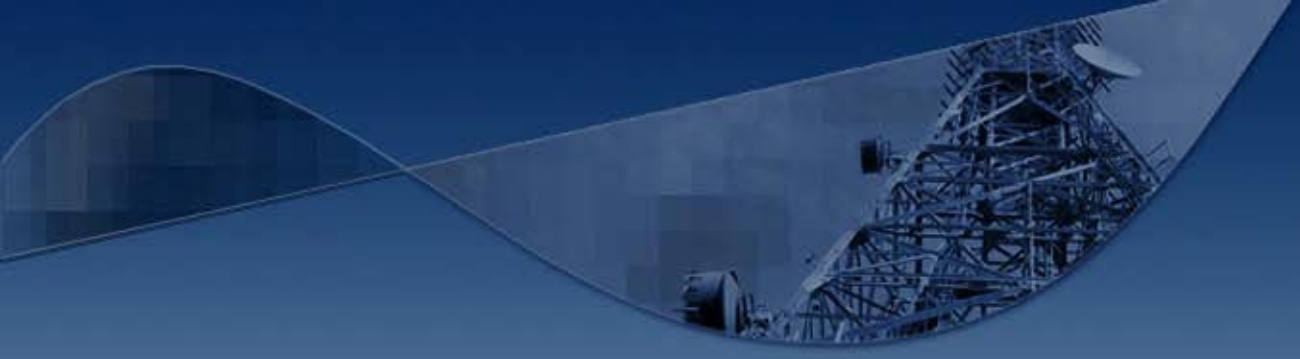

EBU Workshop on Frequency and Network Planning Aspects of DVB-T2 Part 2

ITU WP6A, Geneva, 23 April 2012

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System Properties

Why DVB-T2?

More flexibility / frequency planning
More flexibility / specific to services
Higher robustness
More capacity
Improved SFN performance

Further parameters

C/N values, protection ratios
Available net data rates

Flexibility

More bandwidths available
Scattered pilot patterns variable

Robustness

Time interleaving
Improved channel coding
Rotated constellation

Capacity

Additional modulation schemes
Bandwidth extension

SFN performance

Additional guard interval sizes
Additional FFT sizes

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Overview Part 2

- Network Planning Parameters
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- Implementation Scenarios
- SFN Extension
- Receiver Modelling
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Network Planning Parameters

Minimum signal input levels

Signal levels for planning

- Bands III and IV/V

- Fixed rooftop reception
- Portable indoor/outdoor reception
- Mobile reception
- Handheld portable/mobile reception

Protection ratios

- DVB-T2 vs. DVB-T/DVB-T2
- DVB-T2 vs. Other Services (LTE etc.)

Overload thresholds

- DVB-T2 vs. Other Services (LTE etc.)

Partly available yet

Signal Levels for Planning

Required signal levels are basic network planning parameters

Information required on:

- **Robustness: C/N**
- **Receiver: Receiver noise figure, antenna gain, feeder loss**
- **Receiver site: Man-made noise, penetration loss, height loss (transmission channel characteristics in C/N)**
- **Coverage quality: Reception mode, location probability**

Methodology identical to known digital broadcasting systems (DVB-T and T-DAB)

Details are collected in Annex 1 of EBU Tech 3348

Signal Levels for Planning

Examples described in EBU Tech 3348 for Band III and Band IV/V:

Reception mode	Example DVB-T2 variant	C/N [dB]
Fixed reception	256-QAM, FEC 2/3, 32k, PP7	20.0
Portable outdoor reception / urban (Class A)	64-QAM, FEC 2/3, 32k, PP4	17.9
Portable indoor reception / urban (Class B)	64-QAM, FEC 2/3, 16k, PP1	18.3
Mobile reception / rural	16-QAM, FEC 1/2, 8k, PP1	10.2
Handheld portable outdoor reception (Class H-A)	16-QAM, FEC 1/2, 16k, PP3	9.8
Handheld mobile reception (Class H-D) (i.e. terminals are used within a moving vehicle)	16-QAM, FEC 1/2, 8k, PP2	10.2

Signal Levels for Planning

Simplified table from EBU Tech 3348 for two cases in Band IV/V:

DVB-T2 in Band IV/V			Fixed	Portable indoor/urban
Frequency	Freq	MHz	650	650
Minimum C/N required by system	C/N	dB	20.0	18.3
System variant (example)			256-QAM FEC 2/3, 32k, PP7 Extended	64-QAM FEC 2/3, 16k, PP1 Extended
Bit rate (indicative values)		Mbit/s	35-40	23-28
Receiver Noise Figure	F	dB	6	6
Feeder loss	Lf	dB	4	0
Antenna gain relative to half dipole	Gd	dB	11	0
Min equivalent field strength at receiving location	Emin	dBµV/m	45.3	50.6
Allowance for man-made noise	Pmmn	dB	0	1
Penetration loss (building or vehicle)	Lb, Lh	dB	0	11
Location probability		%	70	70
Minimum median equivalent field strength at reception height; 50% time and 50% locations	Emed	dBµV/m	48.2	66.8
Location probability		%	95	95
Minimum median equivalent field strength reception height; 50% time and 50% locations	Emed	dBµV/m	54.3	75.9

Protection Ratios / Overload Thresholds

All PRs for reference DVB-T2 mode from Draft [2NDDTTBPlan]

DVB-T2 vs. DVB-T / DVB-T2

Co-channel PR:	**Identical with C/N (for appropriate transmission channel)**
Adjacent channel PR:	**from Draft [2NDDTTBPlan]**
Extended bandwidth mode:	**Identical with normal mode**
Into DVB-T:	**Identical with interference from DVB-T**

DVB-T2 vs. other broadcasting systems (T-DAB, Analogue TV, etc.)

Co-channel and Adjacent channel PR:	**not available yet**
Into T-DAB, AnTV, etc.:	**Identical with DVB-T figures**

DVB-T2 vs. non-broadcasting systems (LTE, …)

For LTE Base Station and LTE Terminal

Co-channel PR:	**not available yet**
Adjacent channel PR:	**from Draft [2NDDTTBPlan]**

Protection Ratios / Overload Thresholds

Protection ratios for other DVB-T2 modes

Simple adaption method: Use respective difference from C/N figures

(Comment: Is rough approximation; measurements preferable)

Overload Thresholds: DVB-T2 vs. DVB-T2

Adjacent channel O_{th}: from Draft [2NDDTTBPlan]

Overload Thresholds:
DVB-T2 vs. non-broadcasting systems (LTE, …)

For LTE Base Station and LTE Terminal

Adjacent channel O_{th}: from Draft [2NDDTTBPlan]

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Network Planning Objectives

Number of programmes:	**Capacity of DVB-T/T2 MUX**
Quality of programmes:	**Capacity of DVB-T/T2 MUX**
Quality of coverage:	**Robustness of DVB-T/T2 mode**
Frequency efficiency:	**MFN/SFN performance**

Trade-off between capacity and robustness

Costs
(Economic aspect which rules the technical choice)

MUX Capacity - Example

MFN Rooftop reception (UK case)

Same coverage area for both DVB-T and DVB-T2

DVB-T Parameters		DVB-T2 Parameters	
Bandwidth:	8 MHz	**Bandwidth:**	8 MHz
FFT size:	2k	**FFT size:**	32k
Carrier mode:	N/A	**Carrier mode:**	extended
Scattered Pilot Pattern:	N/A	**Scattered Pilot Pattern:**	PP7
Guard interval:	1/32 (7 µs)	**Guard interval:**	1/128 (28 µs)
Modulation:	64-QAM	**Modulation:**	256-QAM
Code rate:	2/3	**Code rate:**	2/3
C/N (Rice):	20.1 dB	**C/N (Rice):**	20.0 dB
Resulting data rate:	**24.1 Mbit/s**	**Resulting data rate:**	**40.2 Mbit/s**

Gain in data rate: 16 Mbit/s

Usable for: More programmes or better picture quality

Overview on MUX data capacity in Annex 2 of EBU Tech 3348

Robustness - Example

SFN Portable reception

Same data rate for both DVB-T and DVB-T2

DVB-T Parameters		DVB-T2 Parameters	
Bandwidth:	8 MHz	**Bandwidth:**	8 MHz
FFT size:	8k	**FFT size:**	16k
Carrier mode:	N/A	**Carrier mode:**	extended
Scattered Pilot Pattern:	N/A	**Scattered Pilot Pattern:**	PP3
Guard interval:	1/4 (224 µs)	**Guard interval:**	1/8 (224 µs)
Modulation:	16-QAM	**Modulation:**	16-QAM
Code rate:	2/3	**Code rate:**	1/2
C/N (Rayleigh):	**17.2 dB**	**C/N (Rayleigh):**	**9.8 dB**
Resulting data rate:	13.3 Mbit/s	**Resulting data rate:**	13.1 Mbit/s

Gain in C/N: 7 dB

Usable for: Less transmitter power or Larger coverage area or Improved reception mode

SFN Performance

SFN performance is restricted by self-interference

Limitation on inter-transmitter distance and size of SFN

Crucial parameter: Guard interval GI

Larger GI -> Larger inter-transmitter distance / size of SFN

Rule of thumb: GI length x c = inter-transmitter distance

Trade-off between data capacity and GI length

higher FFT/same GI: higher MUX capacity

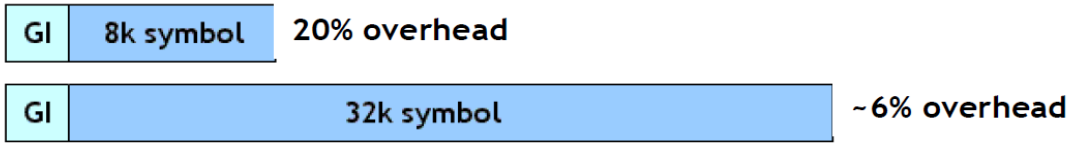

Figure 2.12: Guard interval overhead reduction with larger FFT size

higher FFT/same MUX capacity: larger SFN

Overview Part 2

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Implementation Scenarios

Which combination of DVB-T2 parameters for a specific purpose?

Fixed rooftop reception

Scenarios:

1 Same coverage as DVB-T, Transition period

2 SFN, maximum coverage

3a SFN, limited areas

3b SFN, large areas

Portable & mobile reception

Scenarios:

4 Maximum data rate

5 Maximum coverage

6 Optimal spectrum usage

7 Mobile reception, small bandwidth

8 Common MUX usage, Different services

Fixed Rooftop Reception

Implementation Scenario	Fixed rooftop reception MFN (UK mode) 1	Fixed rooftop reception (maximum coverage area extension) 2	Fixed rooftop reception Limited area SFN (GE06 Allotment) 3a	Fixed rooftop reception Large area SFN 3b
Bandwidth	8 MHz	8 MHz	8 MHz	8 MHz
FFT mode	32K	32K	32K	32K
Carrier mode	Extended	Extended	Extended	Extended
Scattered Pilot Pattern	PP7	PP2	PP4	PP2
Guard interval	1/128 (28 µs)	1/8 (448 µs)	1/16 (224 µs)	1/8 (448 µs)
Modulation	256 QAM	16QAM	256 QAM	256 QAM
Code rate	2/3	2/3	2/3	2/3
C/N	20.0 dB	11.6 dB	20.8 dB	21.2 dB
Data rate	40.2 Mbit/s	16.7 Mbit/s	37.0 Mbit/s	33.4 Mbit/s

Table 5.1: Overview of the Rooftop Implementation Scenarios

Portable and Mobile Reception

Implementation Scenario	portable reception (maximum date rate) 4a	portable reception (maximum date rate, alternative) 4b	portable reception (maximum coverage area extension) 5	portable reception (optimum spectrum usage) 6	mobile reception Band III 7a	mobile reception Band III (alternative) 7b	portable and mobile reception (common usage of MUX by different services)I 8	
							high data rate	low data rate
Bandwidth	8 MHz	8 MHz	8 MHz	8 MHz	1,7 MHz	1,7 MHz	8 MHz	
FFT mode	16K	32K	16K	16K	4K	4K	8K	
Carrier mode	Extended	Extended	Extended	Extended	Normal	Normal	Extended	
Scattered Pilot Pattern	PP3	PP4	PP3	PP1	PP2	PP1	PP1	
Guard interval	1/8 (224 µs)	1/16 (224 µs)	1/8 (224 µs)	1/4 (448 µs)	1/8 (278 µs)	1/4 (555 µs)	1/4 (224 µs)	
Modulation	64 QAM	64 QAM	16 QAM	64 QAM	16 QAM	16 QAM	64 QAM	16 QAM
Code rate	2/3	2/3	1/2	2/3	1/2	1/2	2/3	1/2
C/N	17.9 dB	17.9 dB	9.8 dB	18.3 dB	10.2 dB	10.2 dB	18.3 dB	10.2 dB
Data rate	26,2 Mbit/s	27,7 Mbit/s	13,1 Mbit/s	22,6 Mbit/s	2,5 Mbit/s	2,2 Mbit/s	22,4 Mbit/s (max)	11,2 Mbit/s (max)

Table 5.2: Overview of the Portable and Mobile Implementation Scenarios

Overview Part 2

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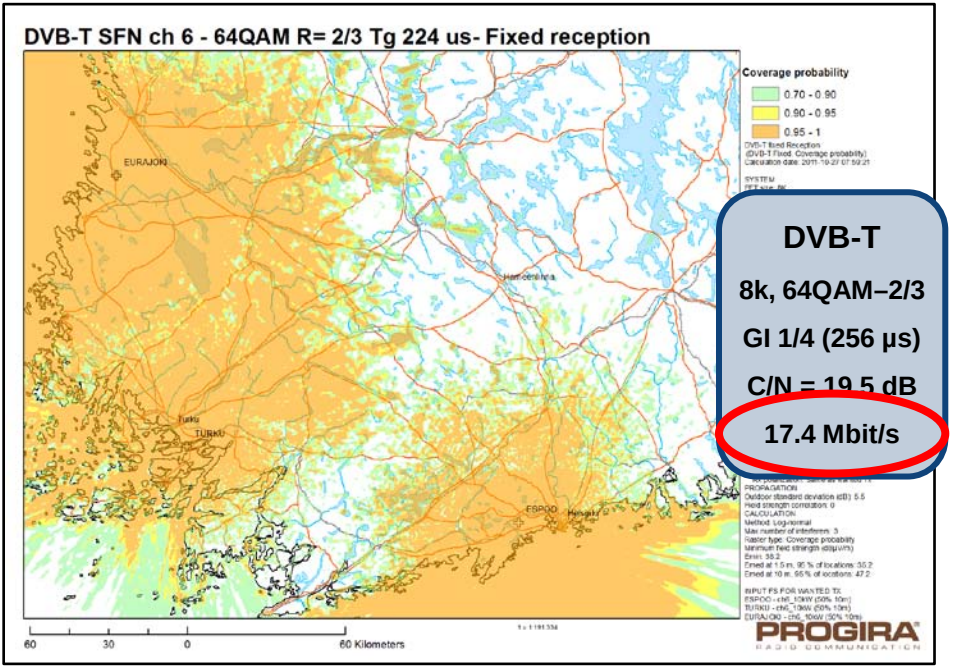
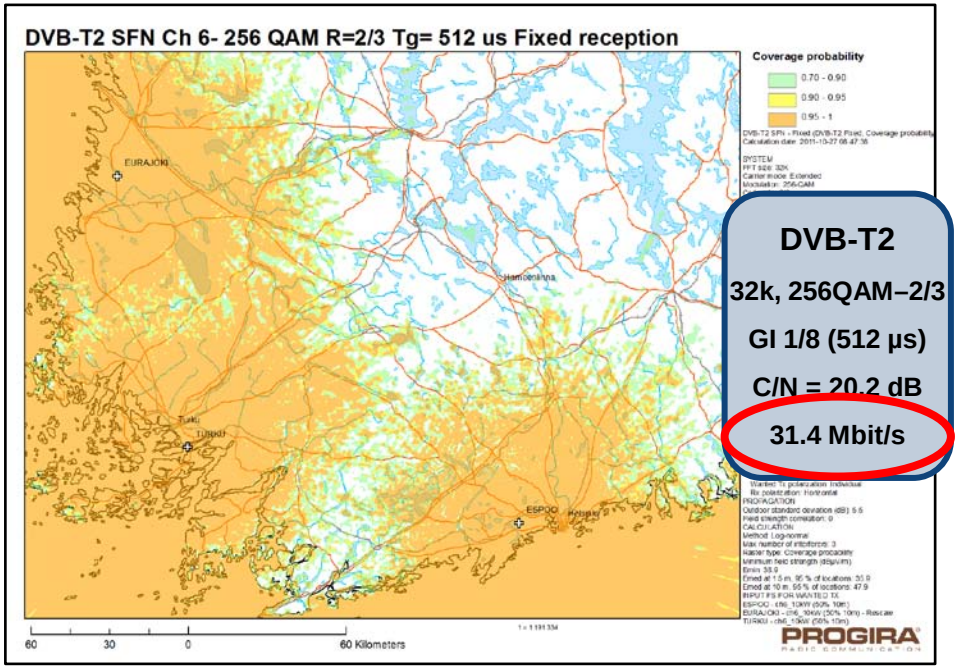
Scenario 3b: Rooftop Reception SFN, Large Area

Planning exercise in Finland (Progira)

3 transmitter network, fixed rooftop reception, channel 6 (VHF)

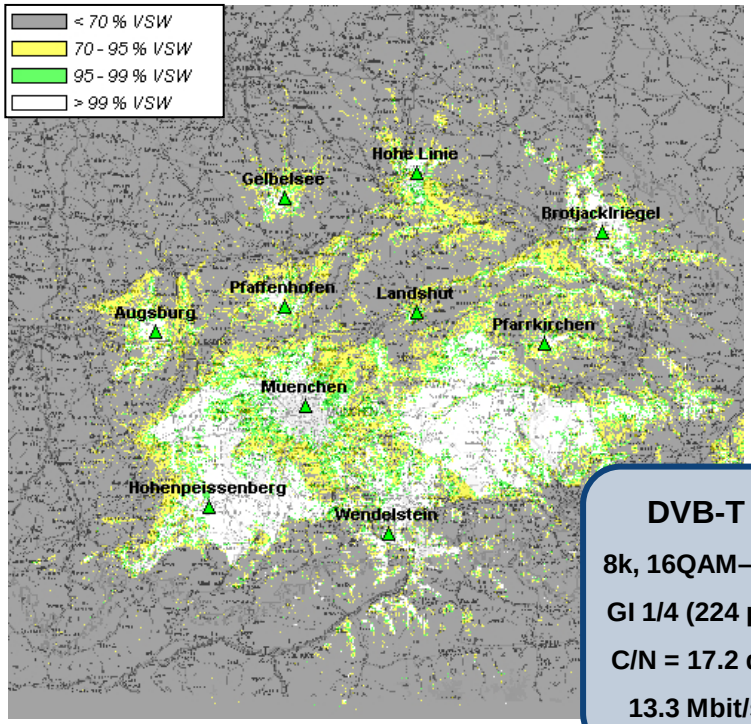




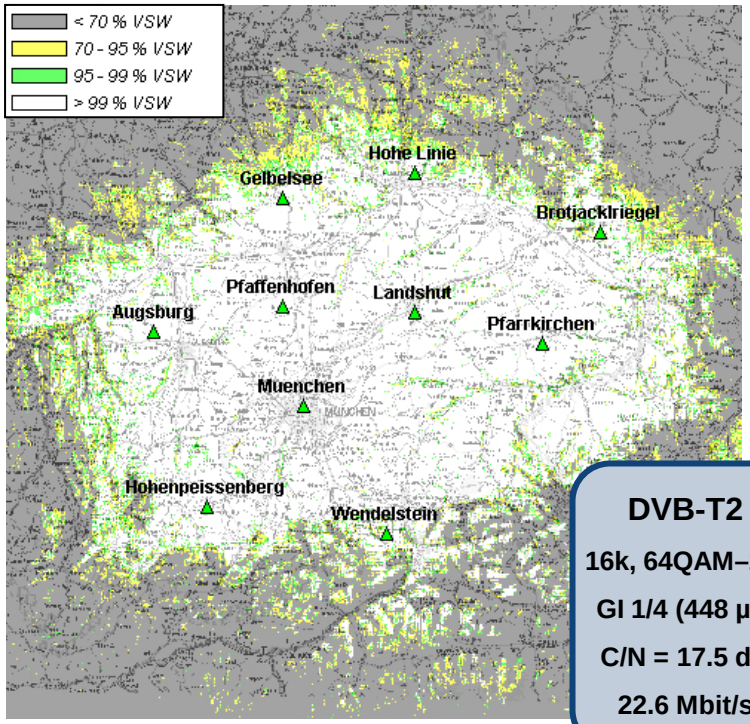
Scenario 6: Portable reception Optimal Spectrum Usage

Planning exercise in Bavaria (IRT)

10 transmitter network, portable outdoor reception (UHF), (Map: 300 km x 300 km)



DVB-T
8k, 16QAM–2/3
GI 1/4 (224 µs)
C/N = 17.2 dB
13.3 Mbit/s

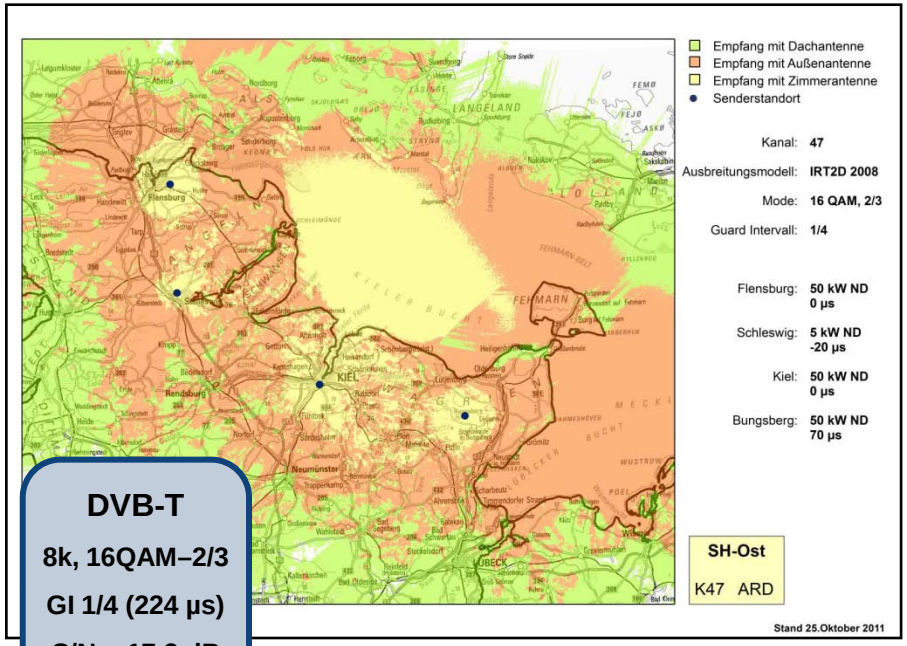


DVB-T2
16k, 64QAM–2/3
GI 1/4 (448 µs)
C/N = 17.5 dB
22.6 Mbit/s

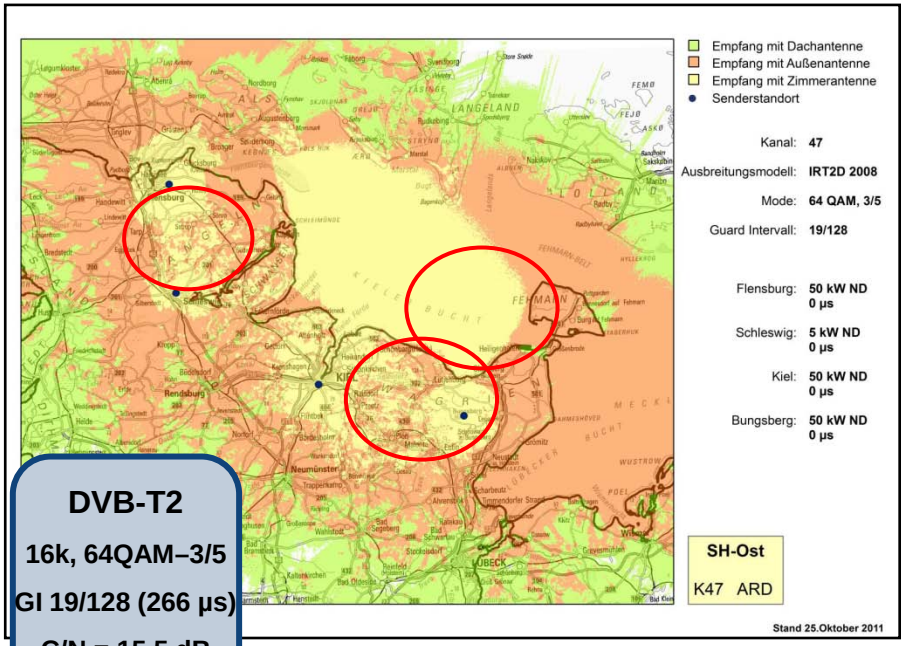
Mixture of Scenarios: Maximum Data Rate / Maximum Coverage Area

Planning exercise in northern part of Germany (NDR)

4 transmitter network, portable outdoor reception, channel 47 (UHF)



DVB-T
8k, 16QAM–2/3
GI 1/4 (224 µs)
C/N = 17.2 dB
13.3 Mbit/s

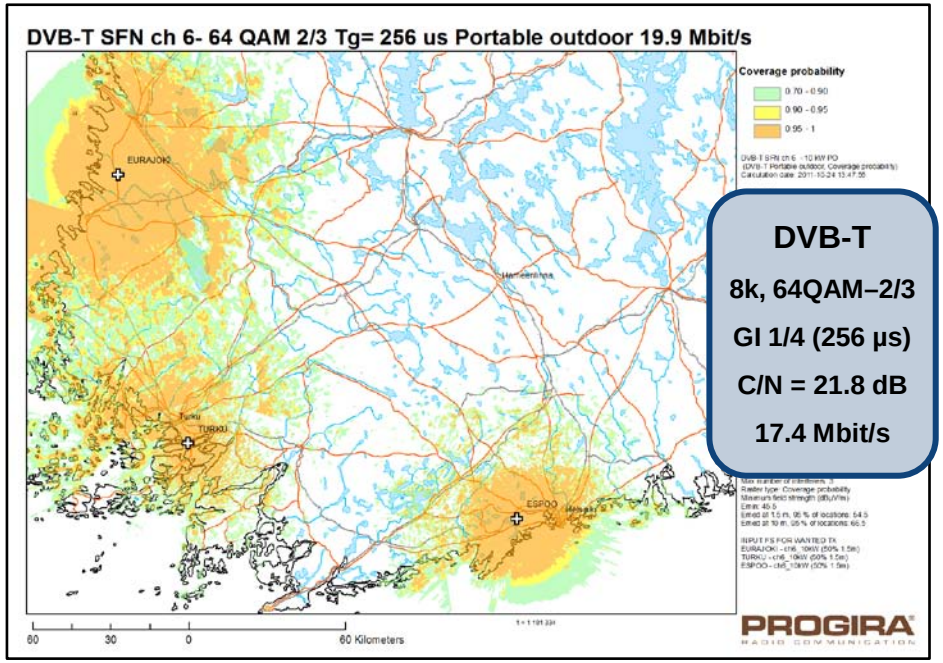


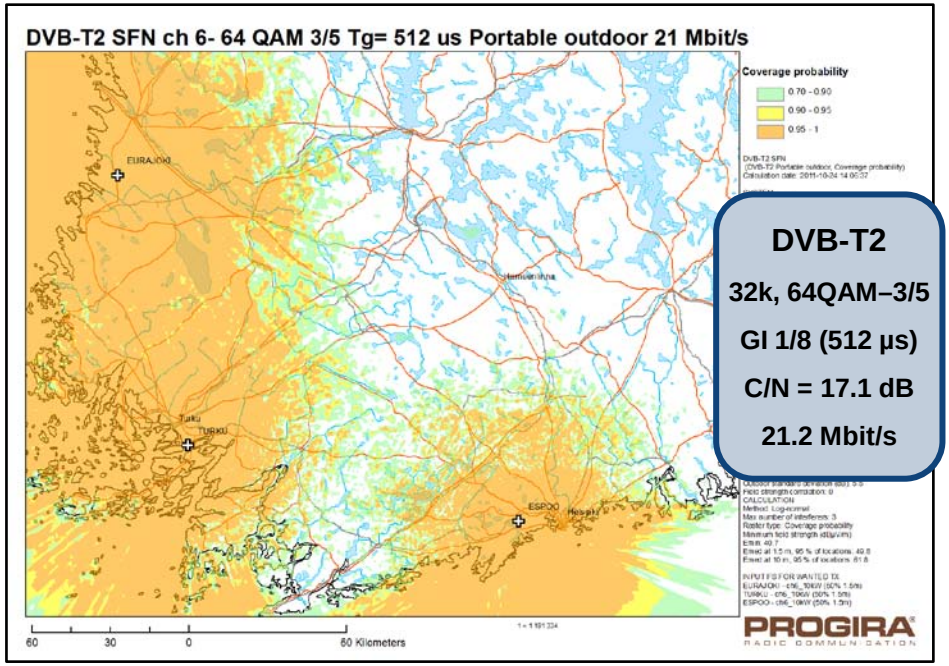
DVB-T2
16k, 64QAM–3/5
GI 19/128 (266 µs)
C/N = 15.5 dB
23.0 Mbit/s

Scenario 3b: for portable reception (with 64QAM) SFN, Large Area

Planning exercise in Finland (Progira)

3 transmitter network, portable outdoor reception, channel 6 (VHF)





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Receiver Modelling

Synchronisation of Useful Signals

In multipath environment (SFN or/and echoes) signals arrive at different times. This requires synchronisation strategy for FFT evaluation window.

Description of synchronisation strategies, e.g., in EBU BPN066.

Performance beyond Guard Interval

Useful signals beyond guard interval degrade gradually. This gradual degradation is restricted by Nyquist limit given by pilot pattern choice and interpolation mode: Interval of correct equalisation.

Receiver modelling is an issue for a network planning tool.

Interval of Correct Equalisation

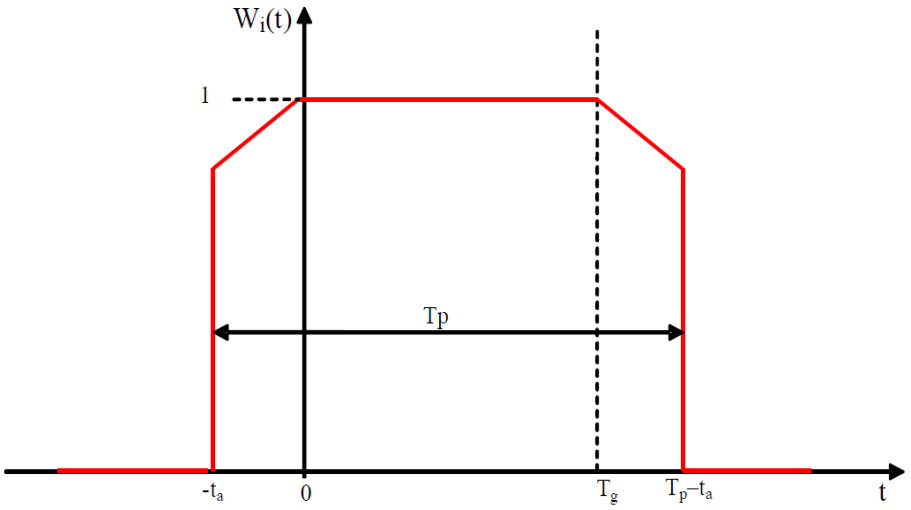

Figure 3.1: Weighting function $w_i(t)$ (with an equalization interval EI starting at $t = -t_a$)

MODE	UHF 2 (Large area SFN-Rooftop)	UHF 4 (Large area SFN–Portable)
Modulation	256-QAM	16-QAM
FFT size	32k	16k
Code rate	3/4	1/2
Pilot Pattern	PP2	PP3
Guard interval fraction	1/8	1/8
T_g (µs)	**448**	**224**
T_u (µs)	3584	1792
Nyquist limit as fraction of T_u	1/6	1/6
Nyquist limit (µs)	597	299
Equalisation factor	57/64	57/64
T_p time (µs)	**532**	**266**

Table 3.10: Calculation of interval of correct equalization for two DVB-T2 modes

Table of Nyquist time for frequency and time interpolation vs. guard interval is given in Annex 3 of EBU Tech 3348

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General Planning Methods, Criteria and Parameters

Many general frequency and network planning aspects for DVB-T2 are identical or (very) similar to DVB-T:

- **Reception modes: Fixed, Portable, Mobile, Handheld**

- **Coverage definitions, Location percentage**

- **Calculation of signal levels:**
  Antenna gain, Feeder loss, Man-made noise, Height loss
  Building penetration loss, Vehicle entry loss

Information collected in Annex 1 of EBU Tech 3348

Documents and References

EBU:

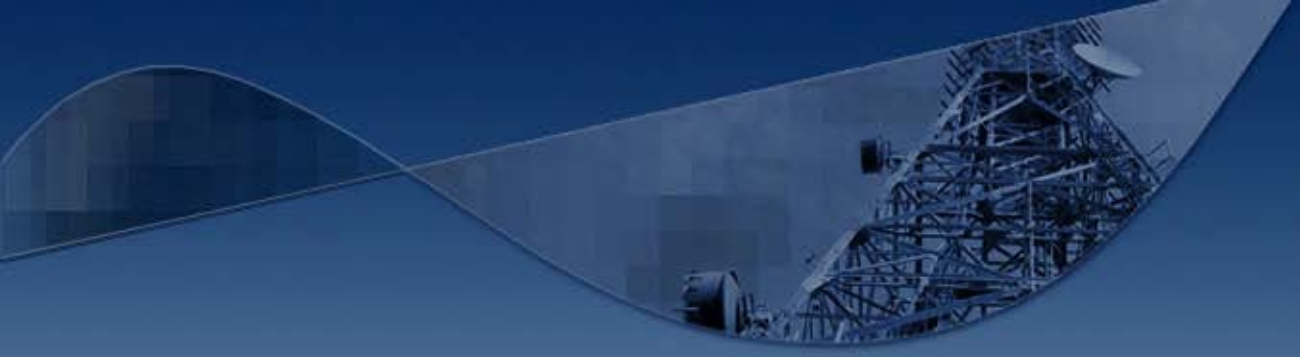
BPN005ed.3: Terrestrial Digital Television – Planning and Implementation Considerations
BPN066: Guide on SFN Frequency Planning and Network Implementation
Tech 3348: Frequency and Network Planning Aspects of DVB-T2
Tech 3317: Planning parameters for hand-held reception

ETSI:

ETSI EN 302 755 V1.3.1 (2011-11): System Specification
ETSI TS 102 831 V1.1.1 (2010-10): Implementation Guideline

ITU-R:

Rec BT.1306, BT.1877, BT.1368, BT.[2NDDTTBPLAN],
Rec P.1546, P.372, SM.1875 etc**.**
Technical Annex GE06 Agreement



Thank you for your attention

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