Digital Video Broadcasting

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Samoa- PMPC

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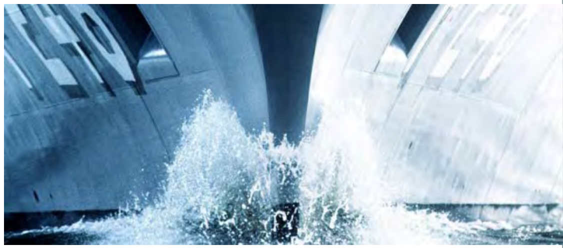
ROHDE&SCHWARZ

Rohde & Schwarz
fields of business

- **Wireless communications**
  Development and production test solutions
  for every second mobile phone in the world
- **Analog & digital TV**
  Transmitters for more than 80 countries
- **Air traffic control**
  Radiocommunications for more than 200 large airports
- **Secure communications**
  Radios in use worldwide for all branches of the armed forces
- **Management of the frequency spectrum**
  Instruments and systems for radiomonitoring
  and radiolocation for about 150 countries
- **Service & services**
  To be as close to the customer as possible, nearly 70
  locations worldwide



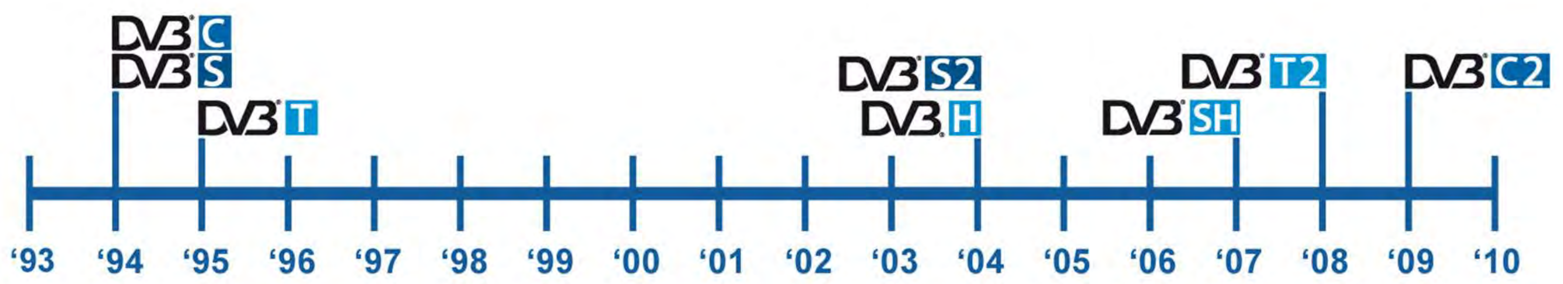
Broadcast & Media equipment

- High-tech for network operators
  - Analog and digital TV and radio transmitters of all power classes
  - Setup of nationwide networks for digital and mobile TV
  - T&M for maintenance and monitoring of operating networks

- Production & Storage solutions
  - Video Servers
  - Storage (Online/ nearline, NAS, SAN)
  - Post Production equipment

- High-tech for manufacturers of broadcasting equipment
  Test solutions from the earliest stages of development up to series production – all from a single source

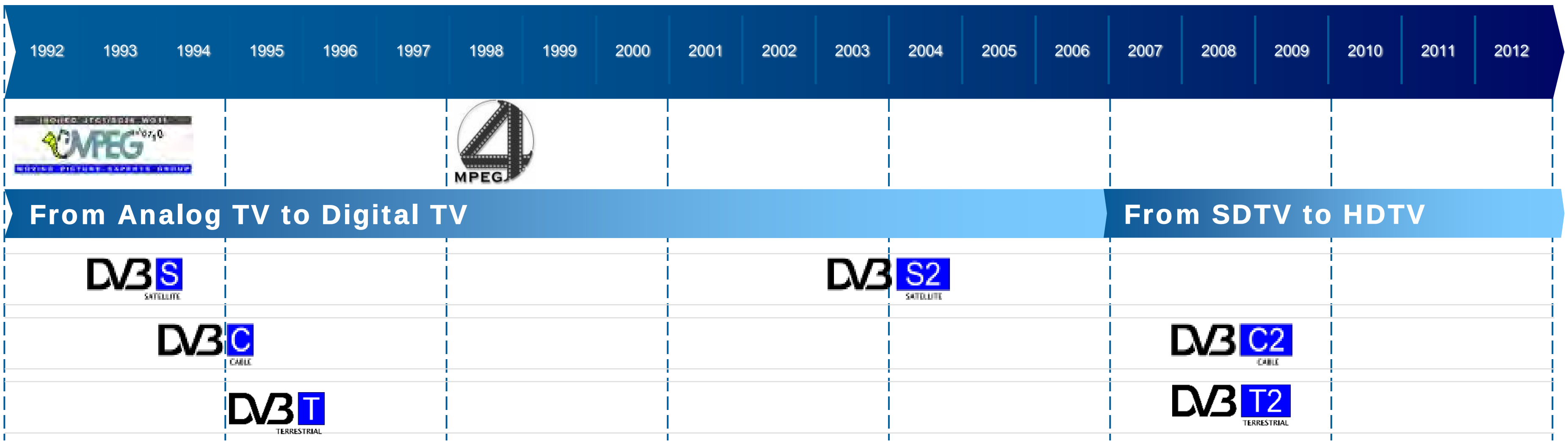
The DVB Project



- **Founded in 1993 with 8 Members**
- **Currently 280 Member Organisations in 34 Countries**
- **First Generation systems widely adopted worldwide**
- **Many DVB standards and specifications adopted by ETSI**
- **Second Generation systems are already deployed**

A long term dynamic to build a coherent Family of standards…

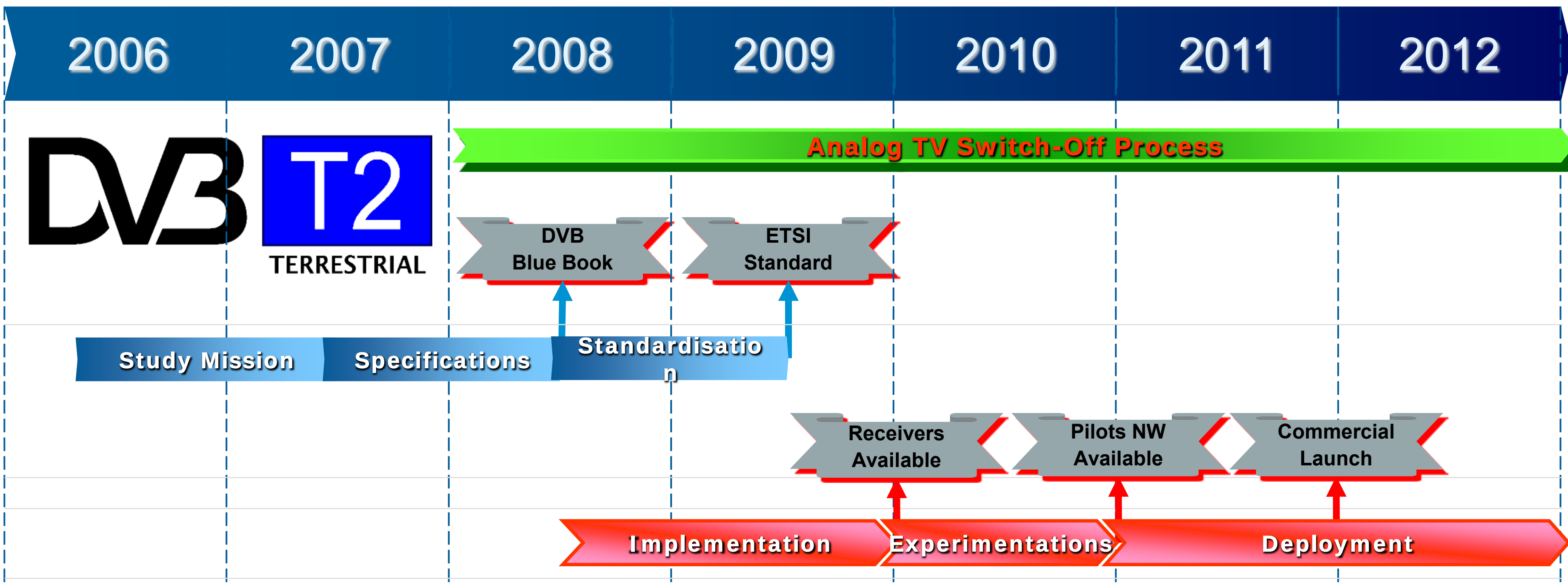
… 270 Member Companies … 45 Published Standards … 130 Million Receivers Deployed … On-Air On 6 Continents …



...DVB-T2 in line with a family of 2° Generation of standards

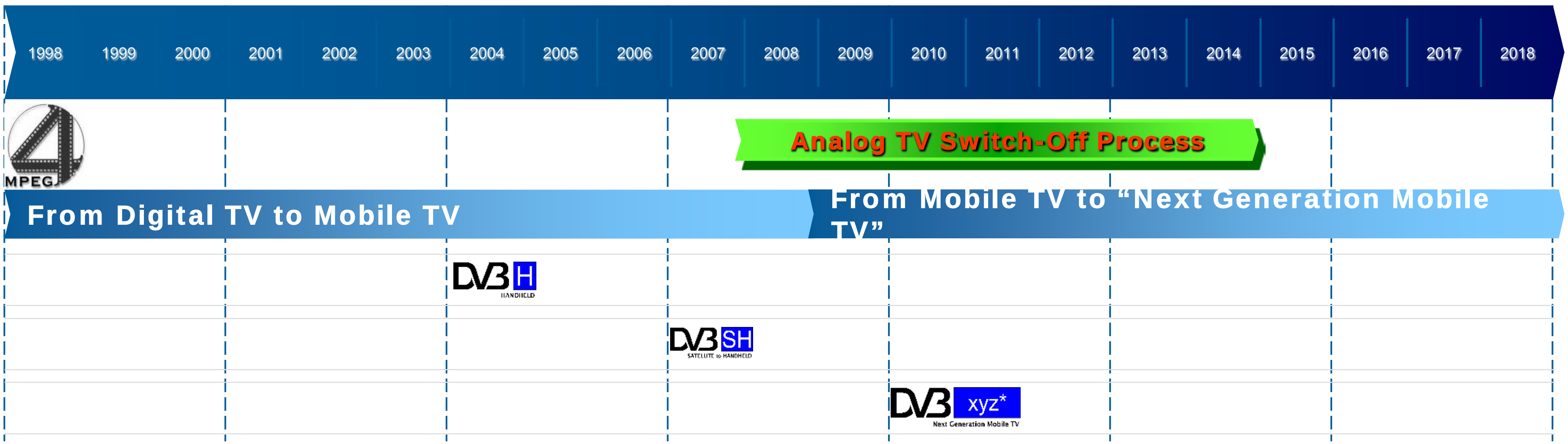
DVB S DVB C DVB T DVB S2 DVB H DVB IP

... 270 Member Companies ... 45 Published Standards ... 130 Million Receivers Deployed ... On-Air On 6 Continents ...



Mobile TV: a coherent but specific Family of standards

... 270 Member Companies ... 45 Published Standards ... 130 Million Receivers Deployed ... On-Air On 6 Continents ...



Analogue / Digital Transition

Analogue TV - PAST

Video – AM Modulation

Sound - FM Modulation

Test Signals in VITS

CCIR17,18,330,331

S/N Ratio , Colour, Black/White + Noise

Smooth Degradation

Transmission

Picture Quality

Digital TV- PRESENCE/FUTURE

Digital Modulation

- DVB-S/S2 QPSK
- DVB-C/C2 QAM
- DVB-T/T2 COFDM

Transport Stream Protocol

Blockiness, Blurring,

Hard Degradation – Cliff Effect

Good Quality or No Picture

Analogue / Digital Transition

Analogue TV – PAST /PRESENCE

Channel Bandwidth

•7 MHz / 8 MHz

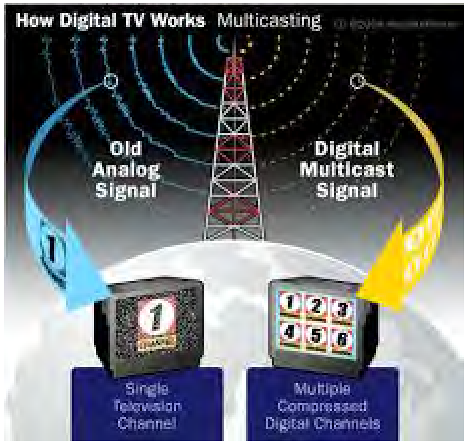
1 Program

•1 Video

•Dual Sound

•1 Teletext

No Interactivity



Digital TV- PRESENCE/FUTURE

Channel Bandwidth

•7 MHz / 8 MHz

1 Transport Stream / Multiple Streams

- up to 20 Video Programs
  - •Dual Sound / Surround
  - •Teletext
  - •MetaData

Interactivity with return path

First Generation Broadcast TV Standards

Based on the highest performance consumer technology then available

Some Early UK STBs could only support 2K modes

Development time/costs minimised by re-using common modules

DVB-S Approved in December 1993

Single carrier QPSK mode

Single Transport Stream

DVB-C Approved in March 1994

Single carrier with 4, 16 and 64QAM modes

Single Transport Stream

DVB-T Approved in December 1995

2K and 8K COFDM with 4, 16 and 64QAM

Two transport streams using Hierarchical Modulation

Why Are New Standards Being Developed?

New Services Require Increasingly Higher Bandwidths

HDTV, 3DTV and Interactive TV

New Business Models Demand More Flexible Delivery

IP, Mobile and Fixed Broadcasting

Increasingly Expensive Spectrum must be Better Utilized

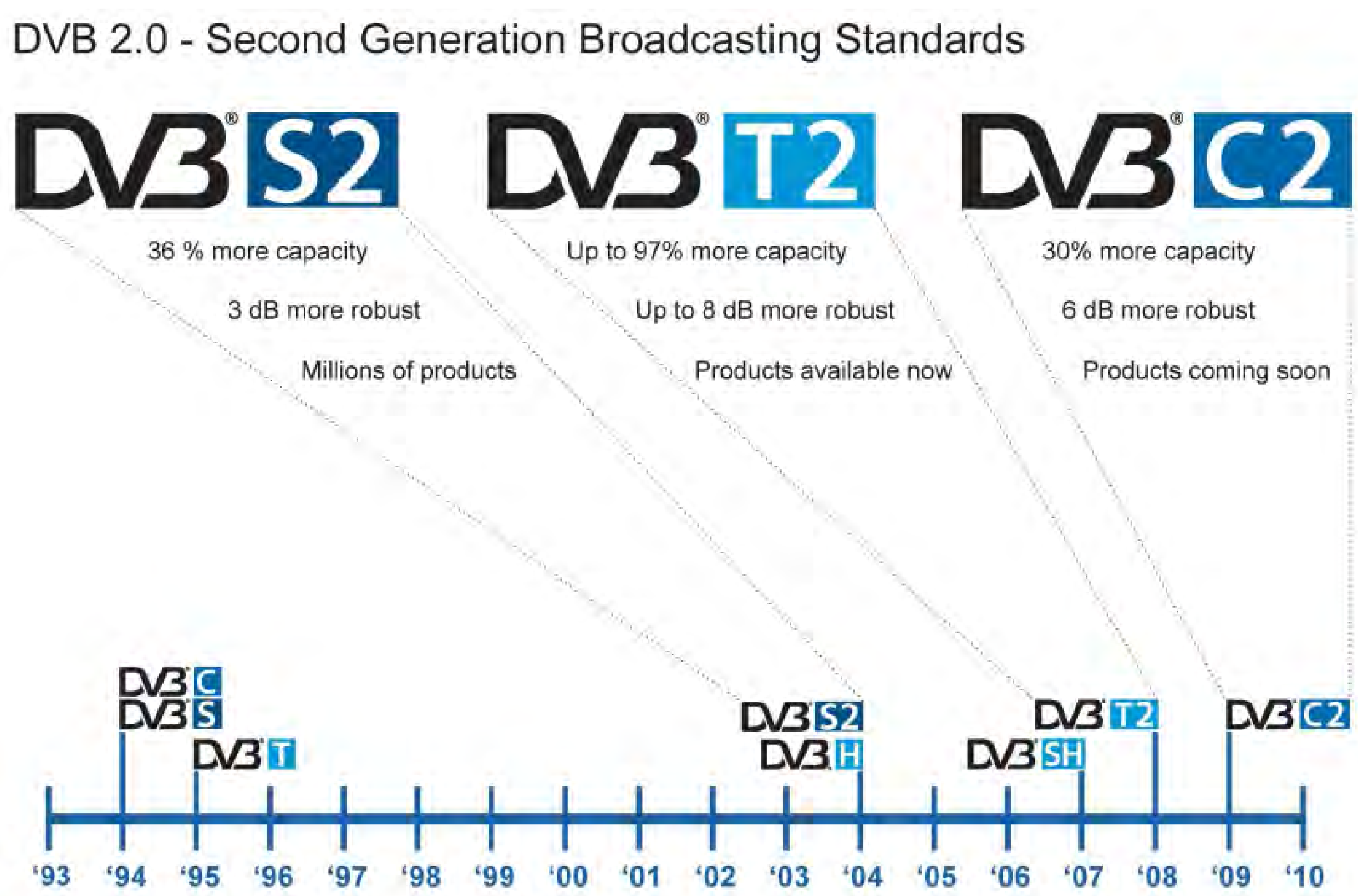
Competition for limited resources with telcos

New Technologies enable more complex systems

Low Cost High Speed Processors

High Performance Algorithms

DVB ... 2nd Generation



Source: DVB-Projekt

DVB-S2
EN302 307

Dec 2003

DVB-S2: New Features over DVB-S

New Modulation and Forward Error Correction (FEC)

30% Higher bandwidth enables more HDTV, SDTV and IP services

Dynamically variable modulation and FEC

Optimal bandwidth utilization for different service types

Robust delivery in poor weather conditions

Multiple Input streams

Independent and Flexible Operation between service providers

Hierachical Mode for backwards compatibility with legacy STBs

Supports non-compliant Transport Stream formats e.g. IP

“Null” (PID8191) TS packets need not always be transmitted

No need for Transport Stream packetization overhead

No conversion simplifies interoperability

DVB-S2: New Technology Requirements

“New” High Performance FEC (BCH, LDPC)

- Originally developed in the 1960s
- Large Frame Size (64800bits)
- Also adopted for DVB-T2 and DVB-C2
- Requires large memory and high processing power

New modulation schemes (8PSK, 16APSK, 32APSK)

- Requires high performance demodulators

Modulation can be changed for every Physical Layer Frame

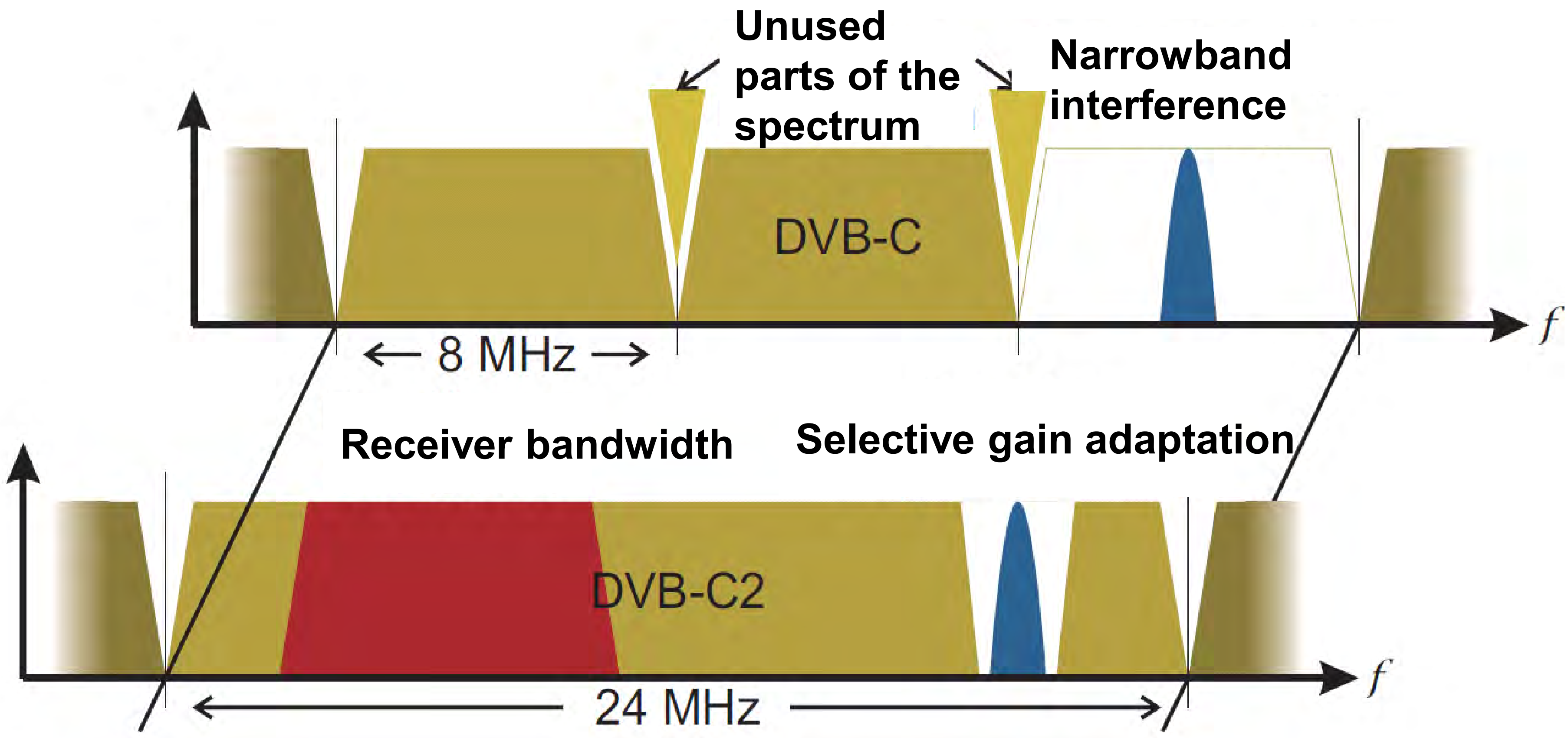
- Different/variable bit rates for each Input Stream
- Different FEC for robust reception in bad weather (snow/rain)
- Requires more complex demodulators

DVB-C2
EN302 769

April 2009

ROHDE&SCHWARZ

DVB-C2: Channel Bonding

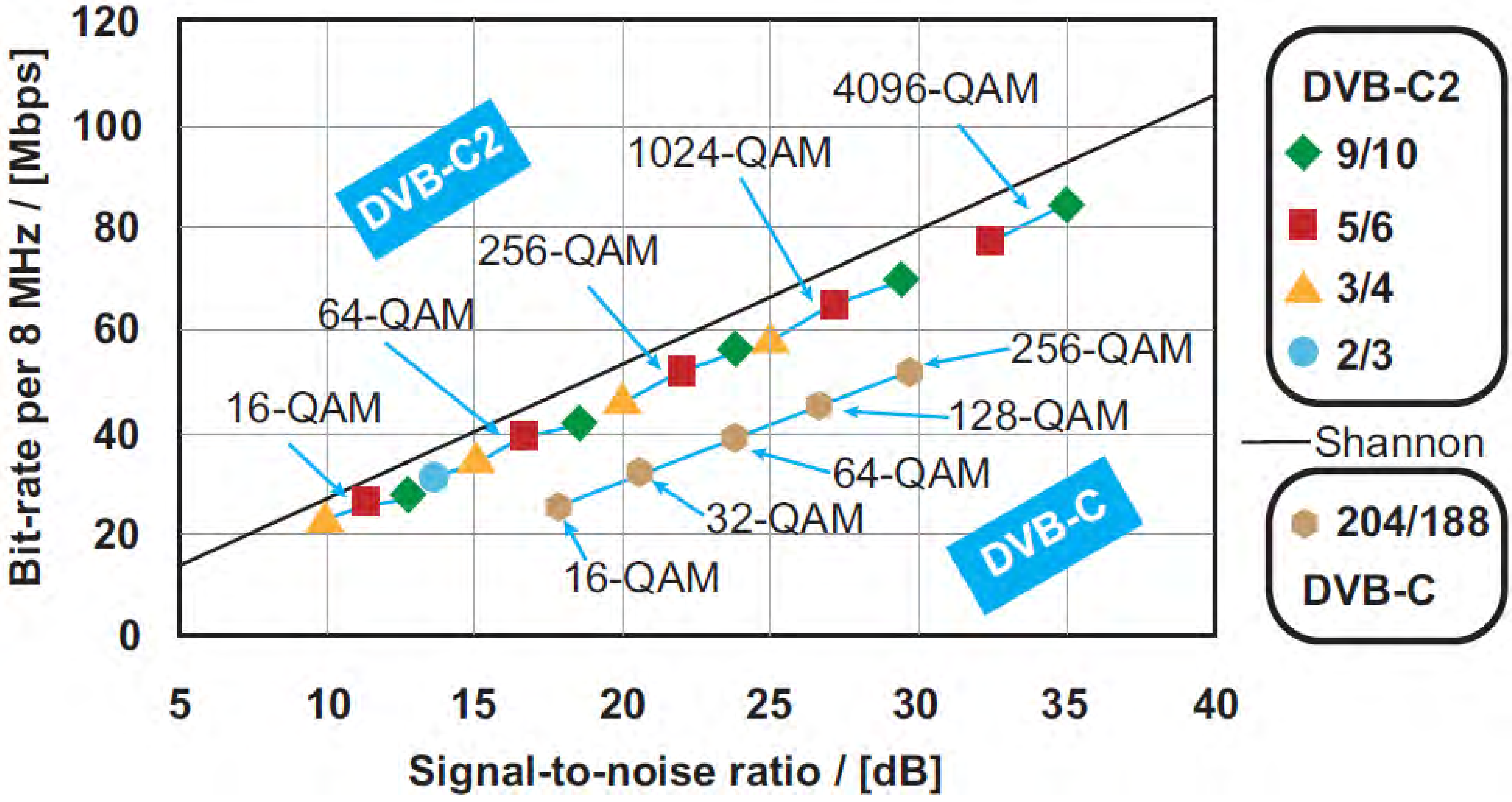


DVB-C2: Technical Summary

Based on DVB-T2
COFDM (4K mode, 2 short guard intervals)
Channel raster bandwidth 6 or 8 MHz
QPSK … 4096QAM
Variable coding and modulation
Channel bundling
Copes with notches (interfered frequency ranges)
Uses the same BBFRAME/FEC structure as DVB-S2
Multiple TS and GSE
Single and multiple input streams
Data slices
Reserved carriers for Peak to Average Power Reduction

>50% Higher Bit rates than DVB-C

DVB-C2 Bit Rates



DVB-T2
EN302 755

May 2008

DVB-T2: Key Commercial Requirements

Re-use existing domestic antennae and transmiitter network

Support Portable and fixed Receivers

At least 30% > capacity than DVB-T

Improved SFN Performance

Service Specific Robustness

Bandwidth and Frequency Flexibility

Reduce Peak to Average Power Ratio

DVB-T2: New Technology over DVB-T

Many new transmission options:

- New Channel Bandwidths, Guard Intervals and FFT Modes
- 8 Different Pilot Patterns
- Extended Carrier Modes
- Rotated and Q-delayed constellations
- Multiple Input Single Output (MISO) Modes
- Peak to Average Power Reduction (PAPR) Modes

Modulation dynamically variable for each "COFDM Cell"

- Every carrier in each symbol independently controllable
- System/Control data sent in fixed format highly robust symbols

DVB-S2 FEC plus extensive time and frequency interleaving

- Further improves robustness in noisy environments

DVB-T2: Benefits over DVB-T

New Modulation, FEC and Transmission modes

30 - 60% More Bandwidth enables more HDTV, SDTV and IP services

Multiple Input streams (Physical Layer Pipes = PLPs)

Common (e.g. SI) Data and service specific (Video, audio) streams

Independent and Flexible Operation with multiple service providers

Dynamically variable modulation and FEC

Mobile (time/frequency sliced) and Fixed Services in same bandwidth

Optimal bandwidth utilization for different service types

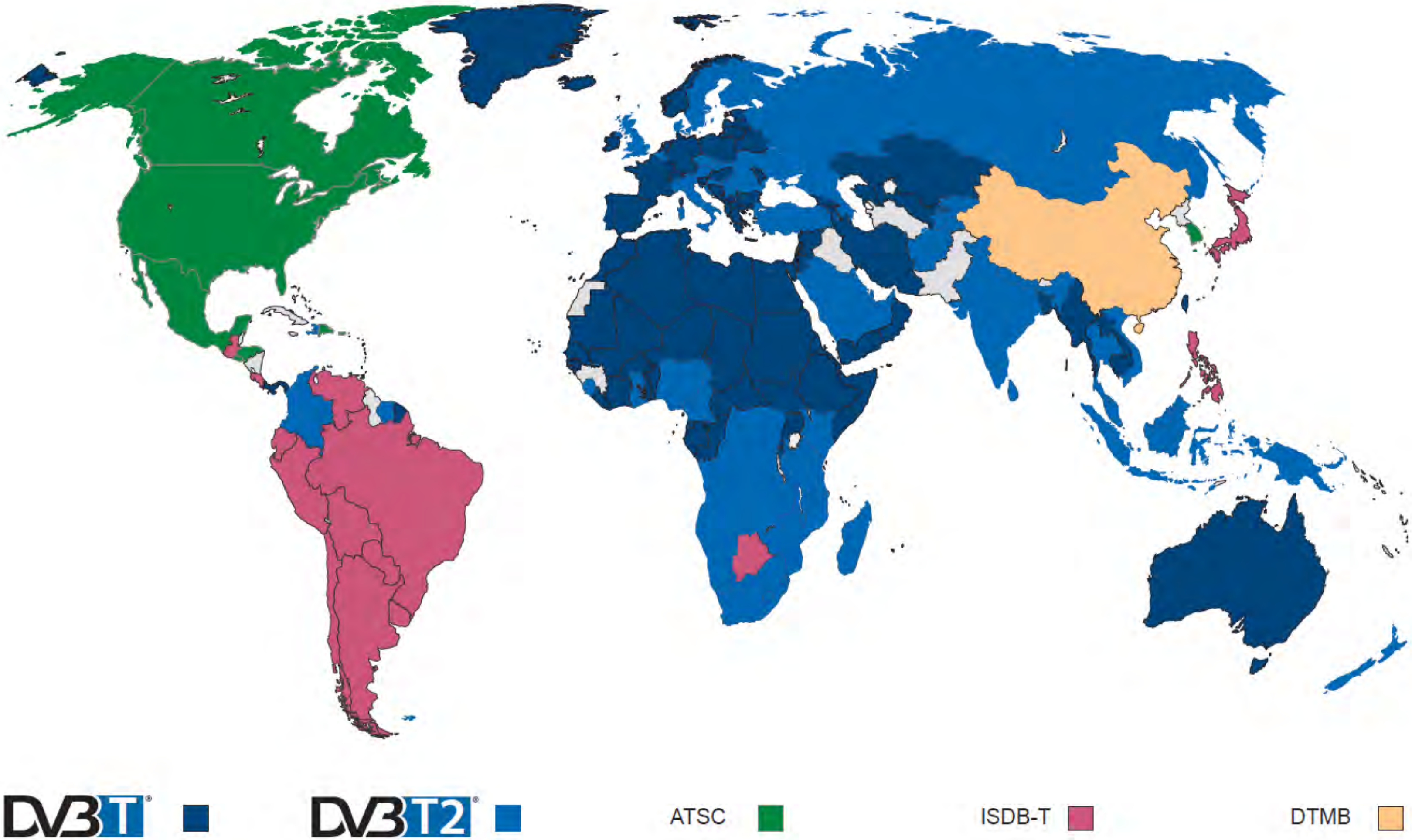
Direct Support for non-TS formats e.g. IP

No Transport Stream packetization overhead

Repeated (null packets) or common (SI) data need not always be sent

No conversion simplifies interoperability

DVB Worldwide



Digital Terrestrial Television Systems. Blue indicates countries that have adopted or deployed DVB-T and DVB-T2. June 2014

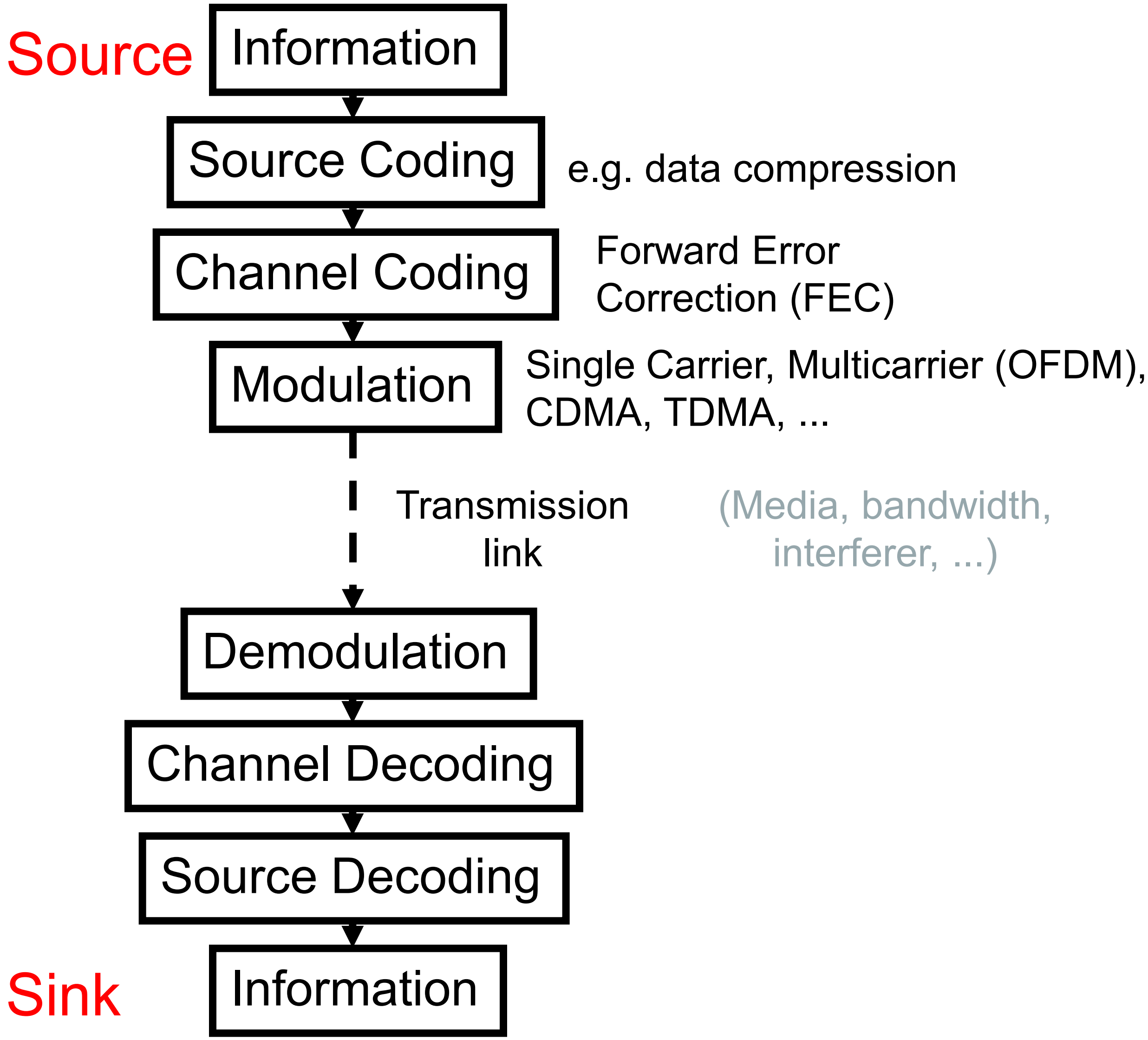
Source:
DVB-Projekt

Typical Datarates Digital Broadcast

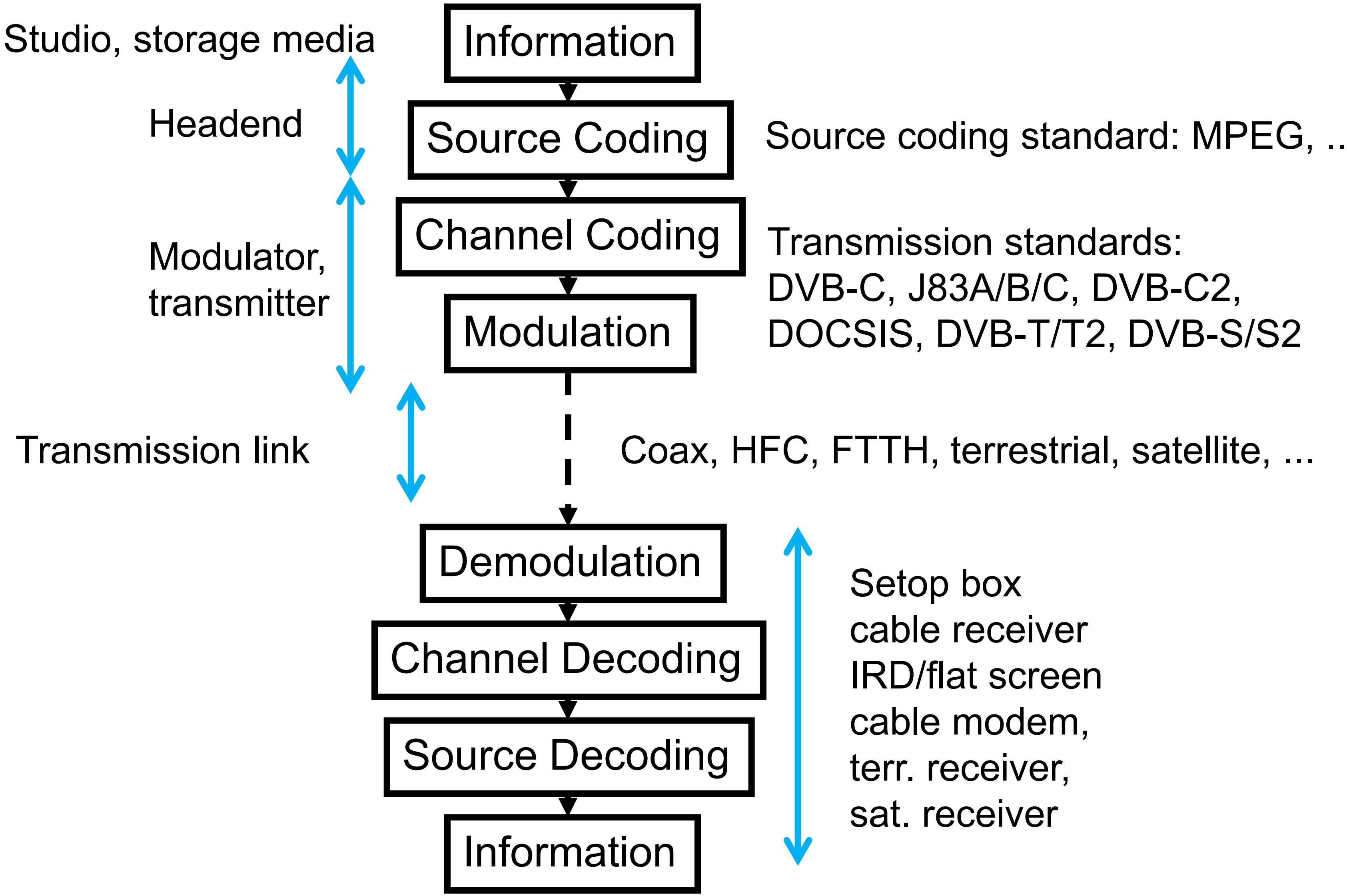
Source Coding:	
MPEG-2 video SDTV	2.5 ... 5 Mbit/s
MPEG-4 video SDTV	1.5 ... 3 Mbit/s
MPEG-4 video HDTV	8 ... 12 Mbit/s
MPEG-1 LII audio	192 kbit/s
Dolby AC-3 audio	448 kbit/s
Teletext	260 kbit/s

Physical Layer before FEC (net data rate):	
DVB-S (27.5 MS/s, CR=3/4)	38.01 Mbit/s
DVB-S2 (22 MS/S, 8PSK, CR=2/3)	42.58 Mbit/s
DVB-S2 (27.5 MS/s, QPSK, CR=9/10)	49.2 Mbit/s
DVB-T (16QAM, CR=2/3, g=1/4)	13.27 Mbit/s
DVB-T (64QAM, CR=3/4, g=1/4)	22.39 Mbit/s
DVB-C (64QAM)	38.15 Mbit/s
DVB-C (256QAM)	50.87 Mbit/s
DAB/DAB+	1.2...1.7 Mbit/s

Transmission of Information



Transmission of Information: DVB



MPEG Standards

MPEG = Moving Pictures Expert Group

- MPEG-1
- MPEG-2
  H.262
- MPEG-4
  H.264
  AVC
- MPEG-H,
  …
  MPEG-DASH

HEVC = High Efficiency Video Coding

H.265
HEVC

Current Digital Broadcast Transmission Standards

DVB – Digital Video Broadcasting (1994 – 2014)
DVB-T/T2, -C/C2, -S/S2, DVB-IP

DAB/DAB+/T-DMB – Digital Audio Broadcasting (1988, 2007)

ATSC – Advanced Television Systems Committee (USA, 1995)

ISDB-T – Integrated Service Digital Broadcast – Terrestrial (Japan, 1999)

DTMB – Digital Terrestrial Multimedia Broacasting (China, 2004)

DVB-T2 + HEVC

Source coding:

M

HEVC (H.265, MPEG-H): HEVC = High Efficiency Video Coding

M

Datarate reduction by approx. 50% in comp. to H.264

M

MPEG-1 LII audio	192 kbit/s
Dolby AC-3 audio	448 kbit/s
Teletext	260 kbit/s

Physical layer before FEC (net data rate):

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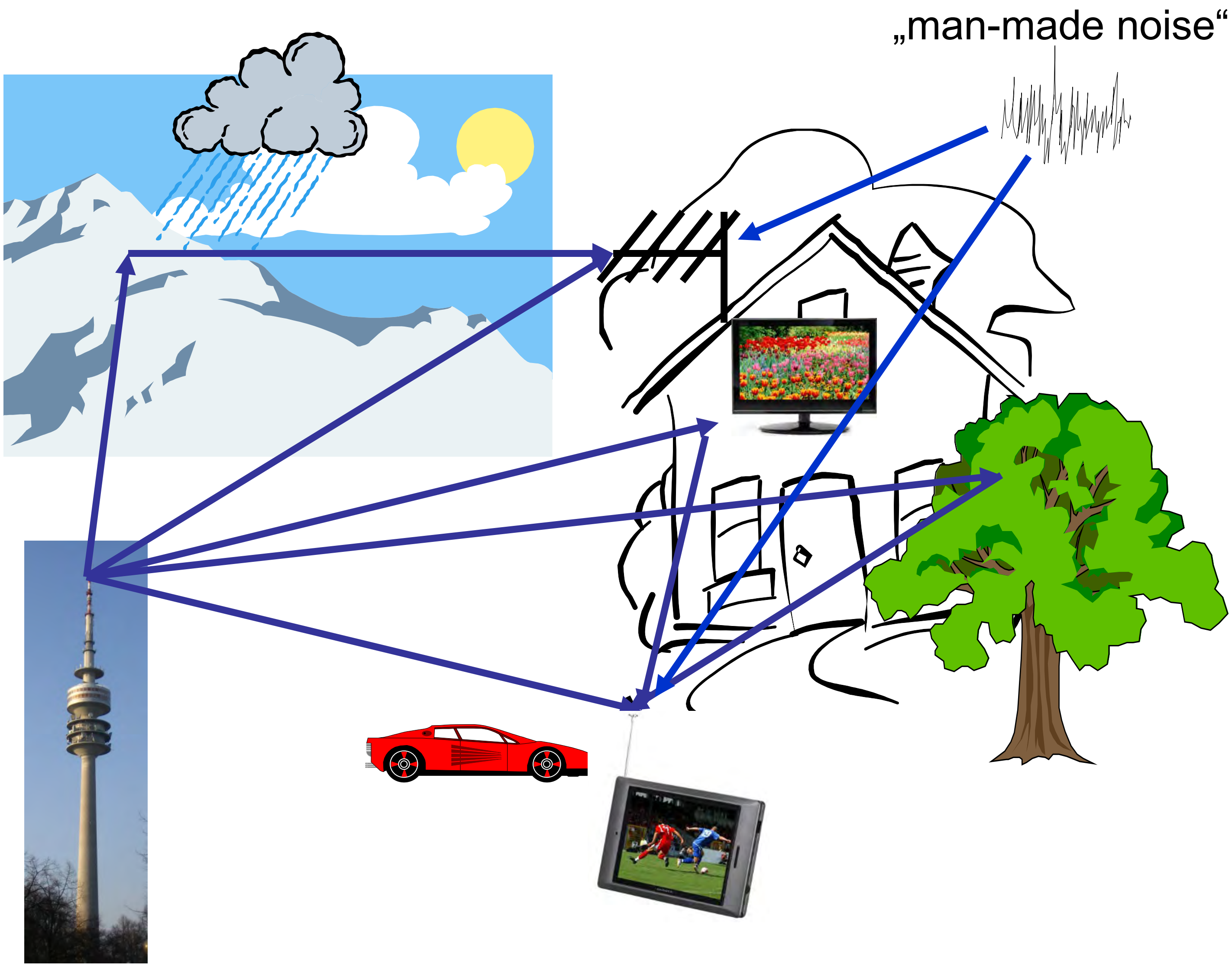
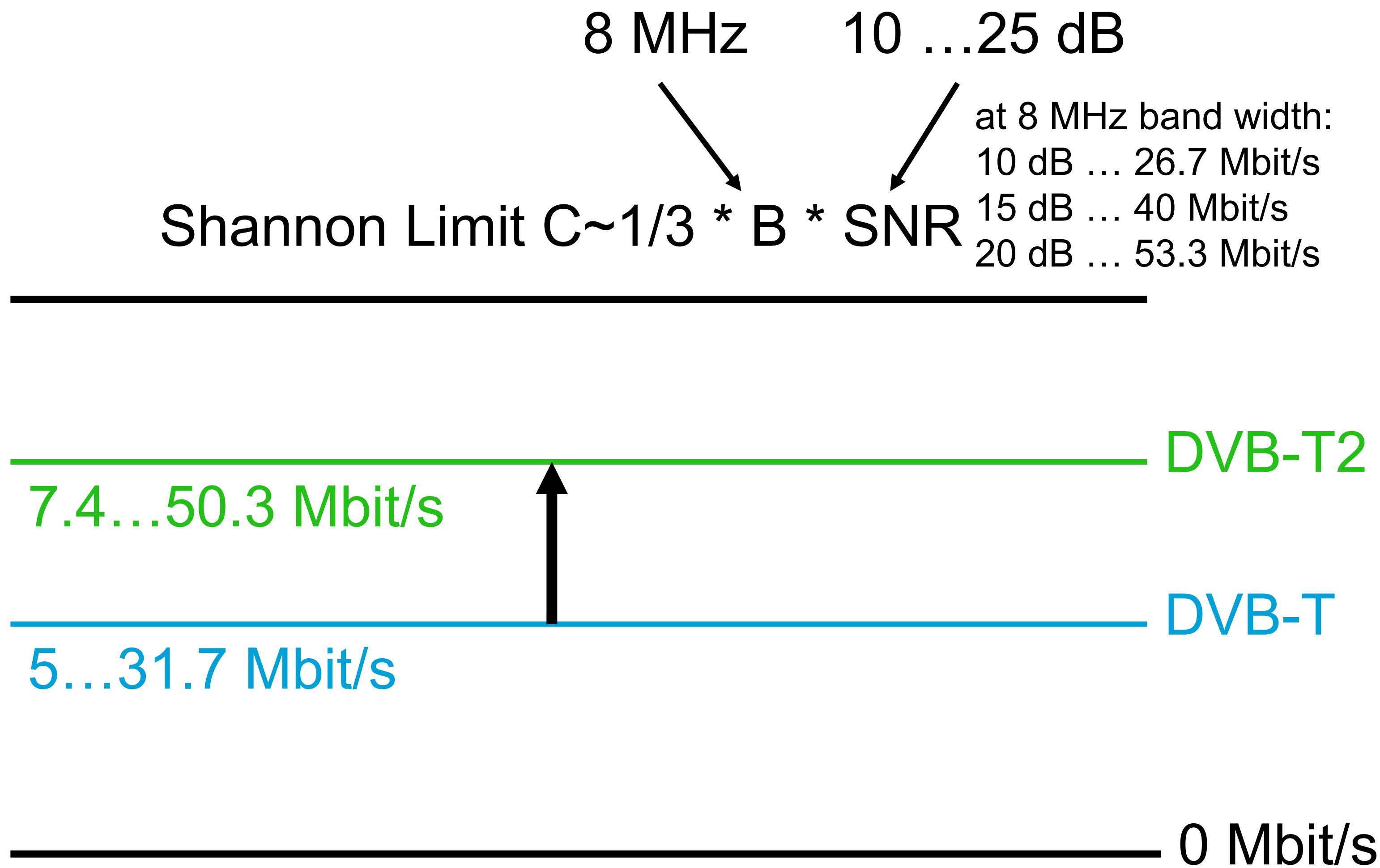
DV	bit/s
DV	bit/s
DVB-C (64QAM)	38.15 Mbit/s
DVB-C (256QAM)	50.87 Mbit/s
DAB/DAB+	1.2...1.7 Mbit/s

DVB-T2: DVB-T datarate x 1.7 ... 2

Terrestrial Braodcast Channel



DVB-T2: Closer to the Shannon Limit ...

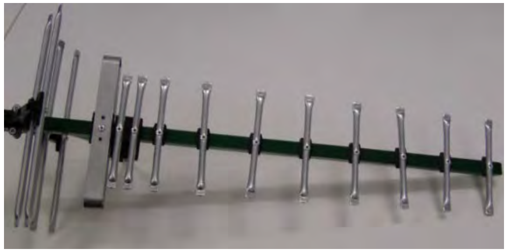


CNR Limits at DVB-T

Modula-tionsart	Coderate	Gauß-Kanal	Rice-Kanal	Rayleigh-Kanal
		[dB]	[dB]	[dB]
QPSK	1/2	3.1	3.6	5.4
	2/3	4.9	5.7	8.4
	3/4	5.9	6.8	10.7
	5/6	6.9	8.0	13.1
	7/8	7.7	8.7	16.3
16QAM	1/2	8.8	9.6	11.2
	2/3	11.1	11.6	14.2
	3/4	12.5	13.0	16.7
	5/6	13.5	14.4	19.3
	7/8	13.9	15.0	22.8
64QAM	1/2	14.4	14.7	16.0
	2/3	16.5	17.1	19.3
	3/4	18.0	18.6	21.7
	5/6	19.3	20.0	25.3
	7/8	20.1	21.0	27.9

portable indoor

Roof antenna



DVB-T2 ... more Datarate ...

Shannon limit … channel capacity

C~=1/3 * SNR * B;

B = 6/7/8MHz

„Fixed antenna“ reception
SNR = 18 … 30 dB

„Portable indoor“ reception
SNR = 10 … 20 dB

at 8 MHz bandwidth:
10 dB … 26.7 Mbit/s
15 dB … 40 Mbit/s
20 dB … 53.3 Mbit/s
30 dB … 80 Mbit/s

Theoretical
max. datarates

Datarates at DVB-T

Modulation	CR	Guard 1/4	Guard 1/8	Guard 1/16	Guard 1/32
		Mbit/s	Mbit/s	Mbit/s	Mbit/s
QPSK	1/2	4.976471	5.529412	5.854671	6.032086
	2/3	6.635294	7.372549	7.806228	8.042781
	3/4	7.464706	8.294118	8.782007	9.048128
	5/6	8.294118	9.215686	9.757785	10.05348
	7/8	8.708824	9.676471	10.24567	10.55617
16QAM	1/2	9.952941	11.05882	11.70934	12.06417
	2/3	13.27059	14.74510	15.61246	16.08556
	3/4	14.92941	16.58824	17.56401	18.09626
	5/6	16.58824	18.43137	19.51557	20.10695
	7/8	17.41765	19.35294	20.49135	21.11230
64QAM	1/2	14.92941	16.58824	17.56401	18.0926
	2/3	19.90588	22.11765	23.41869	24.12834
	3/4	22.39412	24.88235	26.34602	27.14439
	5/6	24.88235	27.64706	29.27336	30.16043
	7/8	26.12647	29.02941	30.73702	31.66845

Portable indoor

Roof antenna

DVB-T and DVB-T2

DVB-T, „Germany, portable indoor“: 13.27 Mbit/s

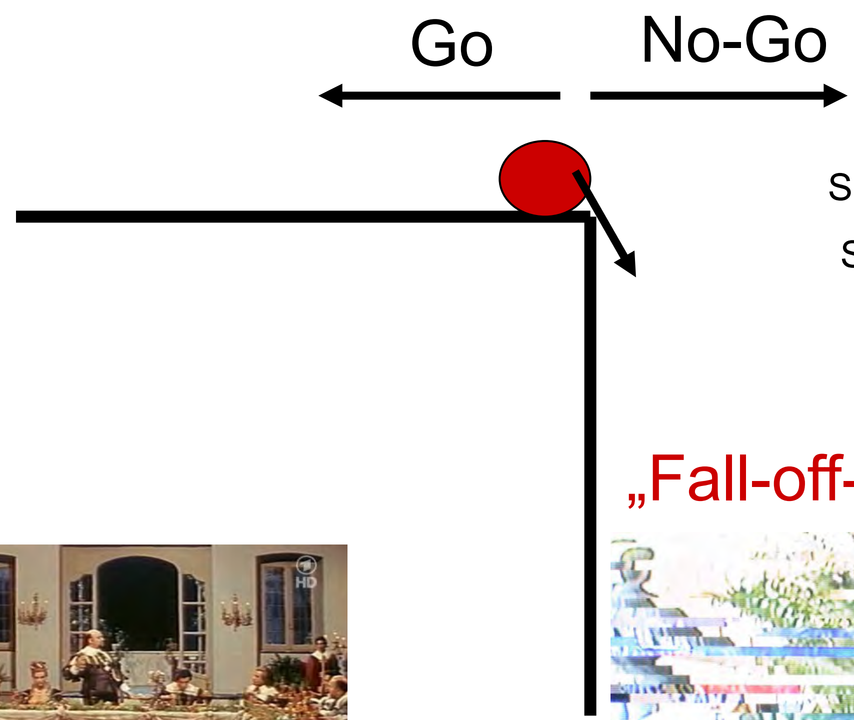
DVB-T, „fixed antenna“: 22.39 Mbit/s

similar modes at DVB-T2:

26.6 Mbit/s „portable indoor“ (32Kext, 64QAM,
CR=2/3, g=1/16)

39.7 Mbit/s „fixed antenna“ (32Kext, 256QAM,
CR=3/4, g=1/16)

DVB and Fall-Off-the-Cliff

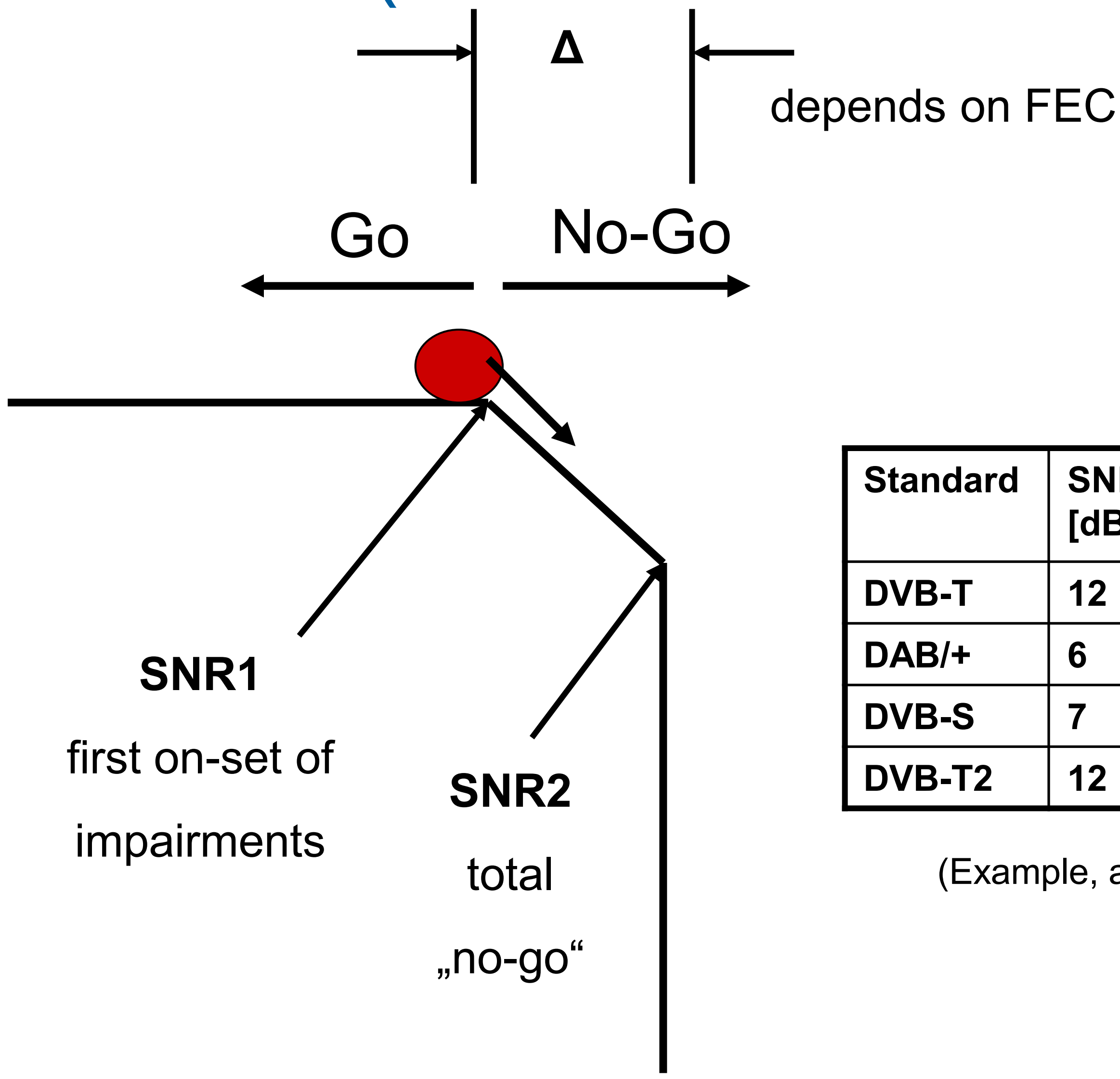


SNR~12 dB (indoor)

SNR~18 dB (fixed)

„Fall-off-the-Cliff“

Fall-off-the-Cliff (… from DVB-x1 to DVB-x2 …)



Standard	SNR1 [dB]	Δ [dB]
DVB-T	12	0.3
DAB/+	6	3 / 0.3
DVB-S	7	0.3
DVB-T2	12	0.03

(Example, approx. values)

CNR Limits @DVB-T2 @ BER=10^{-4} after LDPC

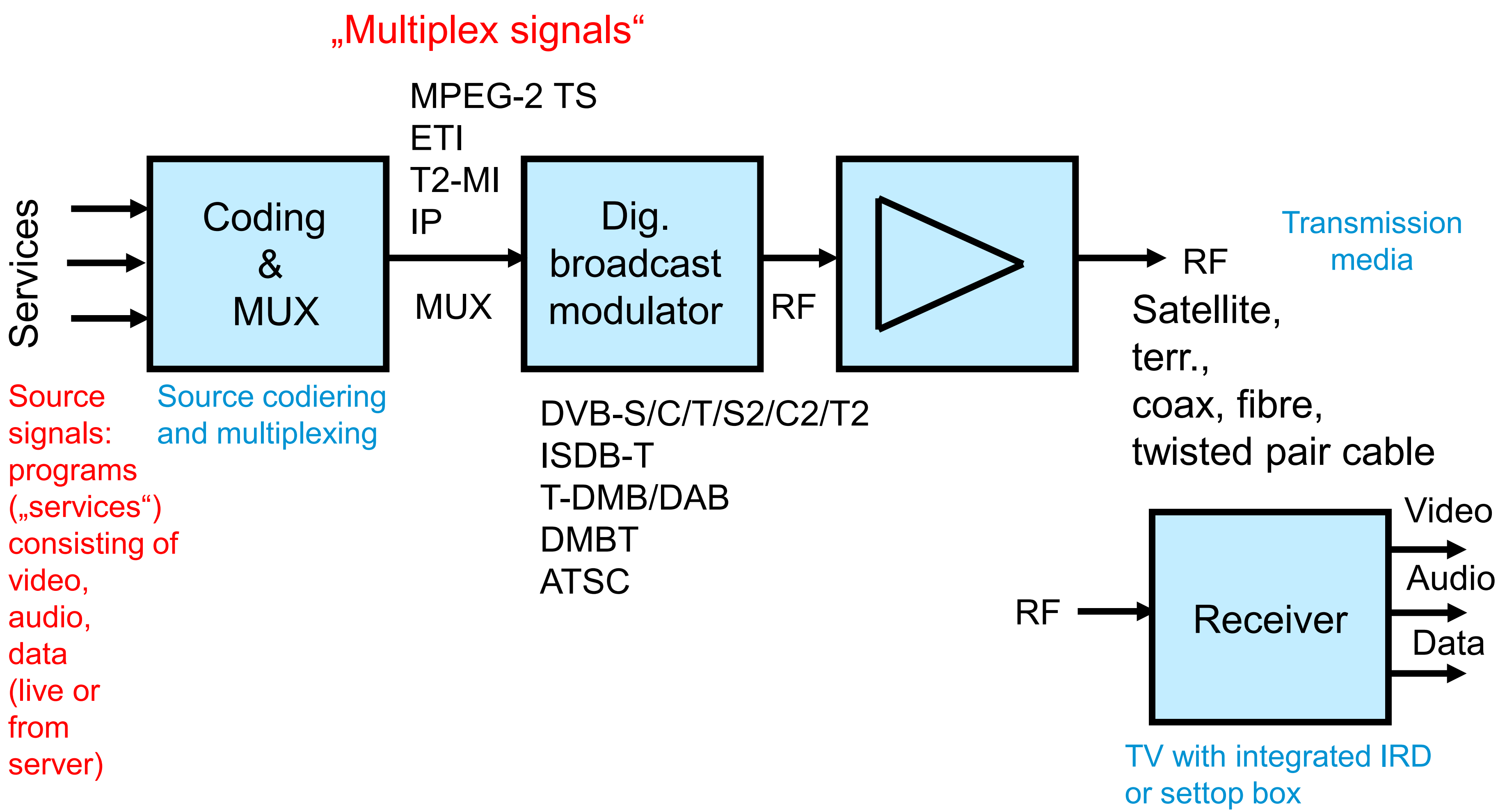
Modulation	Coderate	C/N Gaussian Channel [dB]	C/N Ricean Channel [dB]	C/N Rayleigh Channel [dB]	C/N 0dB Echo Channel @ 90% GI [dB]
QPSK	1/2	0.4	0.7	1.5	1.2
	3/5	2.2	2.4	3.5	3.2
	2/3	3.1	3.4	4.7	4.4
	3/4	4.0	4.5	6.0	5.7
	4/5	4.6	5.1	6.9	6.5
	5/6	5.1	5.7	7.8	7.4
16QAM	1/2	5.2	5.5	6.6	6.3
	3/5	7.5	7.9	9.3	9.0
	2/3	8.8	9.1	10.7	10.4
	3/4	10.0	10.5	12.4	12.1
	4/5	10.8	11.3	13.6	13.3
	5/6	11.4	12.0	14.6	14.4
64QAM	1/2	8.7	9.1	10.7	10.5
	3/5	12.0	12.4	14.2	14.0
	2/3	13.4	13.8	15.7	15.5
	3/4	15.2	15.6	17.8	17.6
	4/5	16.1	16.6	19.1	18.9
	5/6	16.8	17.4	20.3	20.3
256QAM	1/2	12.1	12.4	14.4	14.3
	3/5	16.5	16.9	18.8	18.8
	2/3	17.7	18.1	20.3	20.3
	3/4	19.9	20.4	22.6	22.7
	4/5	21.2	21.7	24.2	24.3
	5/6	22.0	22.5	25.6	25.9

Portable indoor

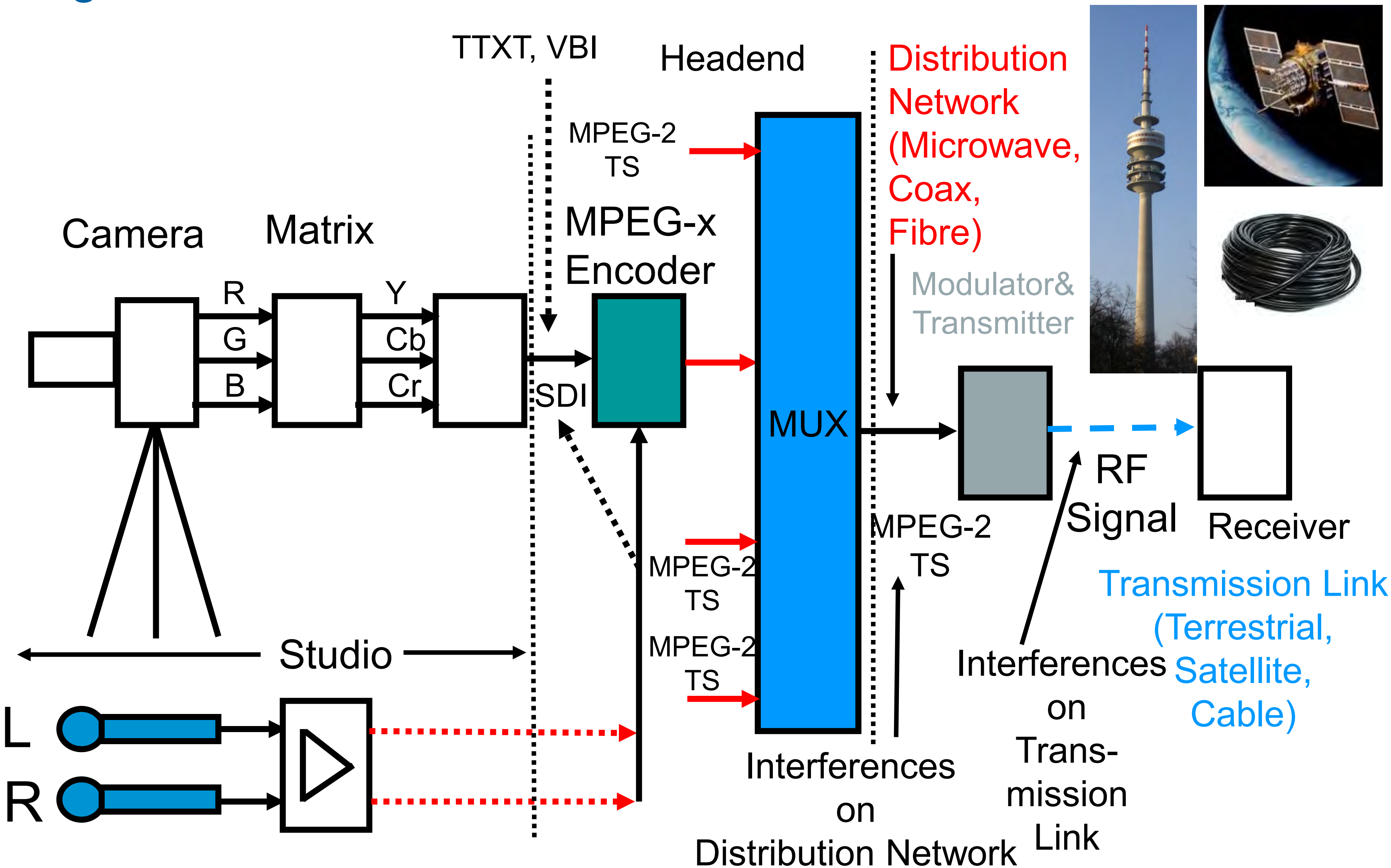
Roof antenna

Source: DVB-T2 Implementation Guidelines

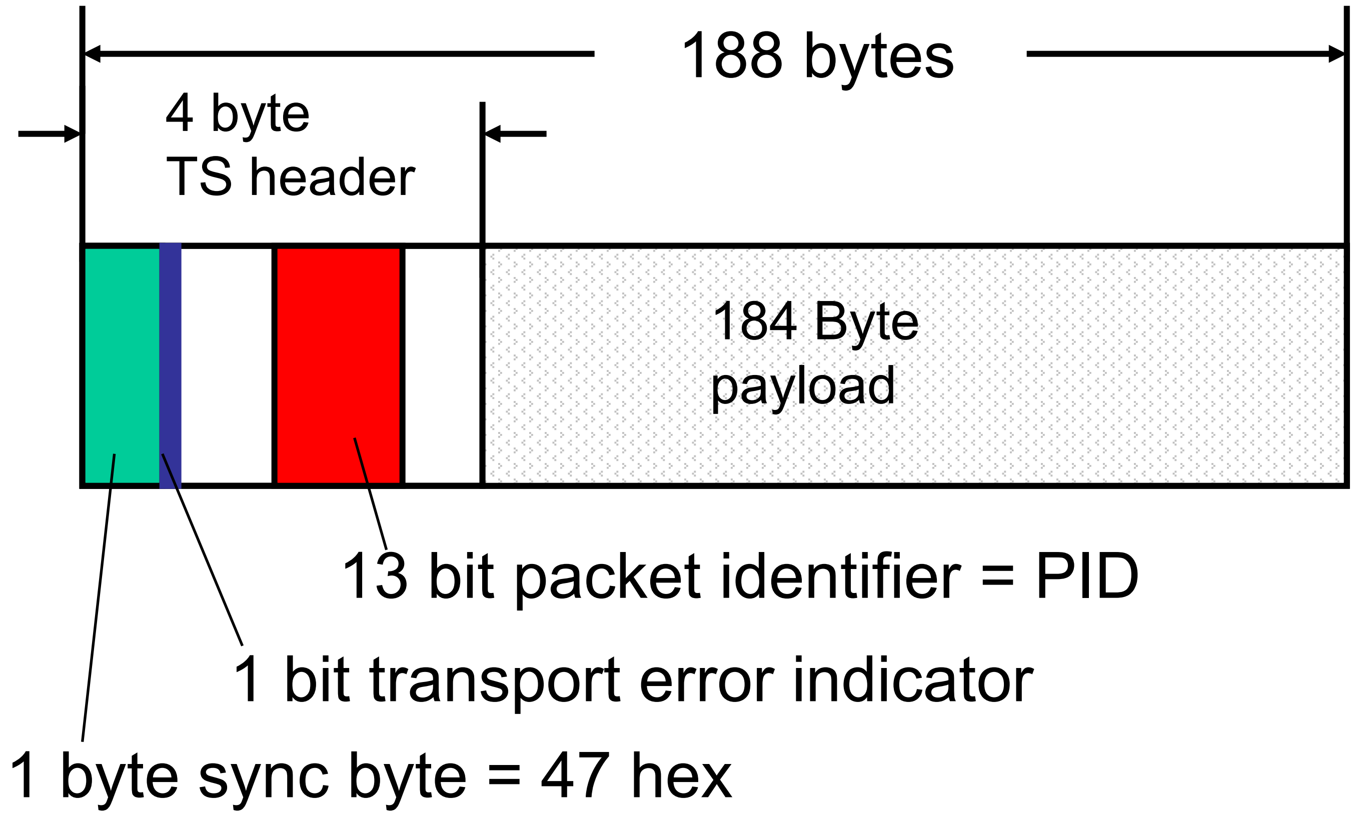
Digital Broadcast Network



Digital TV Network



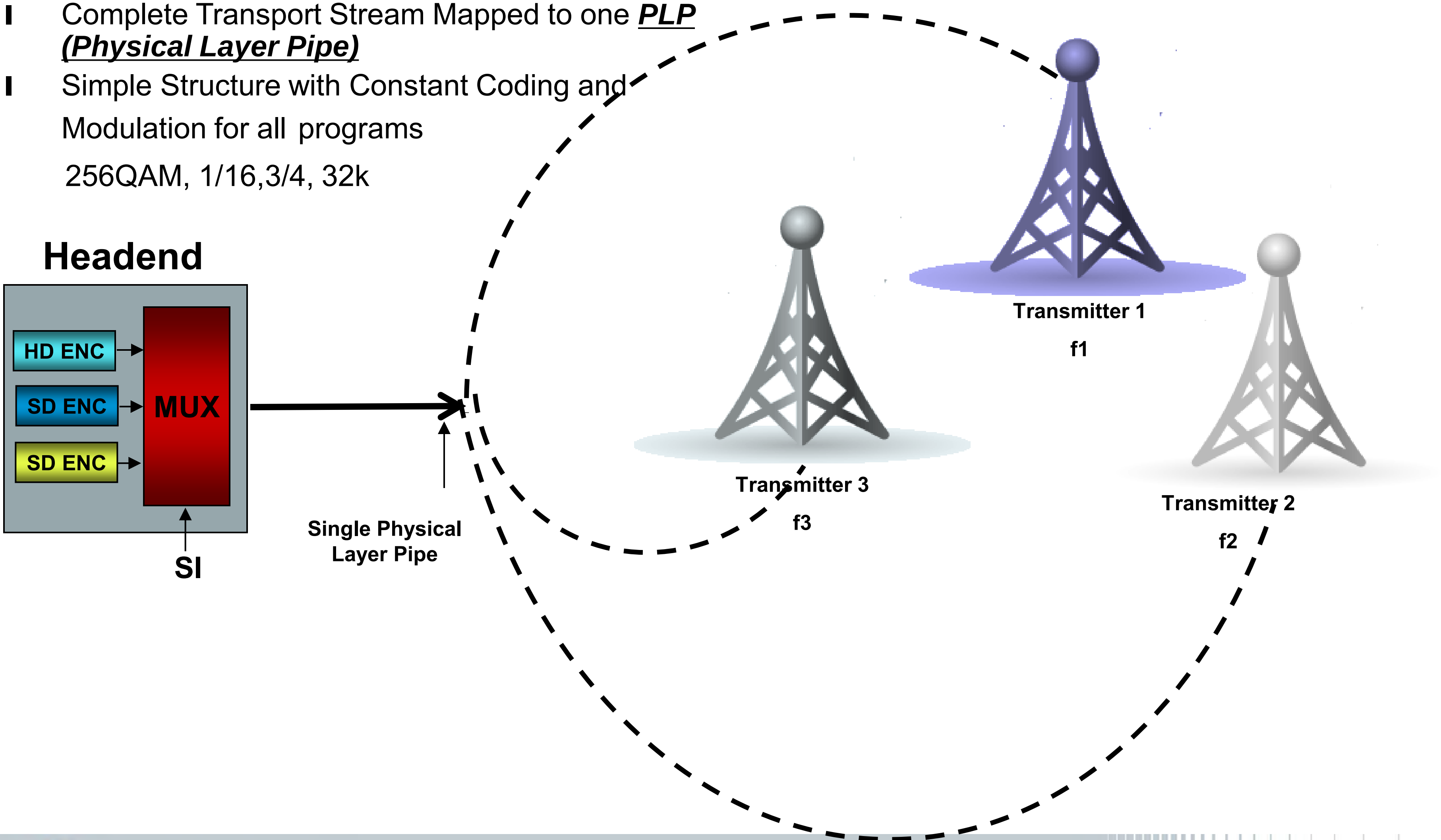
MPEG-2 Transport Stream



Basics of a DVB-T2 Network

Link fed Transmitters

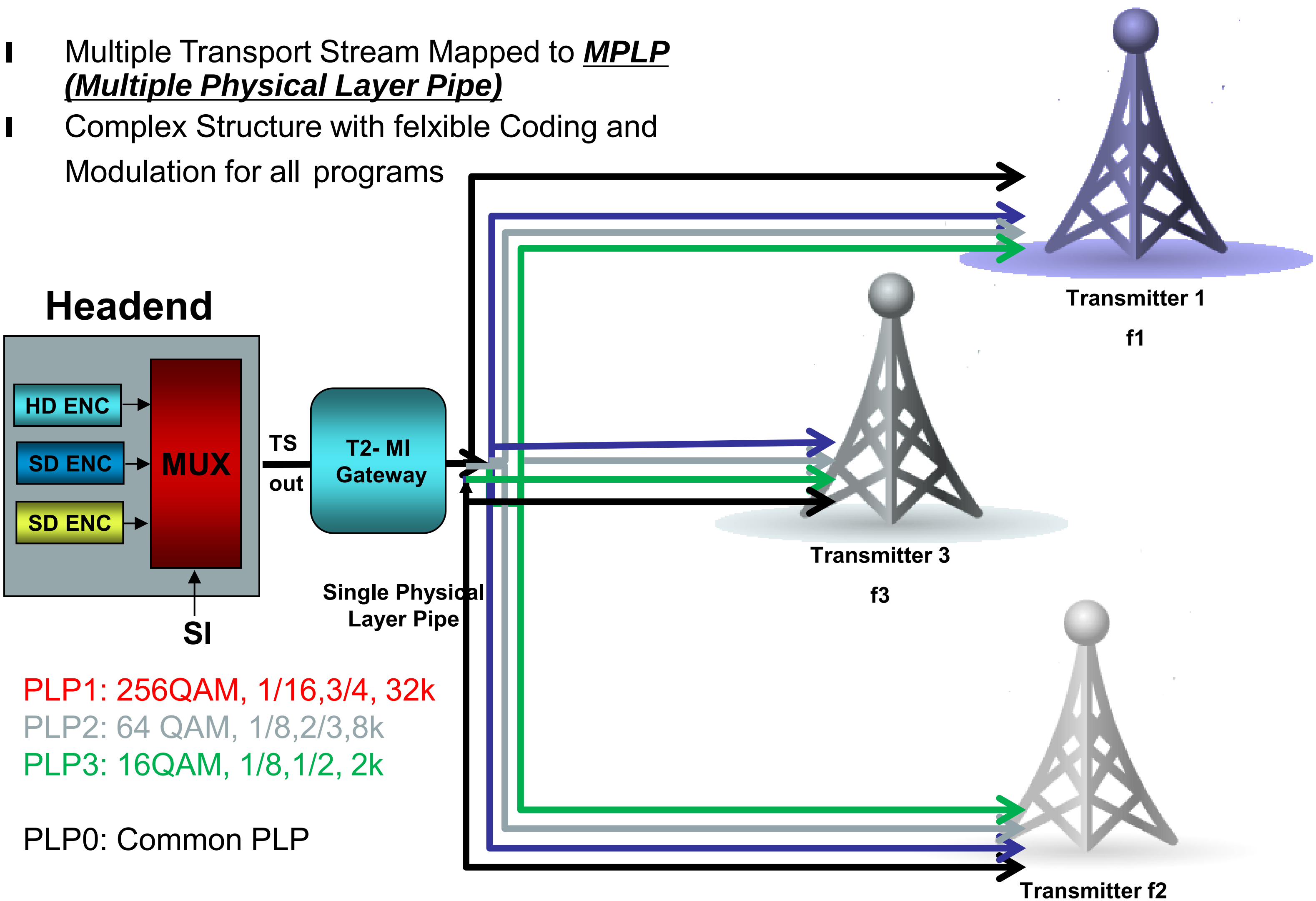
- Complete Transport Stream Mapped to one ***PLP (Physical Layer Pipe)***
- Simple Structure with Constant Coding and Modulation for all programs
  256QAM, 1/16,3/4, 32k



Basics of a DVB-T2 Network

Link fed Transmitters

- Multiple Transport Stream Mapped to ***MPLP (Multiple Physical Layer Pipe)***
- Complex Structure with felxible Coding and Modulation for all programs



PLP1: 256QAM, 1/16,3/4, 32k
PLP2: 64 QAM, 1/8,2/3,8k
PLP3: 16QAM, 1/8,1/2, 2k

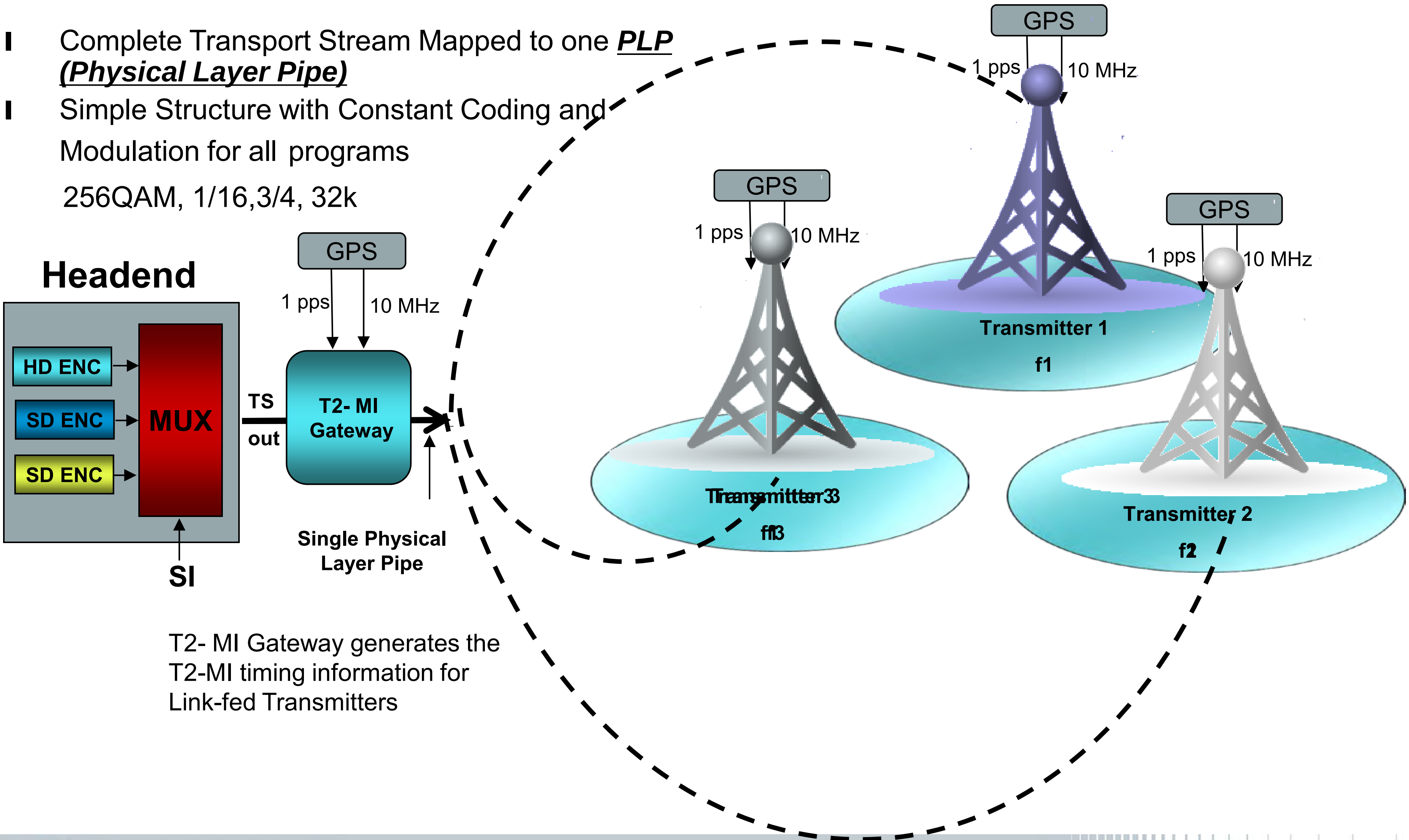
PLP0: Common PLP

SFN Basics of a DVB-T2 Network

Link fed Transmitters

- Complete Transport Stream Mapped to one ***PLP (Physical Layer Pipe)***
- Simple Structure with Constant Coding and Modulation for all programs

  256QAM, 1/16,3/4, 32k



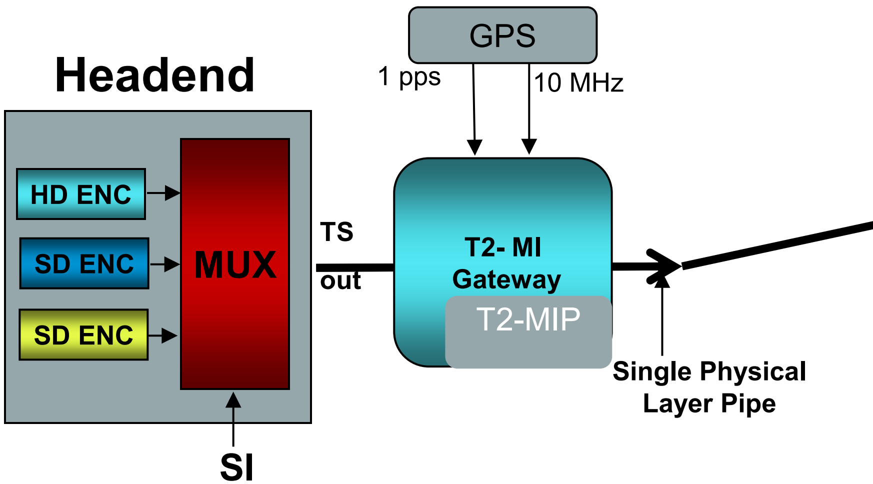
T2- MI Gateway generates the T2-MI timing information for Link-fed Transmitters

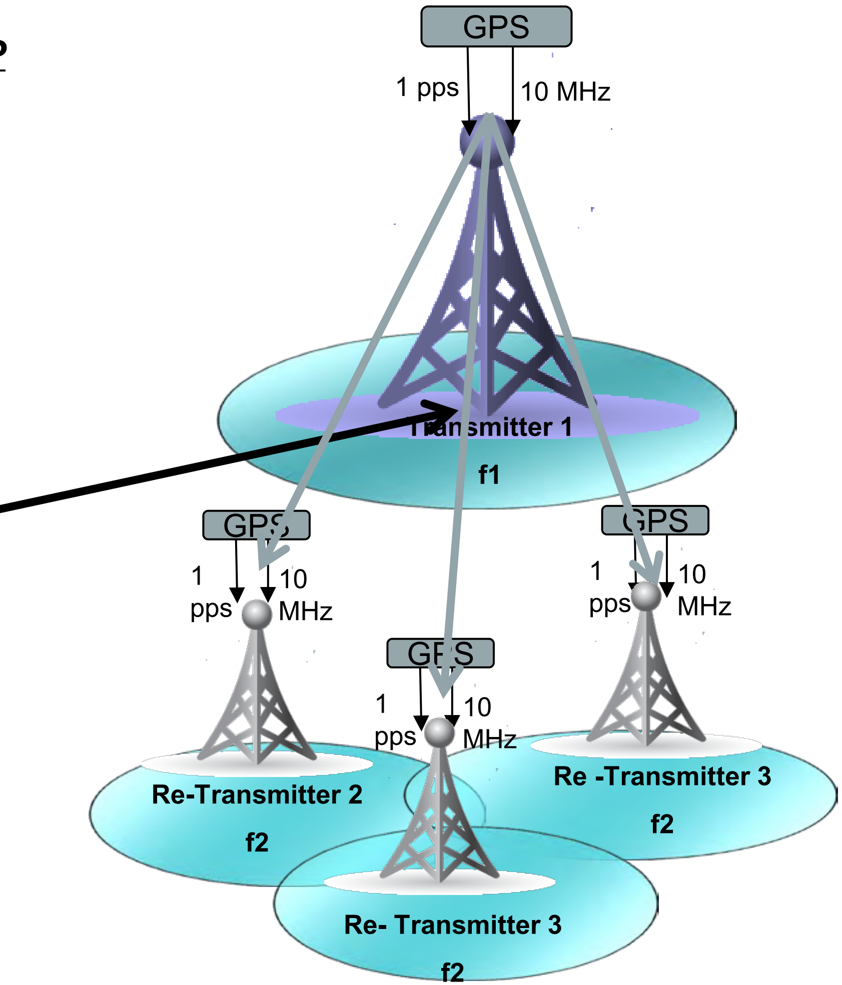
SFN Basics of a DVB-T2 Network

Over the air synchronistation for Re-Transmitters

- Complete Transport Stream Mapped to one ***PLP (Physical Layer Pipe)***
- Simple Structure with Constant Coding and Modulation for all programs

  256QAM, 1/16,3/4, 32k



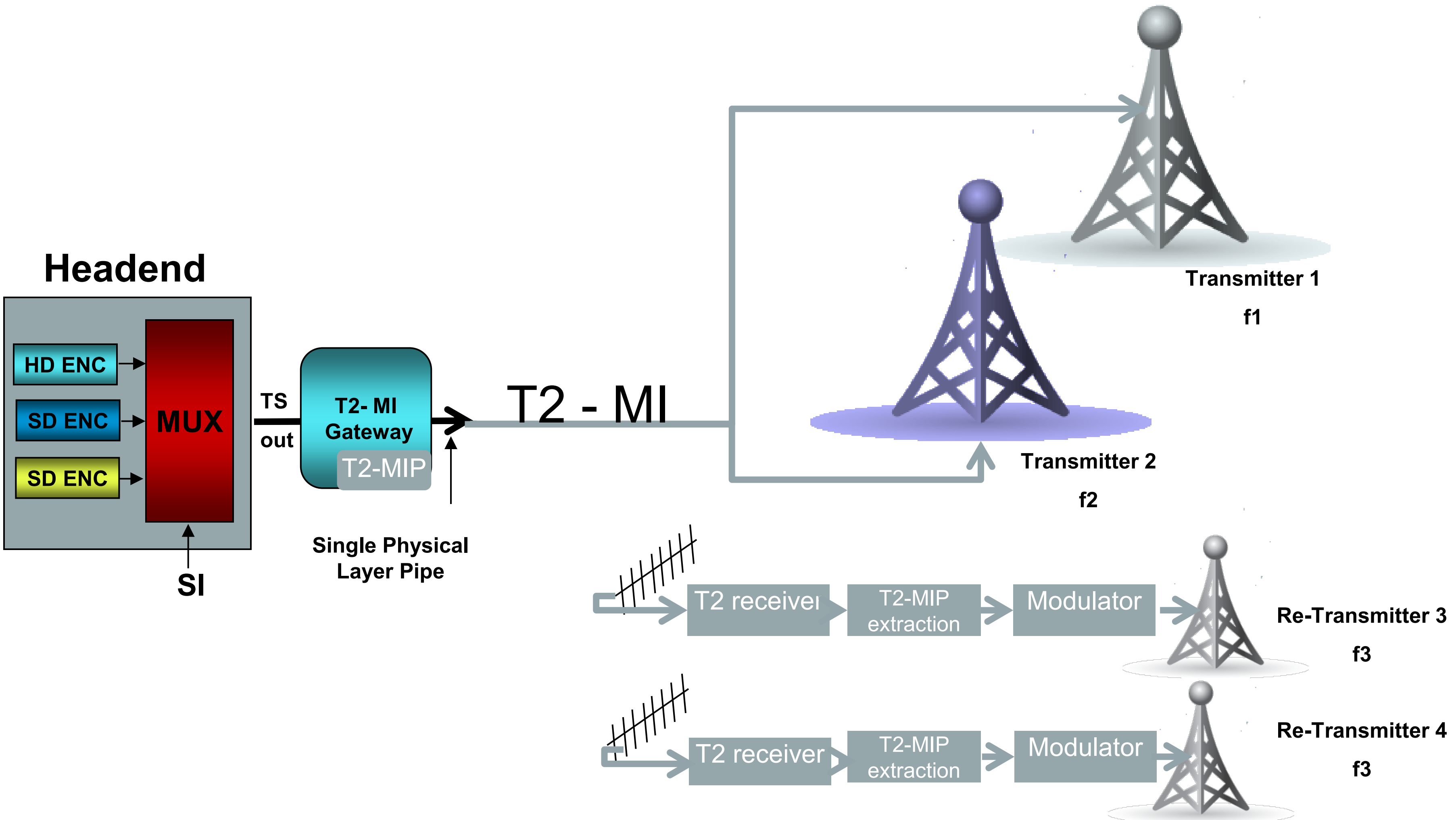


T2- MI Gateway:

- T2-MI timing information for Link fed Transmitters
- Generates the T2-MIP

SFN Basics of a DVB-T2 Network

Over the air synchronistation for Re-Transmitters



- Network Design

- Gap Filler and Re-transmitters

- DVB-T2 Single Frequency Network

- Total Cost of Ownership

ROHDE&SCHWARZ

Network Design: Total-cost-of-ownership Design and implementation

Ensuring a most economic operation

- **Network structure:**

  (few) high power Transmitter – high tower

  (many) low power Transmitter

  mixed setup

- **Network design:**

  Combination of main components driving operational cost

- **Network equipment:**

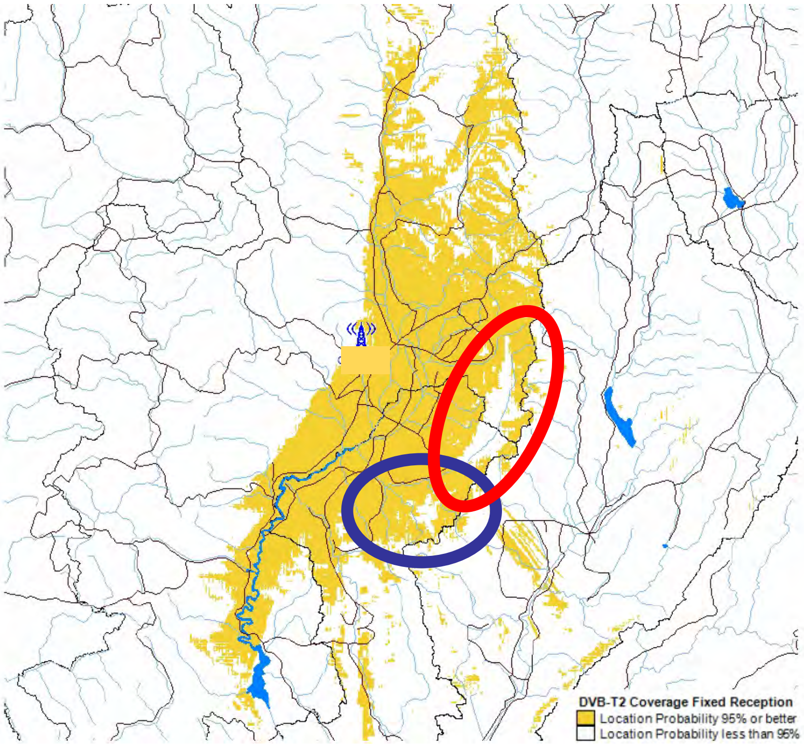
  Energy efficiency

  Reliability and long term stability

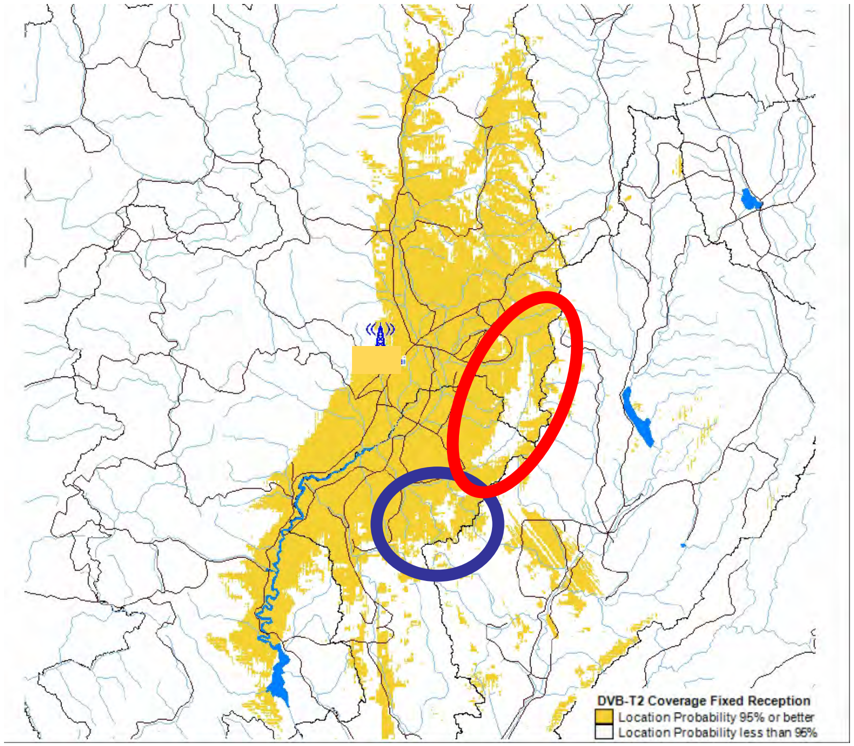
  Mean time between failure

Coverage example

Tx Power: 3 kW



Tx Power: 6 kW



64 QAM, 32k FFT, CR 2/3, C/N 17dB

MORE POWER IS NOT ALWAYS THE BEST SOLUTION

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Why Low Power Transmitters

1. **High Power Transmitters (> 2kW) can not guarantee a 100% coverage**

2. **Low Power Transmitters do support the High Power Transmission to ensure a better / improved coverage for**

   Shadowed areas (buildings, valleys, etc.)

   Indoor coverage for Malls

   Small communities

3. **Power Classes**

   1W – 200W

Low Power:
Transmitter, Re-transmitter & Gap Filler

1. ***Transmitter***

   Must have a link fed (ASI / IP Transport stream inputs)

   VHF & UHF

2. ***Re-Transmitters***

   RF input & ASI / IP Transport stream inputs

   Demodulate the DVB-T2 signal to Baseband (Transport Stream)

   Re-modulate the transport streams to form a regenerated DVB-T2 signal which is then retransmitted

   Transmits in UHF only

3. ***Gap Filler (OCR), Transposers***

   RF input only (VHF & UHF)

   can shift frequency (Transposer)

   amplify

   delay and transmit the received DVB-T2 signal without a full re-modulation

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Re-broadcast systems
Difference: input and output frequency

$f_{out} \neq f_{in}$

Output frequency ≠ frequency parent transmitter

Transposer

Re-transmitter

Repeater/ Gap filler

Relevance for echo cancellation

$f_{out} = f_{in}$

Output frequency = frequency parent transmitter

For SFN single frequency network

Advantages & disadvantages

Low Power Transmitters

- ***Produce a very clean output signal*** +
- ***Can be used in a Single Frequency Network (SFN) together with a Main transmitter*** +
- ***Need a Link Feed (ASI / IP Transport stream) which can be expensive*** -

Advantages & disadvantages

Re-Transmitters

- *Produce a very clean output signal , even with a noisy input signal* +
- *No MER degradation* +
- *Long processing time between input and output* -
- *Cannot be used in a Single Frequency Network (SFN) together with a Main transmitter* -
- *Can be used to build an independent Low power SFN on a frequency f2* +

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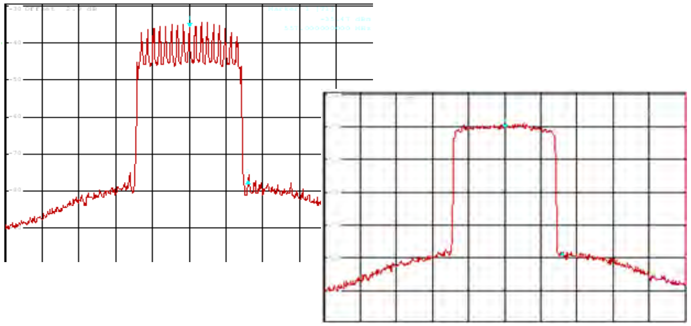
Advantages & disadvantages

Gap Fillers



Provide a degraded output signal -

MER degradation -

Can start to oscillate if not careful installed (Echos between Input & Output have to be suppressed with Echo cancellation) -

Very short processing time between input and output +

Can be used in a Single Frequency Network (SFN) together with a Main transmitter +

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