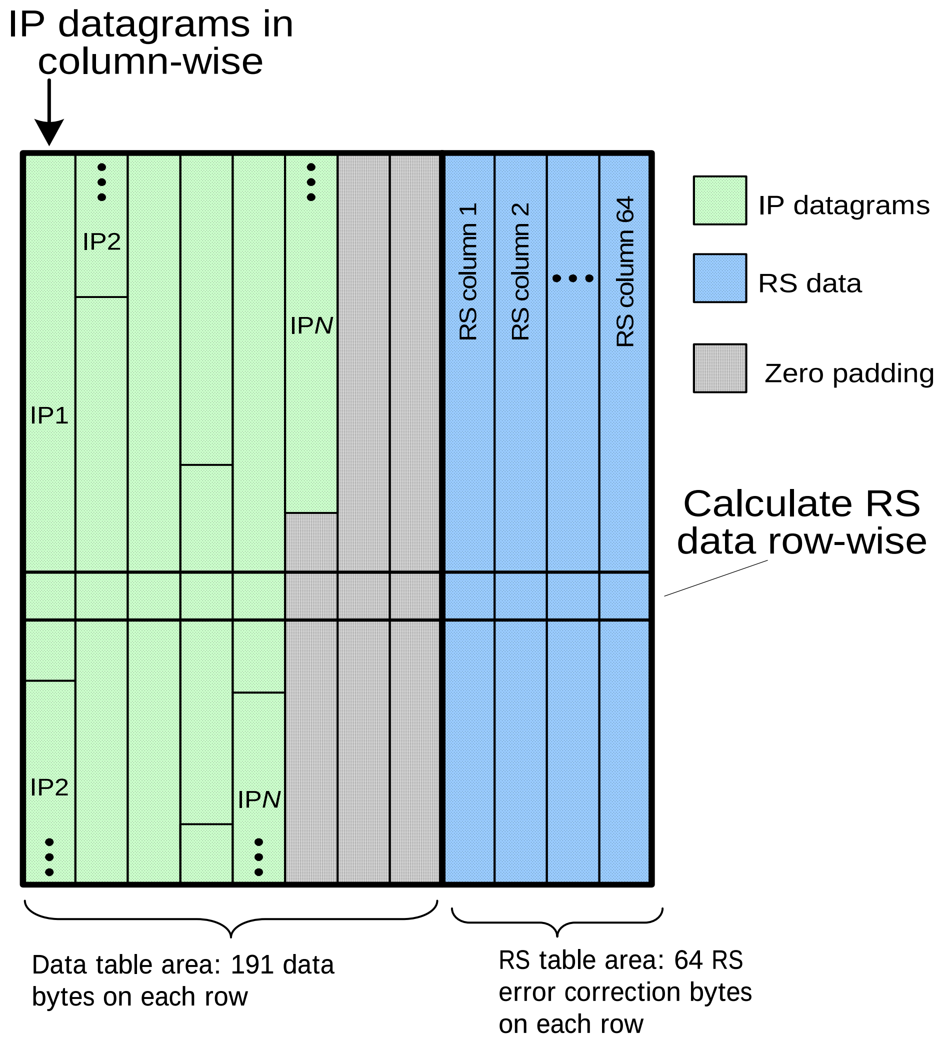
Time Slicing Facts

- DVB-T is by default intended for continuous transmission
  - Synchronisation times are rather long: in the order of 200 ms.
  - Thus long time intervals have to be used to have full gain.
- The receiver has to know when to wake up
  - This is done by sending time difference to the next relevant burst
  - Real time signalling per elementary stream using Delta-T method.
- PSI/SI not Time Sliced
  - Not required for power saving
- Time Sliced and non-Time Sliced services in common multiplex
  - Only receiver switched off, transmitter on all the time
  - Support for Time Slicing not mandatory to receive Time Sliced service
- Buffer in terminal required for constant output rate
- Figure below: “Yellow Service” (Service 3) is of interest



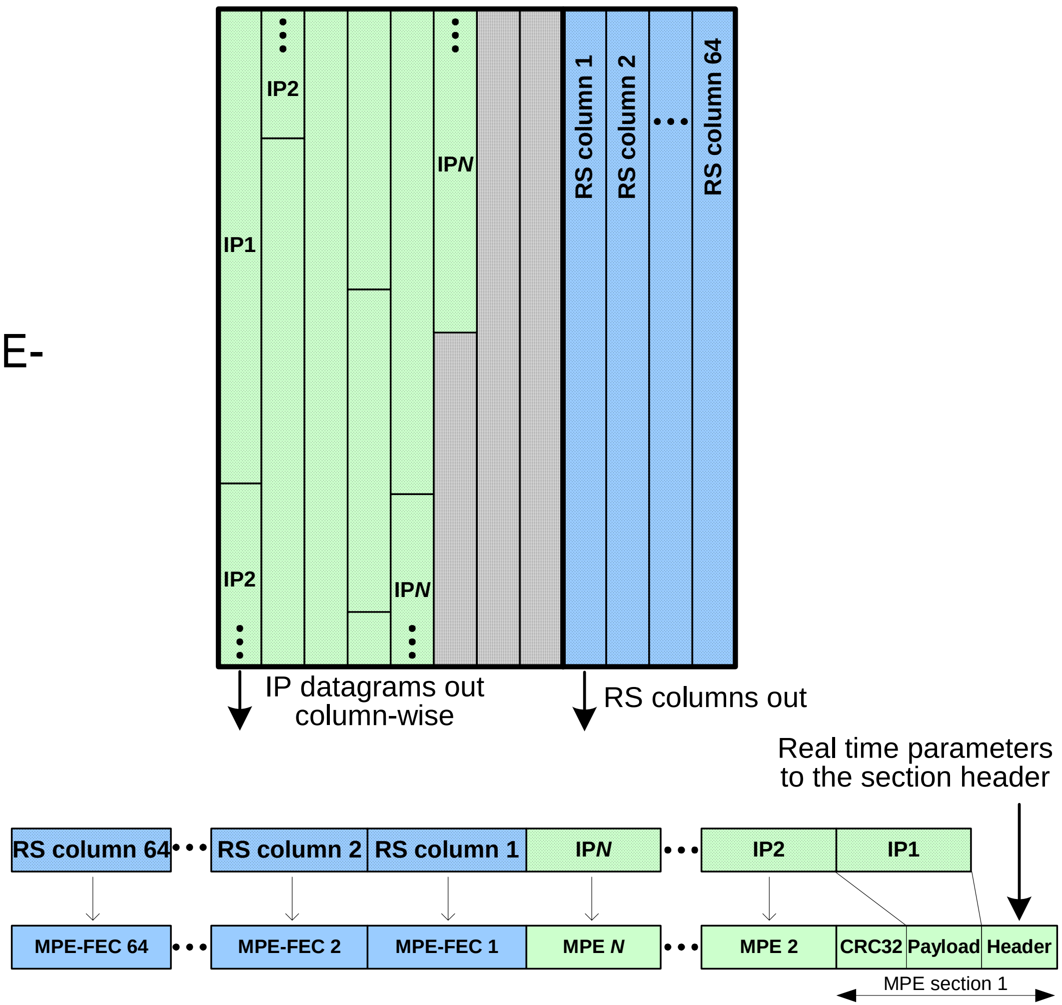
MPE-FEC as Additional Data Protection: Transmission #1

1. Fill in the Application data table column-wise with IP datagrams
   - Fill in until the next IP does not fit
   - Or until delta-t period has passed
2. Add zero padding after the last IP datagram to the end of the table
3. Do the RS encoding for each row in the Application data table
4. Add the resulting 64 RS parity bytes to the corresponding row in the RS data table
   - Now both tables are ready



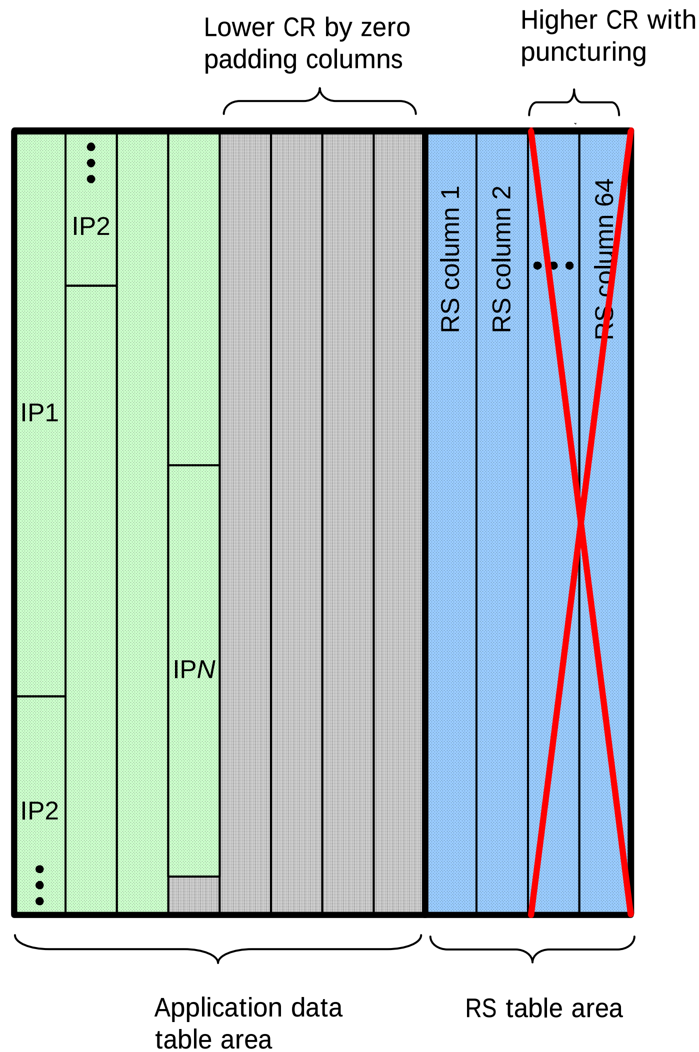
MPE-FEC as Additional Data Protection: Transmission #2

5. Read out IP datagrams column-wise
6. Read out RS columns
7. Encapsulate IP datagrams into the MPE sections
8. Encapsulate RS columns into the MPE-FEC sections
9. Add real time parameters to the header of every section
10. Calculate CRC 32 to the end of the section
11. Write out the sections starting from MPE 1
    - Zero padding is not transmitted



Code Rate Adjustments in MPE-FEC

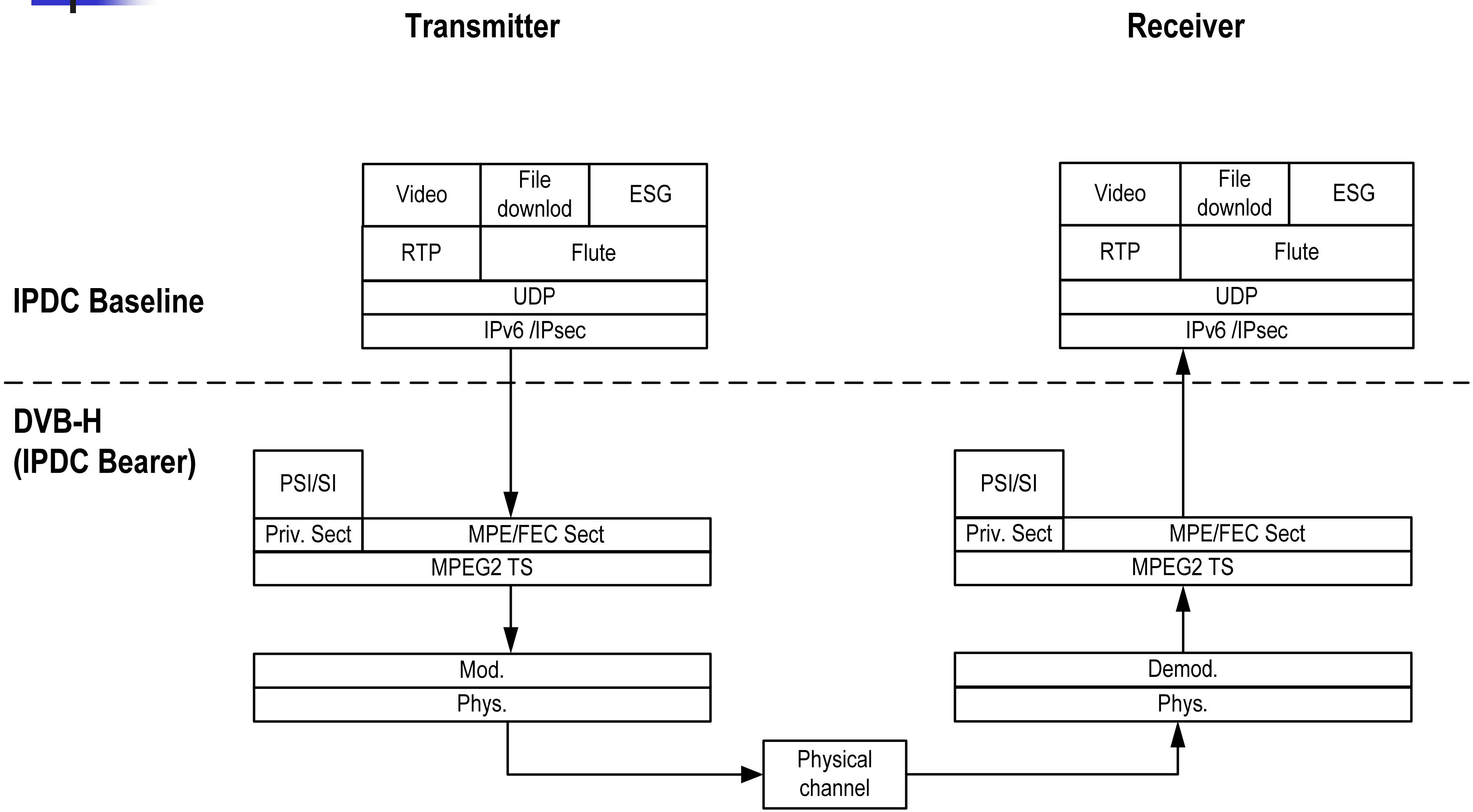
- Code rate k/n can be decreased by having less information bytes (k) and increased by having less parity bytes (n-k)
- Higher code rate can be achieved with puncturing RS data columns after encoding
- Lower code rate can be achieved by adding zero padding columns to the application data area
- Normal code rate for MPE-FEC is CR=191/255≈3/4
- Examples for other rates:
  - CR=1/2 ⇒ number of padding columns is 127
  - CR=2/3 ⇒ number of padding columns is 63
  - CR=5/6 ⇒ number of punctured columns is 26



IPDC Baseline Standardization - Services

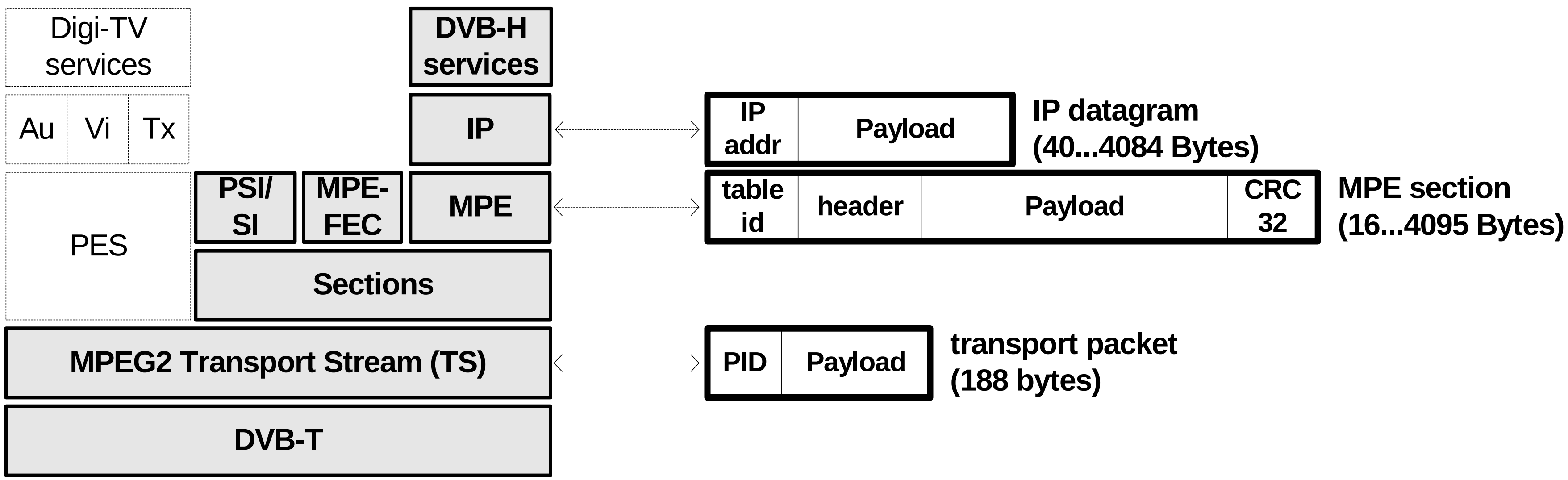
- Video
  - H.263 and H.264 (MPEG-4 AVC)
  - IRD A 128kbps, QCIF-15fps
  - IRD B 384kbps, CIF-15fps => QVGA-15fps
  - IRD C 768kbps, CIF-30fps => QVGA-30fps
- File download
  - Use of FLUTE Protocol by default
- ESG (Electronic Service Guide)
  - Service announcement
  - IP addresses
- Baseline standardization going on in DVB-CBMS

IP Data casting (IPDC) over DVB-H: Protocol Stack



DVB-H Protocol Stacks

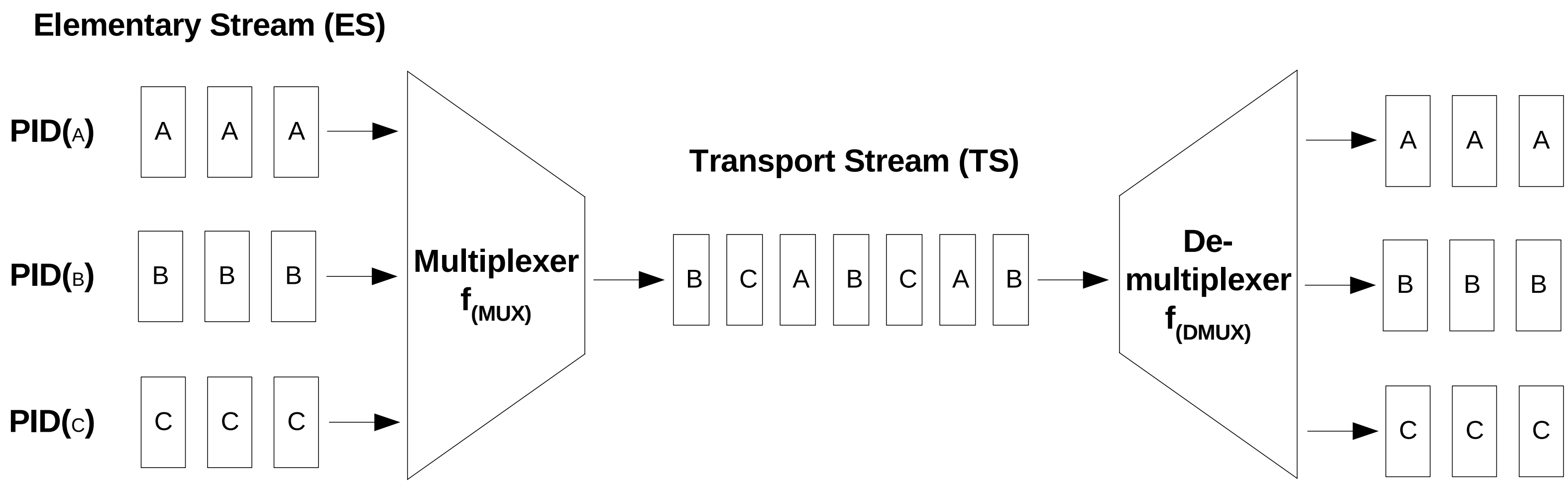
- DVB-H defines the delivery of IP datagrams on DVB-T signal to a mobile terminal



- DVB-T carries a Transport Stream
- Transport Stream is a series of transport packets
  - 188 bytes, PID (Packet Identifier) in the header
- Sections carried on transport packet payload
  - Fragmenting may be required
- PSI/SI sections carry the signalling / announcements
- Payload of each MPE section carries a single IP datagram
- DVB-H services carried on IP

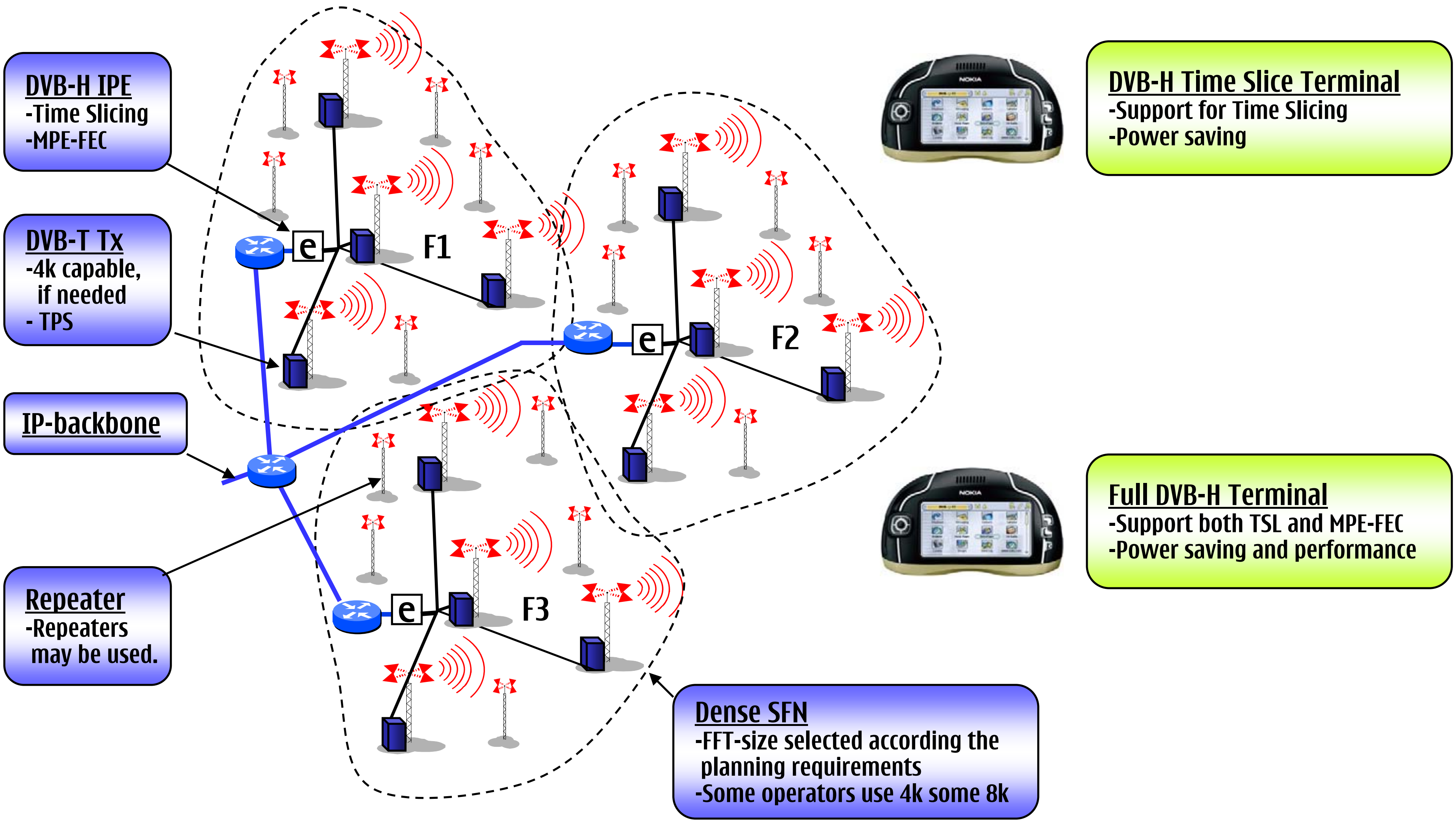
Transport Stream (TS)

- Multiplexer functionality (in a head end) builds a Transport Stream (TS) from multiple Elementary Streams (ES). One PID is allocated for each ES.
- Some PIDs are reserved for PSI/SI only
  - PSI/SI carries the mapping between the input streams and PIDs
- The output bitrate of a multiplexer (i.e. the bitrate of the TS) remains static
  - If input streams require less bandwidth, null-packets (PID = 0x1FFF) added
  - If input streams require more bandwidth, some transport packets dropped

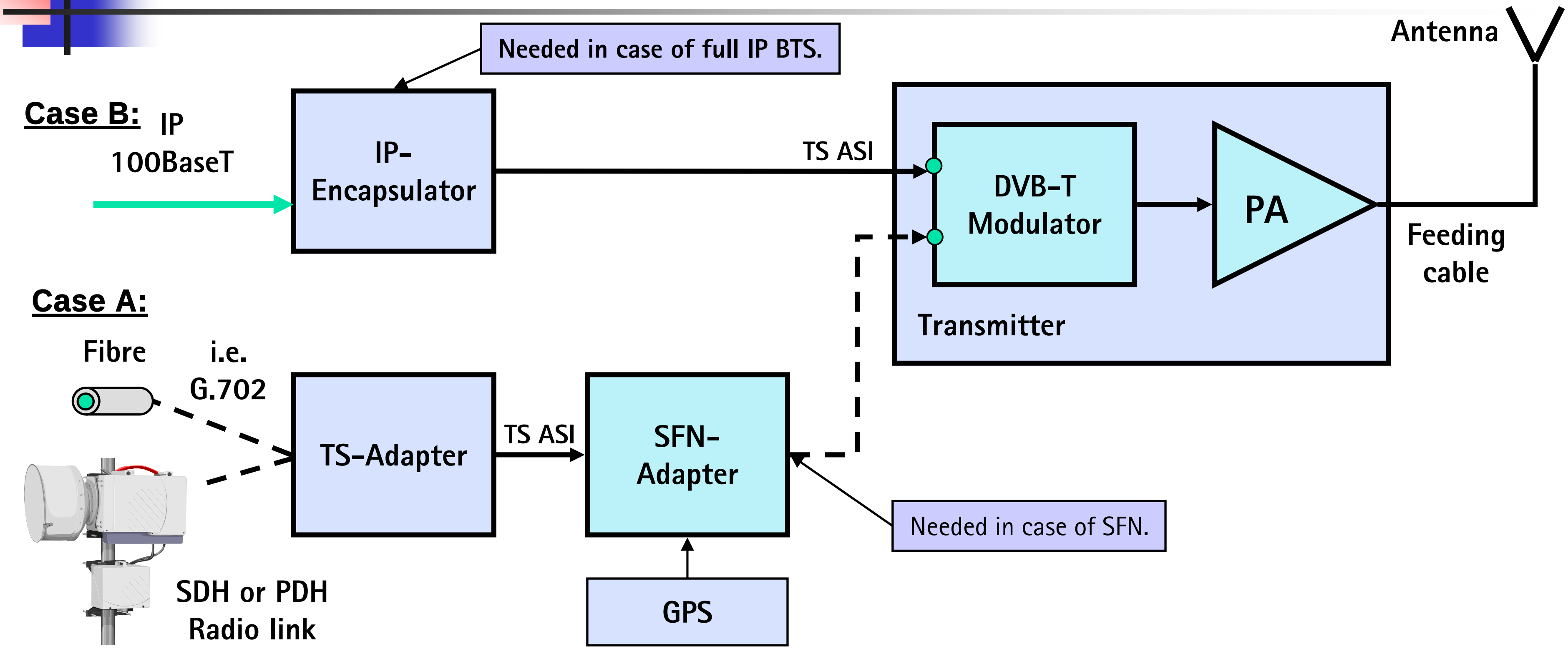


- By reading the PSI/SI, a receiver knows available input streams and used PIDs
- De-multiplexer functionality (in a receiver) filters the requested input stream(s)

DVB-H Network Topology

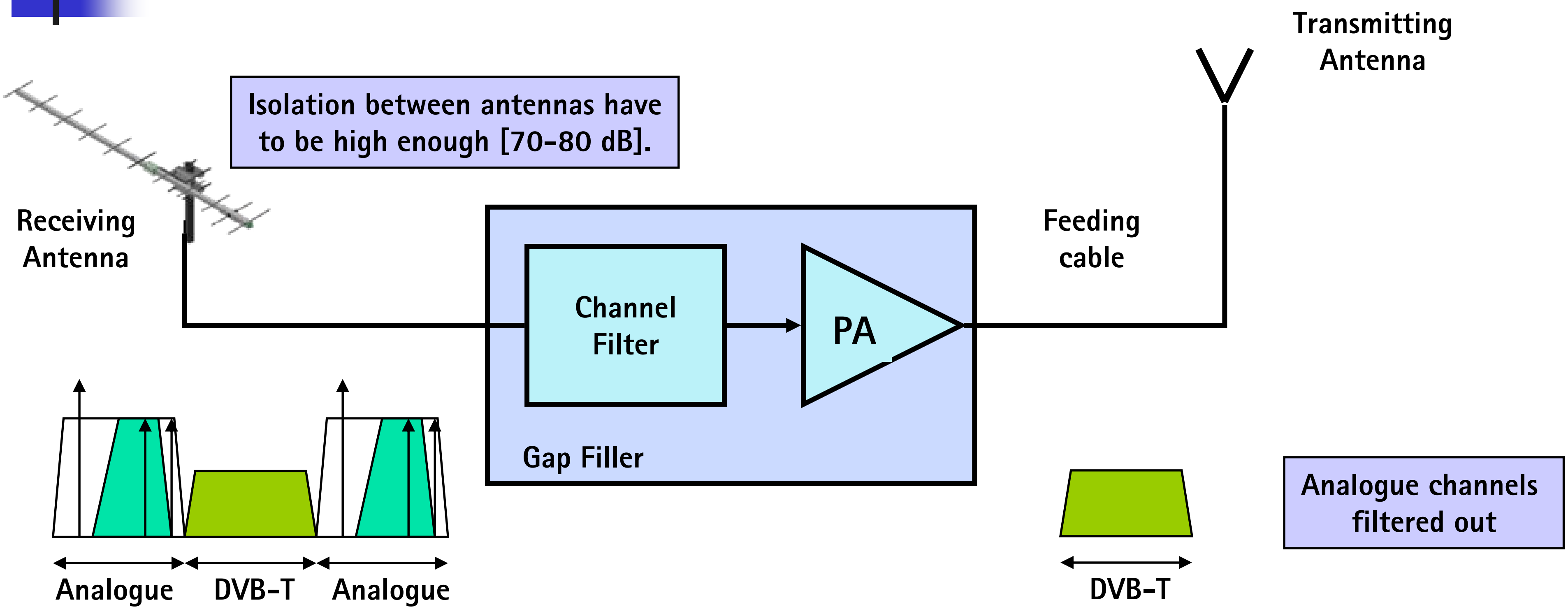


DVB-T/DVB-H Base Station



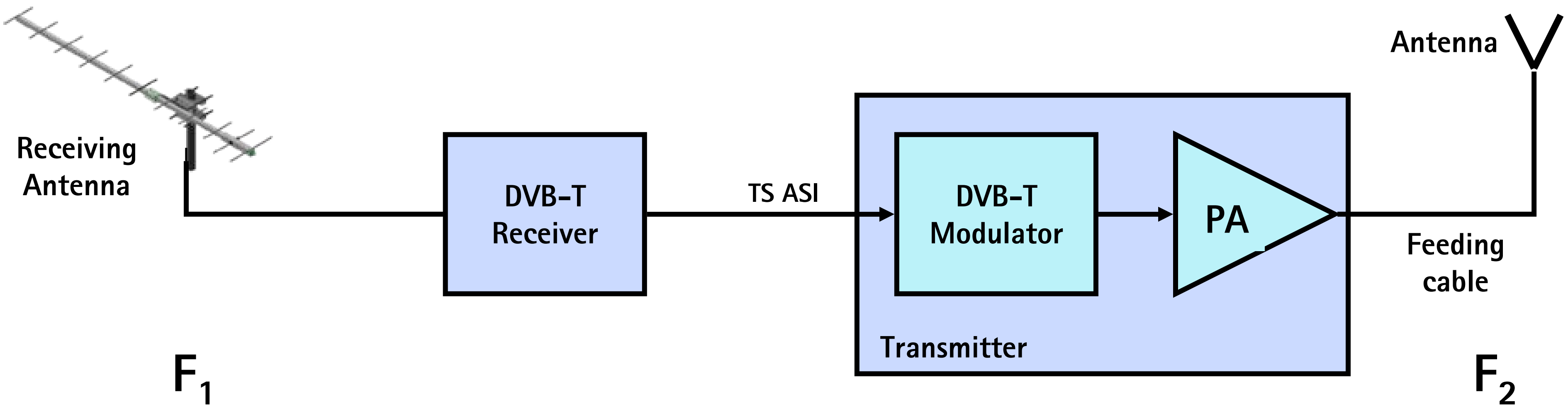
- Case A, Basic Setup: TS-feed is taken to the site via fibre or radio link.
  - SFN: SFN adapter is added between TS-adapter and DVB-T Modulator in case of Single Frequency Network (SFN)
- Case B, IP Transmission (DVB-H): IP-encapsulator on site, IP-connection via 100BaseT.
  - SFN: SFN adapter is added between TS-adapter and DVB-T Modulator in case of Single Frequency Network (SFN)

DVB-T/DVB-H Gap Filler Technology



- Gap Filler is a simple DVB-T transmitter which receives the signal from a main transmitter, filters, amplifies and re-radiates it.
- It does not include any modulator.
- It is a simple way of building SFNs.
- Output power is typically less than 50 W.

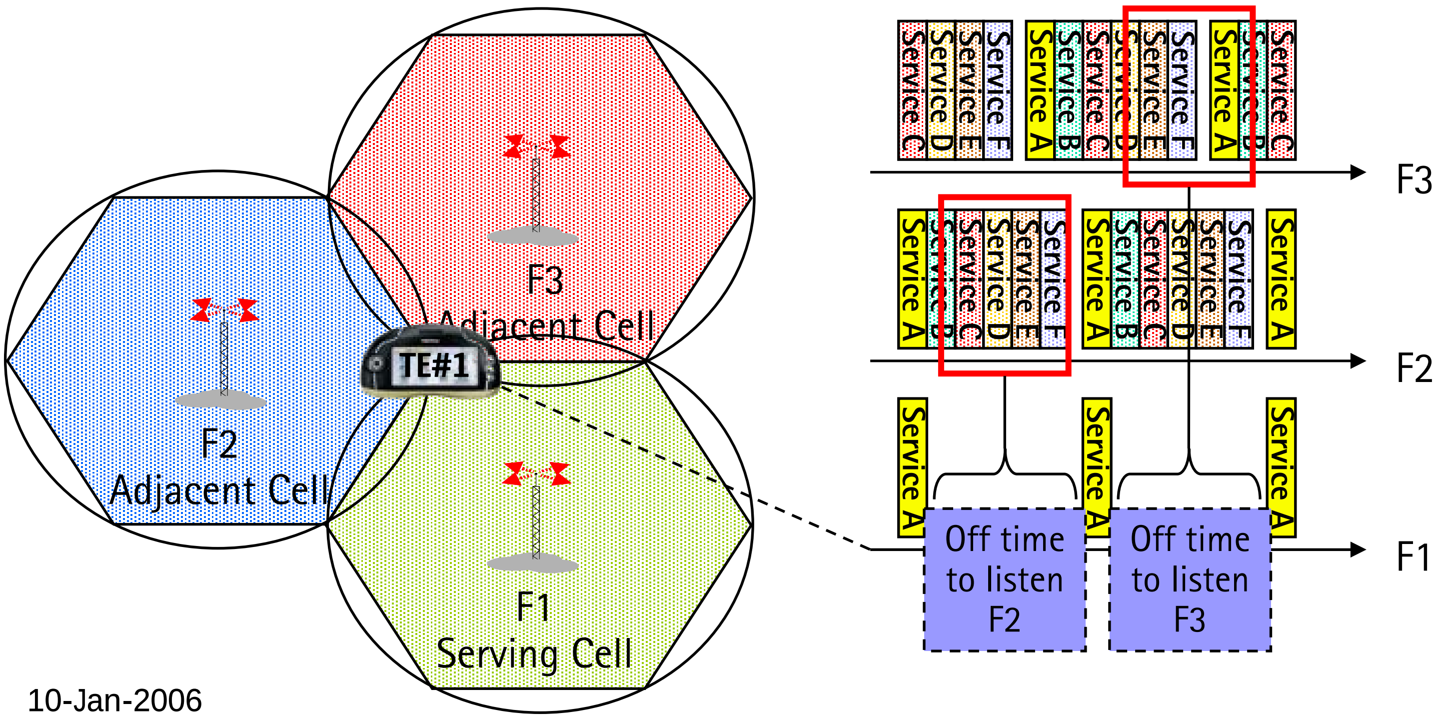
Relaying DVB-T/DVB-H Base Station



- The TS-stream [=IP] can be obtained by receiving the adjacent DVB-T cell with a DVB-T receiver. This is in general called relaying.
- In digital systems relaying does not degrade the signal.
- Relaying is cheaper than radio link.
- The receiving and transmitting frequencies must be different $\Rightarrow$ not suitable for SFN.

Handover Support in DVB-H

- Smooth handovers in regular DVB-T systems would require two front ends in the receiver.
- When receiver is in OFF state (not receiving a service) it can monitor neighbouring cells for possible soft handover
- Soft handover, maintaining the service, is possible with minimal increase in power consumption.
- Example: Terminal Equipment #1 (TE#1) is receiving Service A from service cell F1. During OFF-time TE#1 can listen to adjacent cells F2 and F3



Homework(s)

1. List error correction methods used in each of the DVB transmission media: DVB-S, DVB-C and DVB-T/DVB-H.
2. Make a comparison table of the technical features of 2K, 4K and 8K modes in DVB-T/DVB-H?
3. For what purposes are TPS bits used in DVB-T/DVB-H?

References

1. EN 300 421 DVB Framing structure, channel coding and modulation for 11/12 MHz satellite service (DVB-S)
2. EN 300 429 DVB Framing structure, channel coding and modulation for cable (DVB-C)
3. EN 300 744 DVB Framing structure, channel coding and modulation for digital terrestrial television (DVB-T)
4. EN 302 304 DVB-H Transmission System
5. TS 102 377 DVB-H Implementation Guidelines
6. EN 301 192 DVB specification for data broadcasting
7. EN 301 468 (DVB-SI) DVB service information
8. TS 101 191 SFN Megaframe for SFN Synchronization
9. Etc.