ITU/ASBU Workshop on Frequency Planning and Digital Transmission

Damascus

Planning DTT networks
‘An Introduction’

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Planning a DVB-T station

- What Frequency Band?
  - Band III, Band IV or Band V
  - Why not even another part of the Spectrum?
- Is it clear spectrum?
  - Does the new service have to share with existing Services such as analogue
  - How much of the spectrum is available
  - Are any of the channels adjacent

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General Spectrum Considerations

- In the Spectrum that is available is it?
  - Contiguous (an unbroken chunk with no other services interleaved)
  - Fragmented and all over the band
  - What is the channel Spacing

Regulation and Licensing

- International Co-Ordination
- ERP Limitations
- Acceptable interference to existing services (for example analogue TV).
- DVB-T system to be adopted
  - For what purpose (fixed, portable, mobile, datacasting)
- The number of programmes per channel

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DVB-T Variants

			Required C/N for BER=2. 10^{-4} after Viterbi (quasi error-free after Reed-Solomon, *)			Net bit rate (Mbit/s)			
System variant	Modulation	Code Rate	Gaussian channel	Ricean channel (F_1)	Rayleigh channel (P_1)	D/T_U =1/4	D/T_U =1/8	D/T_U =1/16	D/T_U =1/32
A1	QPSK	1/2	3.1	3.6	5.4	4.98	5.53	5.85	6.03
A2	QPSK	2/3	4.9	5.7	8.4	6.64	7.37	7.81	8.04
A3	QPSK	3/4	5.9	6.8	10.7	7.46	8.29	8.78	9.05
A5	QPSK	5/6	6.9	8.0	13.1	8.29	9.22	9.76	10.05
A7	QPSK	7/8	7.7	8.7	16.3	8.71	9.68	10.25	10.56
B1	16-QAM (M1 **)	1/2	8.8	9.6	11.2	9.95	11.06	11.71	12.06
B2	16-QAM	2/3	11.1	11.6	14.2	13.27	14.75	15.61	16.09
B3	16-QAM	3/4	12.5	13.0	16.7	14.93	16.59	17.56	18.10
B5	16-QAM	5/6	13.5	14.4	19.3	16.59	18.43	19.52	20.11
B7	16-QAM	7/8	13.9	15.0	22.8	17.42	19.35	20.49	21.11
C1	64-QAM (M2 **)	1/2	14.4	14.7	16.0	14.93	16.59	17.56	18.10
C2	64-QAM (M3 **)	2/3	16.5	17.1	19.3	19.91	22.12	23.42	24.13
C3	64-QAM	3/4	18.0	18.6	21.7	22.39	24.88	26.35	27.14
C5	64-QAM	5/6	19.3	20.0	25.3	24.88	27.65	29.27	30.16
C7	64-QAM	7/8	20.1	21.0	27.9	26.13	29.03	30.74	31.67

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Most Common Choices of Variant

- Fixed Services (HDTV and SDTV)
  - 64QAM rate 2/3 guard interval
  - 16QAM rate 2/3 guard interval (tends to be for portable reception)

- Mobile 2K QPSK, 2K 16QAM 1/2 rate 1/4 guard interval
  OR 8K QPSK, 2K 16QAM rate 2/3 1/4 guard interval
  Utilising Diversity receivers

- Datacasting So far not for DVB-T, however DVB-H is promising and is being tested

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Minimum Field Strengths required (1)

Minimum median equivalent field strength in Band IV for fixed reception

Frequency	f {MHz}	500				
Minimum C/N required by system	**{dB}**	**2**	**8**	**14**	**20**	**26**
Min. equivalent receiver input voltage, 75 Ω	$U_{s\,min}$ {dBμV}	13	19	25	31	37
Feeder loss	L_f {dB}	3				
Antenna gain rel. to half wave dipole	G_D {dB}	10				
Effective antenna aperture	A_a {dBm^2}	-3.3				
Min equivalent field strength at receiving place	E_{min} {dBμV/m}	26	32	38	44	50
Allowance for man made noise	P_{mmn} {dB}	0				

Location probability: 70%

Location correction factor	C_l {dB}	2.9				
Minimum median equivalent field strength at 10m a.g.l. 50% of time and 50% of locations	E_{med} {dBμV/m}	29	35	41	47	53

Location probability: 95%

Location correction factor	C_l {dB}	9				
Minimum median equivalent field strength at 10m a.g.l. 50% of time and 50% of locations	E_{med} {dBμV/m}	35	41	47	53	59

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Minimum Field Strengths required (2)

Minimum median equivalent field strength in Band IV for Portable Class B Indoor Ground Floor reception

Frequency	f {MHz}	500				
Minimum C/N required by system	**{dB}**	**2**	**8**	**14**	**20**	**26**
Min. equivalent receiver input voltage, 75 Ω	$U_{s\ min}$ {dBμV}	13	19	25	30	37
Antenna gain rel. to half wave dipole	G_D {dB}	0				
Effective antenna aperture	A_a {dBm^2}	-13.3				
Min equivalent field strength at receiving place	E_{min} {dBμV/m}	33	39	45	51	57
Allowance for man made noise	P_{mmn} {dB}	0				
Height loss	L_h {dB}	16				
Building penetration loss	L_b {dB}	8				
Location probability: 70%						
Location correction factor	C_l {dB}	4				
Minimum median equivalent field strength at 10m a.g.l. 50% of time and 50% of locations	E_{med} {dBμV/m}	61	67	73	79	85
Location probability: 95%						
Location correction factor	C_l {dB}	13				
Minimum median equivalent field strength at 10m a.g.l. 50% of time and 50% of locations	E_{med} {dBμV/m}	70	76	82	88	94

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Mobile DVB-T minimum field Strength requirements (non-diversity receivers)

Frequency	f (MHz)	500					
Representative minimum *C/N* ratio	**(dB)**	**2**	**8**	**14**	**20**	**26**	**32**
Minimum receiver signal input power	$P_{s\,min}$ (dBW)	–126.2	–120.2	–114.2	–108.2	–102.2	–96.2
Minimum equivalent receiver input voltage, 75 Ω	$U_{s\,min}$ (dBμV)	12.6	18.6	24.6	30.4	36.6	42.6
Antenna gain relative to half wave dipole	G_D (dB)	0					
Effective antenna aperture	A_a (dBm^2)	–13.3					
Minimum power flux-density at receiving location	φ_{min} (dB(W/m^2))	–112.9	–106.9	–100.9	–94.9	–88.9	–82.9
Minimum field strength at receiving location	E_{min} (dB(μV/m))	33	39	45	51	57	63
Allowance for man-made noise	P_{mmn} (dB)	0					
Height loss	L_h (dB)	16					
Location probability: 99%							
Location correction factor	C_l (dB)	13					
Minimum median power flux-density at 10 m a.g.l. 50% of time and 50% of locations	φ_{med} (dB(W/m^2))	–84	–78	–72	–66	–60	–54
Minimum median field strength at 10 m a.g.l. 50% of time and 50% of locations	E_{med} (dB(μV/m))	62	68	74	80	86	92

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Location Variation

Location variation of the received signal

- **Within a small area, say 100 m by 100 m, there will be a more-or-less random variation of the received signal level with location which is due to terrain irregularities. The statistics of this variation are characterised by a log-normal distribution.**

- **For calculating the location correction factor C_l used when other than 50% locations are to be considered, a log-normal distribution of the received signal is assumed.**

- **The location correction factor can be calculated by the formula:**
- **$C_l = \mu * \sigma$ {dB}**
- **where:**
- **μ is the distribution factor, being 0.52 for 70% and 1.64 for 95%;**
- **σ is the standard deviation.**

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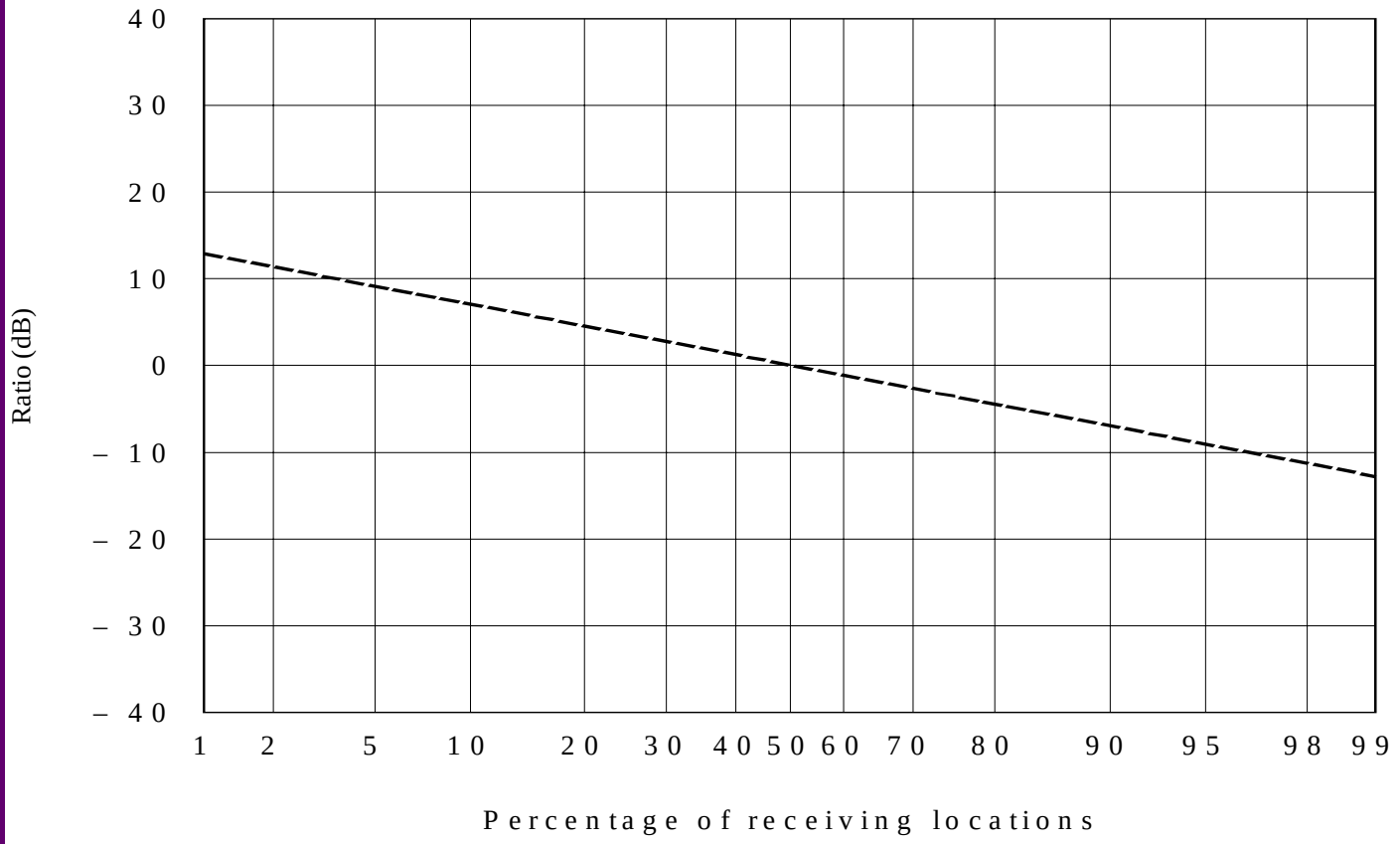
Percentage locations Chart

FIGURE 1

Ratio (dB) of the field strength for a given percentage of the receiving locations to the field strength for 50% of the receiving locations



Frequency: 30-250 MHz (Bands I, II and III)
and 470-890 MHz (Bands IV and V)

1368-01

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Reception Definitions

Fixed antenna reception

Fixed antenna reception is defined as ‘reception where a directional receiving antenna mounted at roof level is used’.

In calculating the field strength for fixed antenna reception a receiving antenna height of 10 m above ground level is considered to be representative.

Portable antenna reception

Portable antenna reception is defined as:

- Class A (outdoor) being reception where a portable receiver with an attached or built-in antenna is used outdoors at no less than 1.5 m above ground level;
- Class B (ground floor, indoor) being reception where a portable receiver with an attached or built-in antenna is used indoors at no less than 1.5 m above floor level in rooms:
    - on the ground floor;
    - with a window in an external wall.

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Coverage Area Definitions

Coverage area

In defining the coverage area for each reception condition a three level approach is taken.

Level 1: Receiving location

The smallest unit is a receiving location. A receiving location is regarded as being covered if the level of the wanted signal is high enough to overcome noise and interference for a given percentage of the time. A value of 99% of time is recommended.

Level 2: Small area coverage

The second level is a "small area" (typically 100 m by 100 m).
In this small area the percentage of covered locations is indicated.

The coverage of this small area is classified as:

"Good" if at least 95% of receiving locations within it are covered;

"Acceptable" if at least 70% of locations within it are covered.

Level 3: Coverage area

The coverage area of a transmitter, or a group of transmitters, is made up of the sum of the individual small areas in which a given percentage (70% or 95%) of coverage is achieved.

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Main DVB-T Protection Ratios

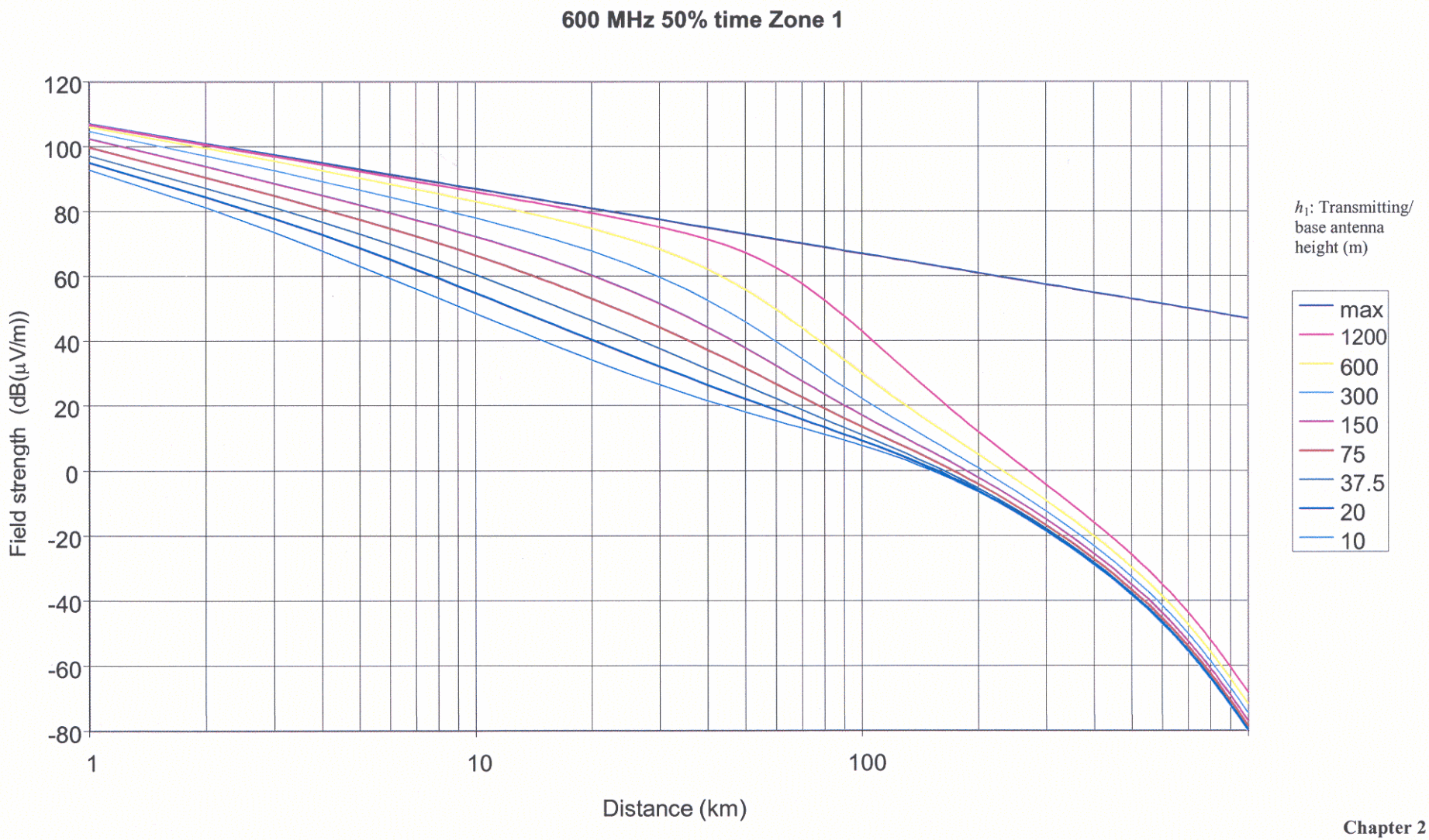
- Protection Ratios
  - Given in ITU-R Rec BT.1368-2
  - Some typical values for 64QAM rate 2/3, Ricean

Wanted system	Interfering system	Relationship	PR (dB)
DVB-T	DVB-T	Co-channel	20
DVB-T	PAL I	Co-channel	3
PAL I	DVB-T	Co-channel	37(tropo)/ 41 (cont)
DVB-T	PAL I	Upper adjacent	-38
DVB-T	PAL I	Lower adjacent	-34

Determining Field strength both interference and wanted

- Recommendation ITU 1546
  - This is a series of graphs and calculations based on statistical data.
  - Will be the standard international agreement method used between countries for co-ordination purposes and for RRC06
  - Curves are calculated for 1kW ERP
- Coverage prediction method
  - Incorporates DTM and clutter data sources
  - Is a computer based algorithm using DTM and clutter
  - Is more accurate over greater range of terrain and clutter types

Land Temperate and subtropical 50% time



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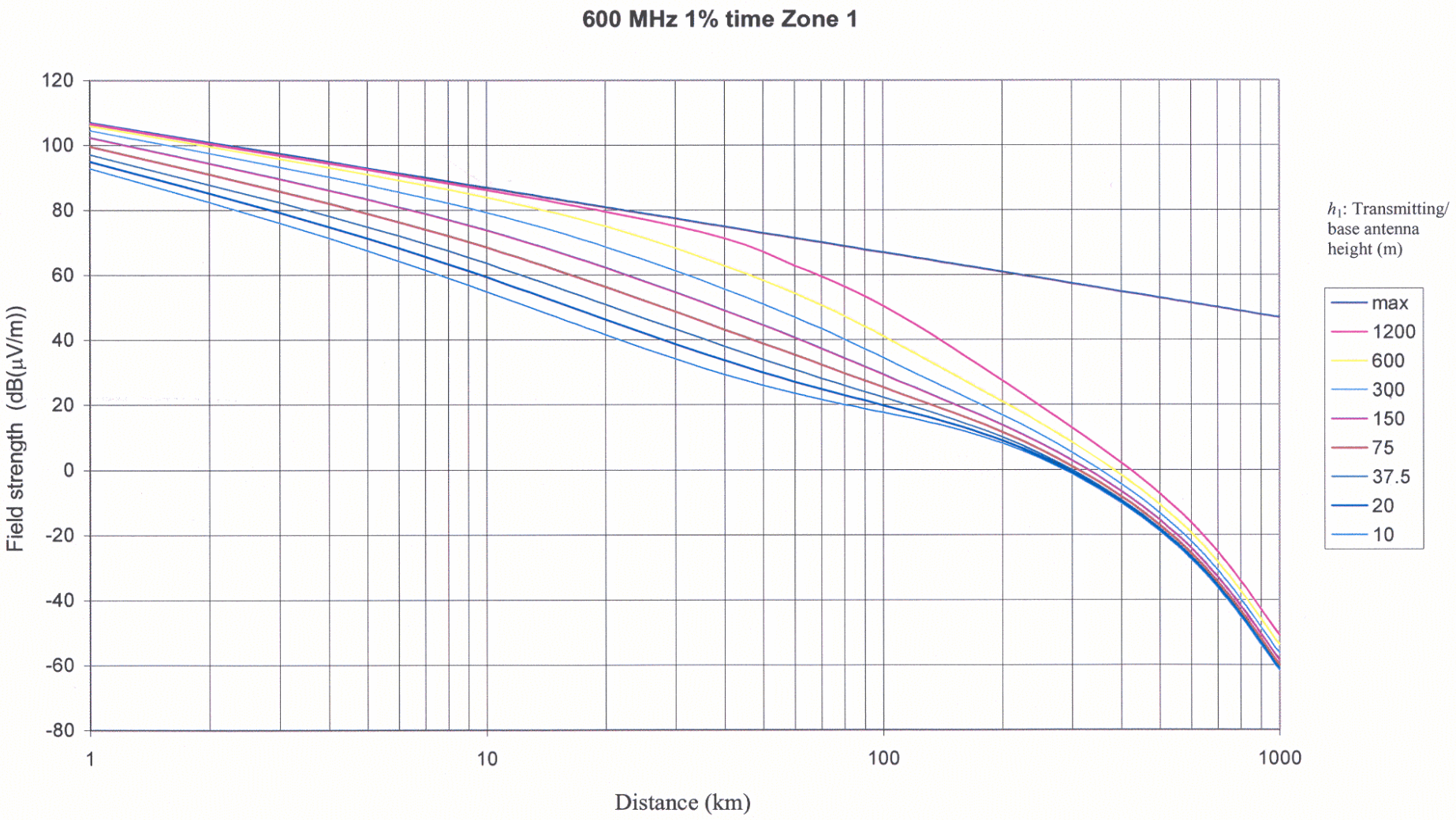
Land Temperate and subtropical 1% time



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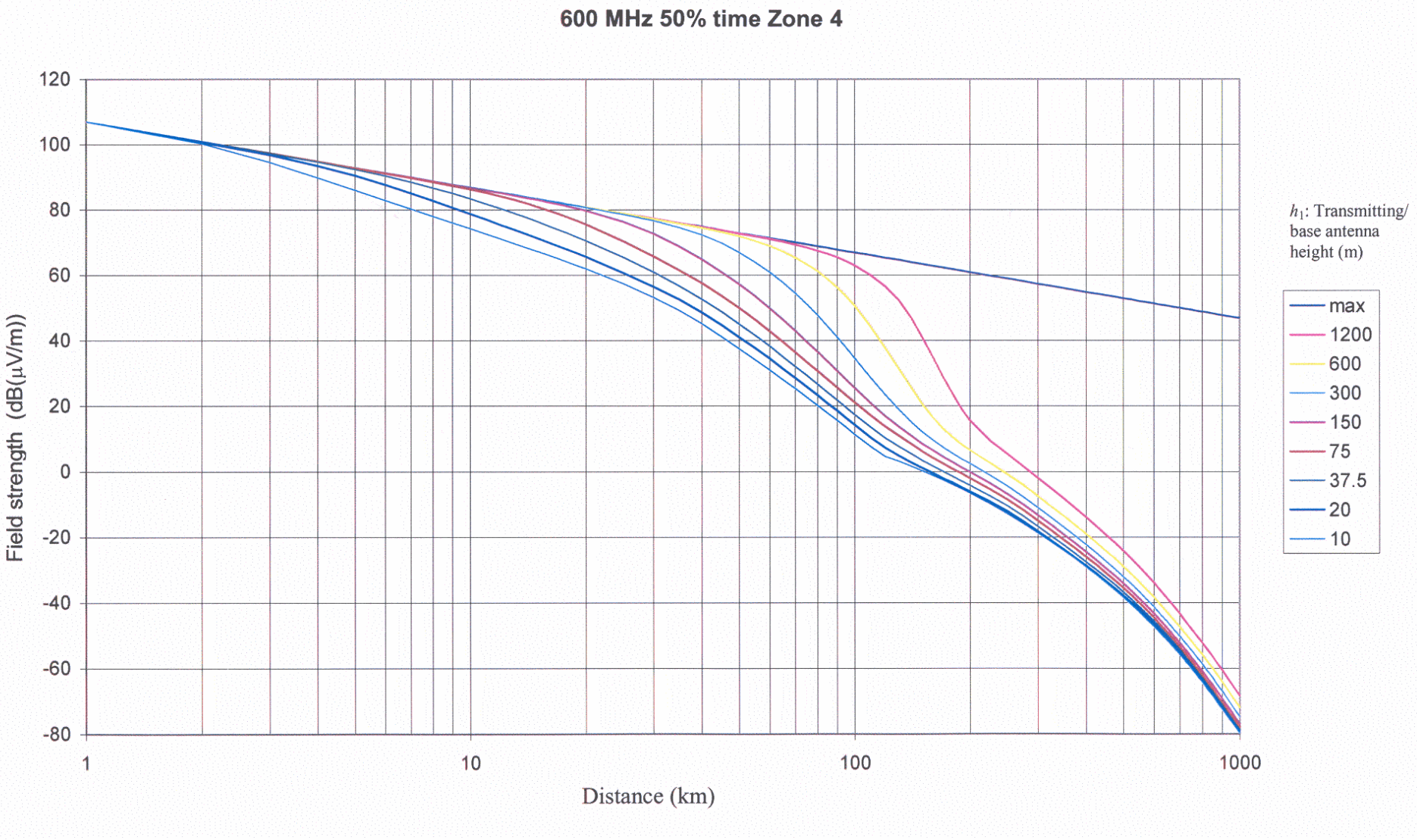
Warm Sea (Mediterranean) 50% time



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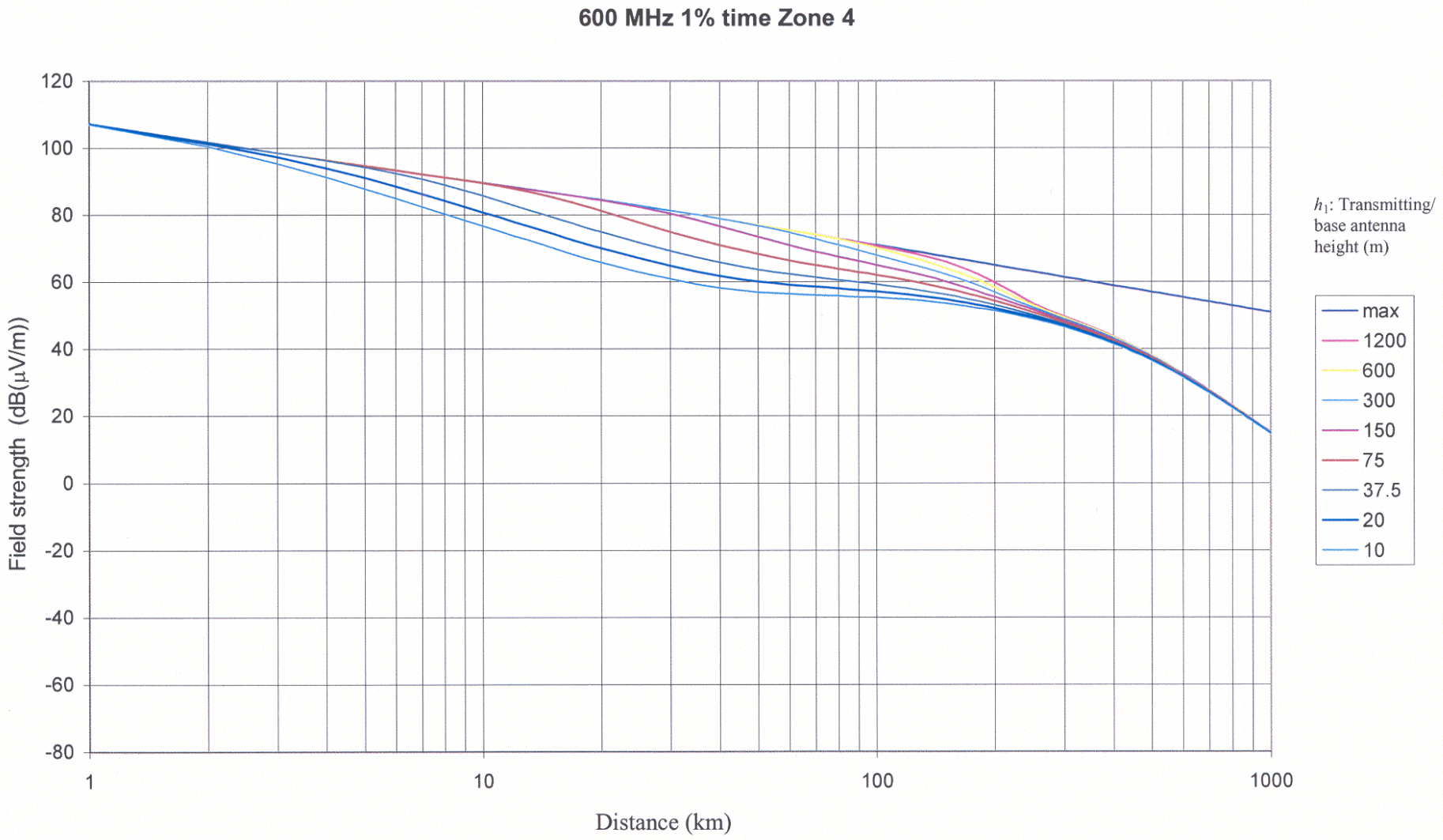
Warm Sea (Mediterranean) 1% time



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Values of maximum interfering field strength (dB(μV/m) for analogue television interfered with by DVB-T used to evaluate coordination distances

	Minimum median field-strength value (dB(μV/m)	Maximum interfering field strength (dB(μV/m) $E_{max\ int}$
Band III	55	14
Band IV	65	24
Band V	70	29

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Comparison of coordination distances (1 kW e.r.p., 300 m effective antenna height)

	Calculated coordination distances with Recommendation ITU-R P.1546 (1% of the time) (km)	ST61 limiting distances (km)	GE89 limiting distances (km)(1)
Case 1 (600 MHz, land)	130	220	150 to 180
Case 2(2) (600 MHz, warm sea)	670	Not given (>1 000 km)	650 to 750
Case 3(3) (600 MHz, cold sea)	500	980	

(1) For the GE89 distances, the distances related to Zone 1 (for land) and Zone 4 (for warm sea) are considered in this document for comparison. No comparison has been drawn for cold sea.

(2) For this case, the ST61 distances for comparison are taken from the “Mediterranean Sea” case.

(3) For this case, the ST61 distances for comparison are taken from the “sea in general” case.

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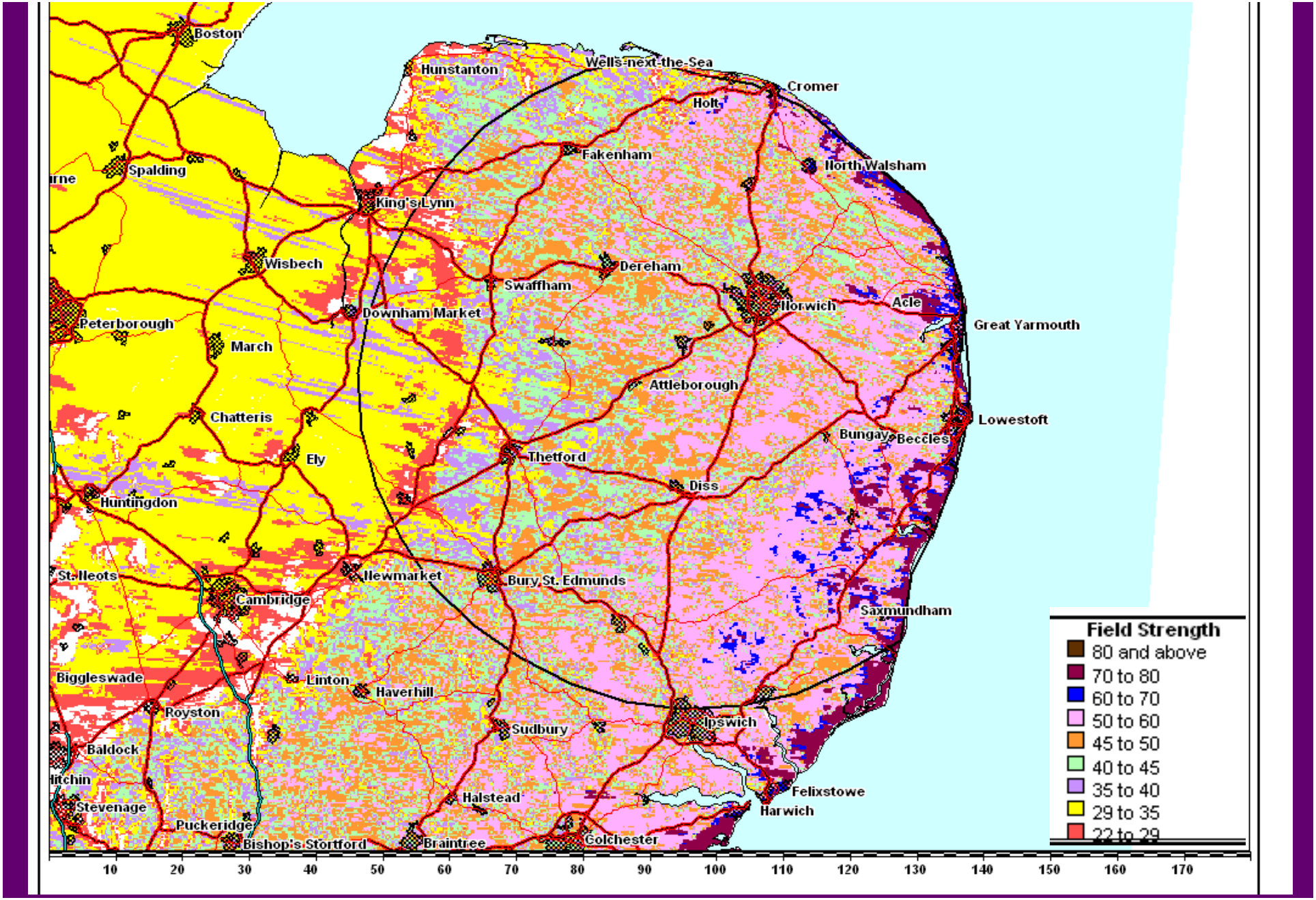

1% time interference from Rotterdam [20kW] ~200km

<10% land Terrain based prediction

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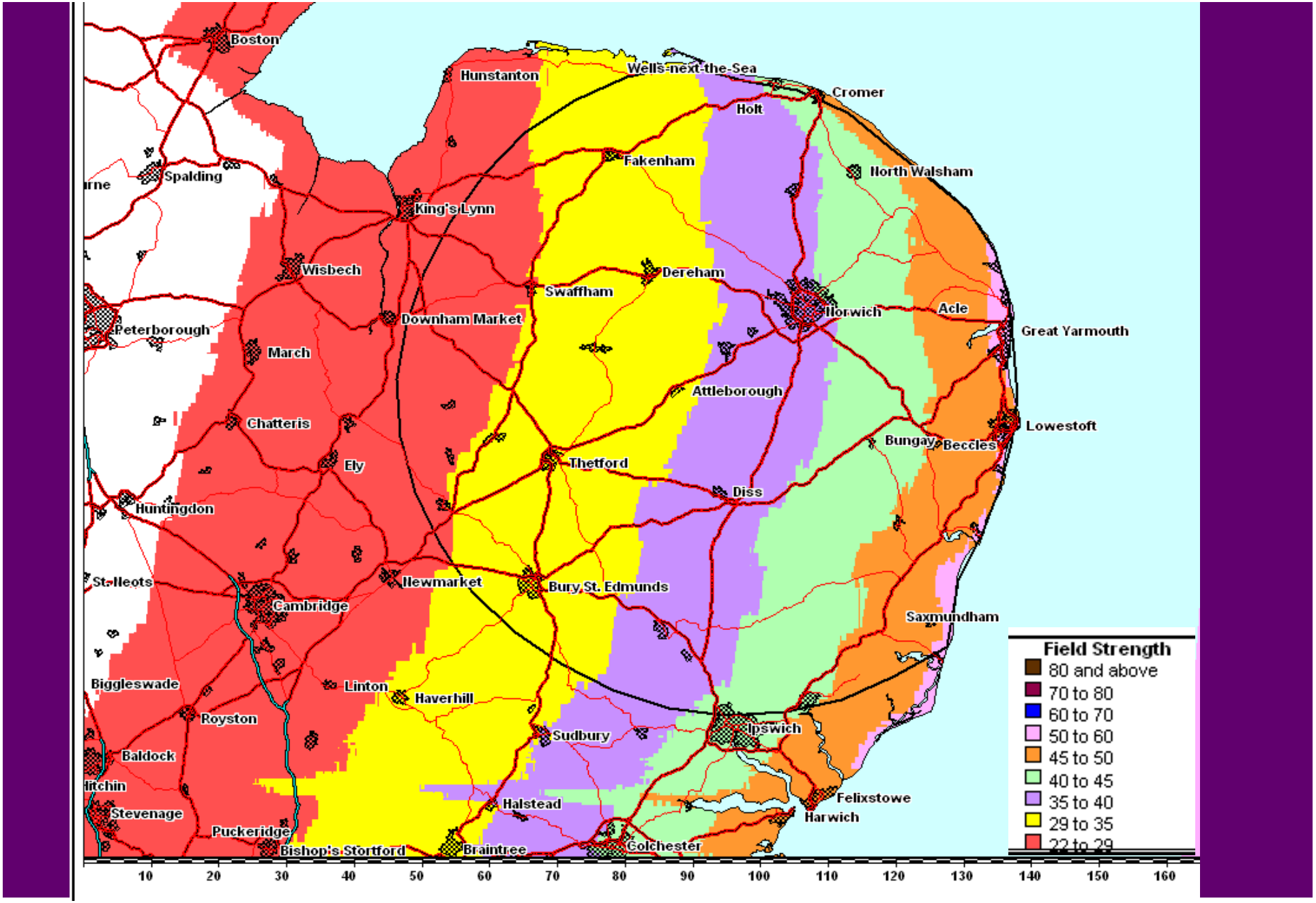

1% time interference from Rotterdam [20kW] ~200km
<10% land; Recommendation 1546 based prediction

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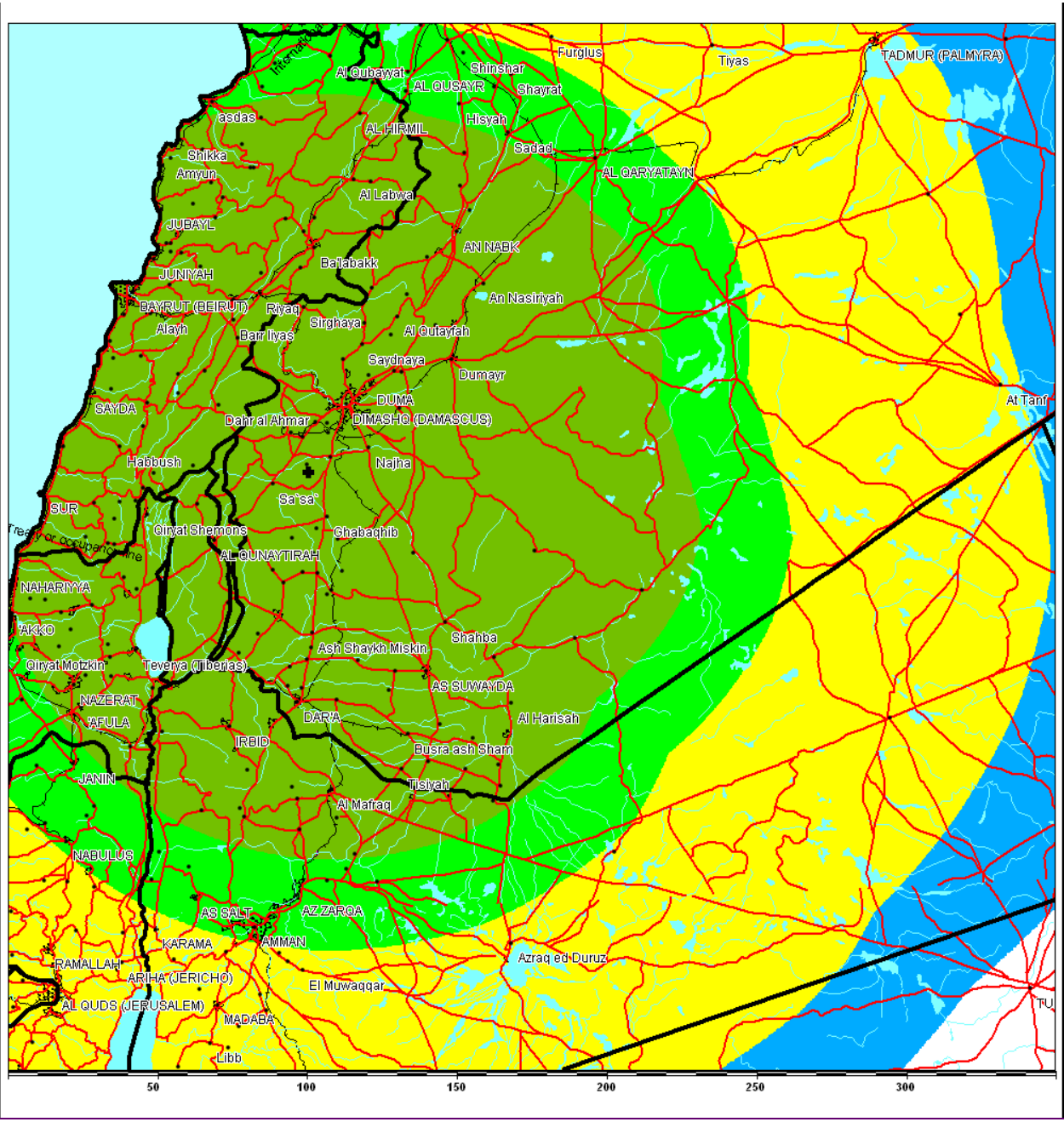

Field Strength

- 45 and above
- 40 to 45
- 29 to 40
- 24 to 29

Co-ordination Countries

Lebanon
Turkey
Iraq
Saudi Arabia
Jordan
Occupied Palestine
Cyprus
Egypt

Damascus DTT 50kW ERP; 1546 1% Time

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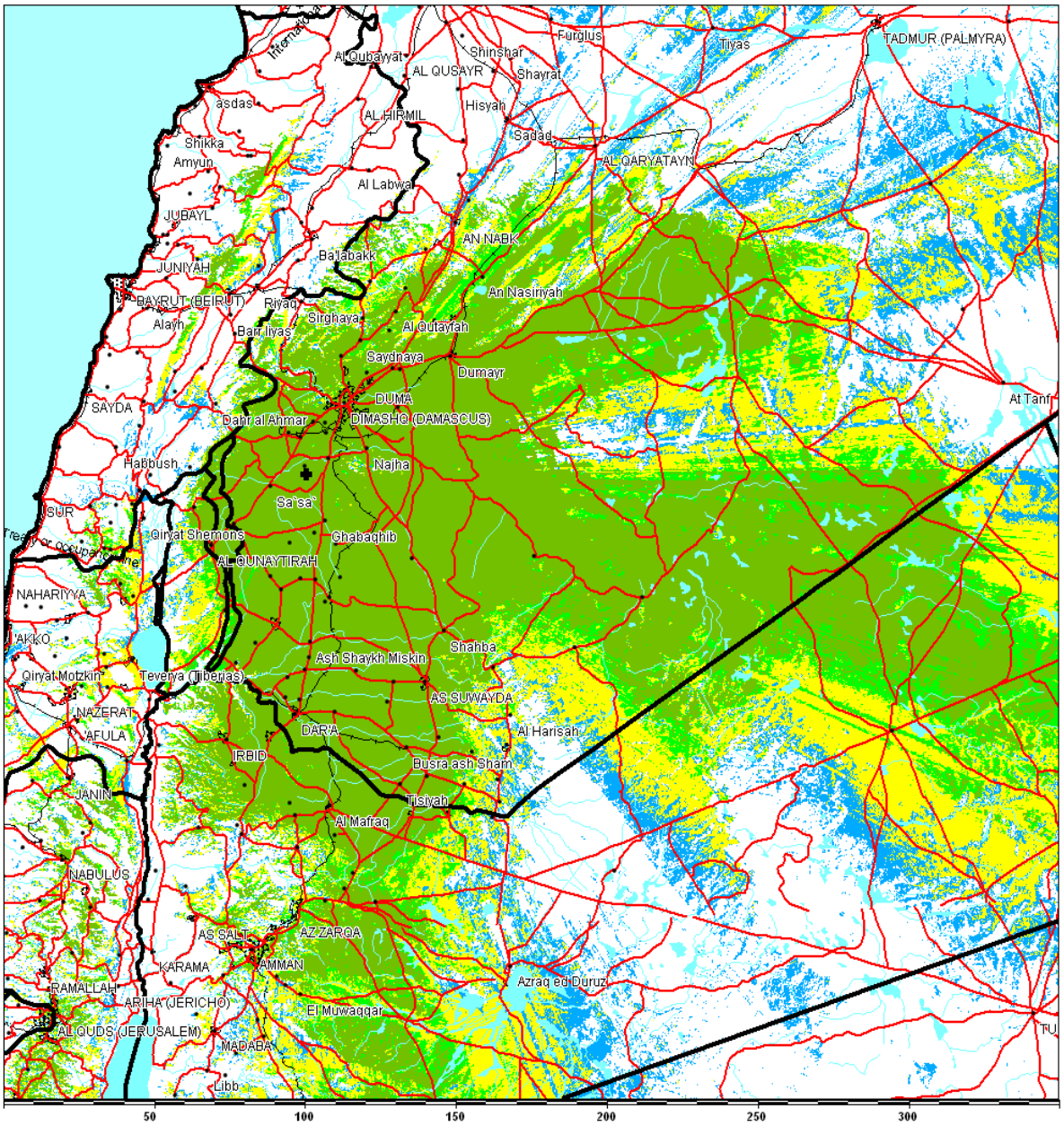

Field Strength

- 45 and above
- 40 to 45
- 29 to 40
- 24 to 29

Co-ordination:

Lebanon
Occupied Palestine
Iraq?
Jordan

Damascus DTT 50kW ERP; Terrain 1% Time

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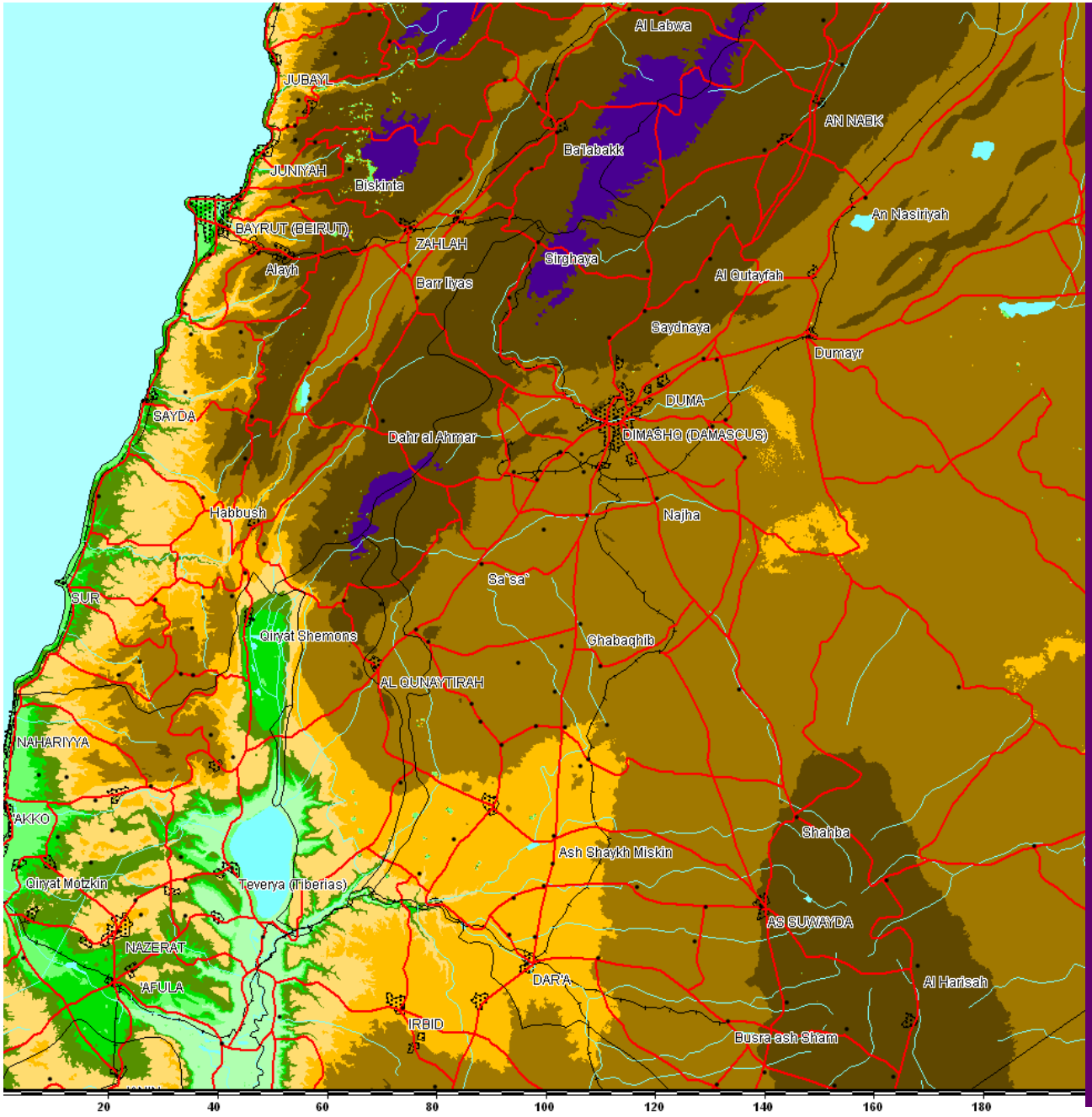
Predictions how good are they?

- Important factors when considering predictions
  - Quality of base data
    - DTM (Digital Terrain map)
    - Clutter Database
  - Prediction algorithm
    - 1546
    - Terrain based
  - Presentation of results



Terrain in metres

- 2000 and above
- 1000 to 2000
- 600 to 1000
- 400 to 600
- 200 to 400
- 100 to 200
- 50 to 100
- 0 to 50
- -300 to 0

DTM used in ntl predictions

Source NASA
3 arc seconds (~100m)

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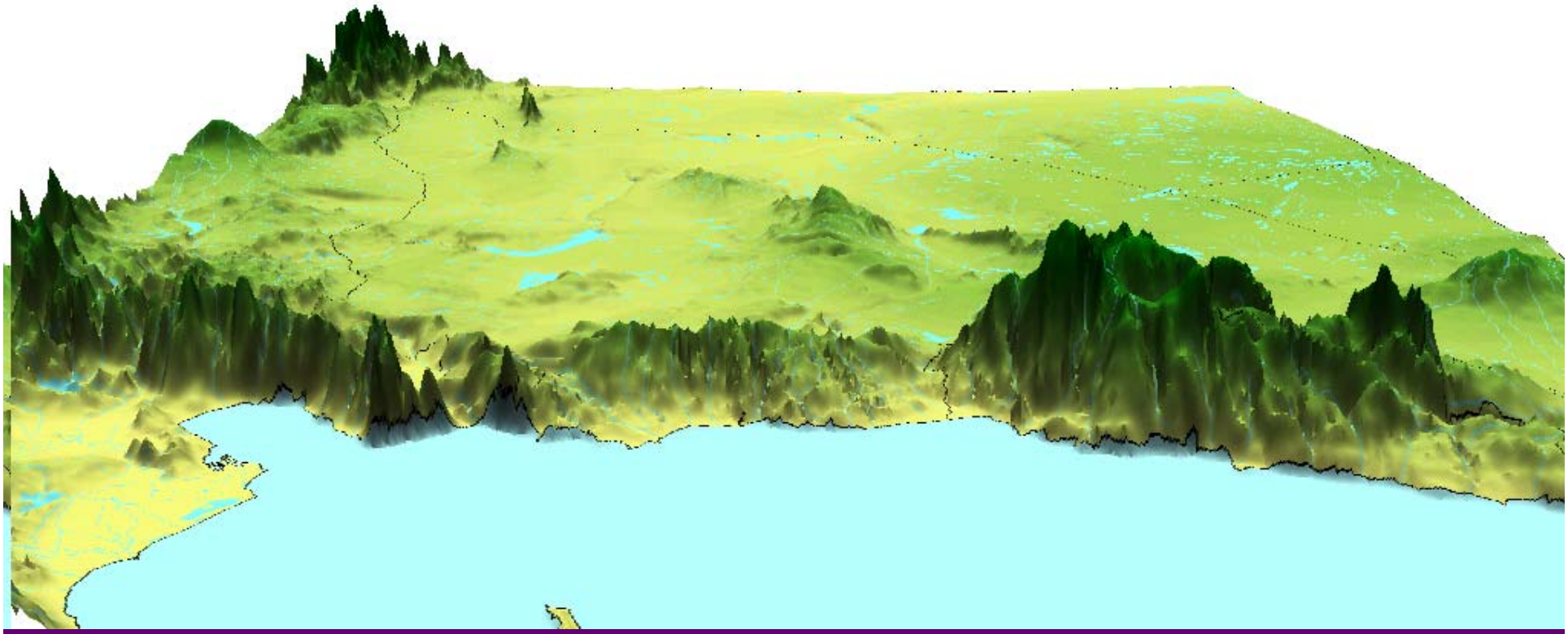
Terrain of Syria/Lebanon viewed from Cyprus



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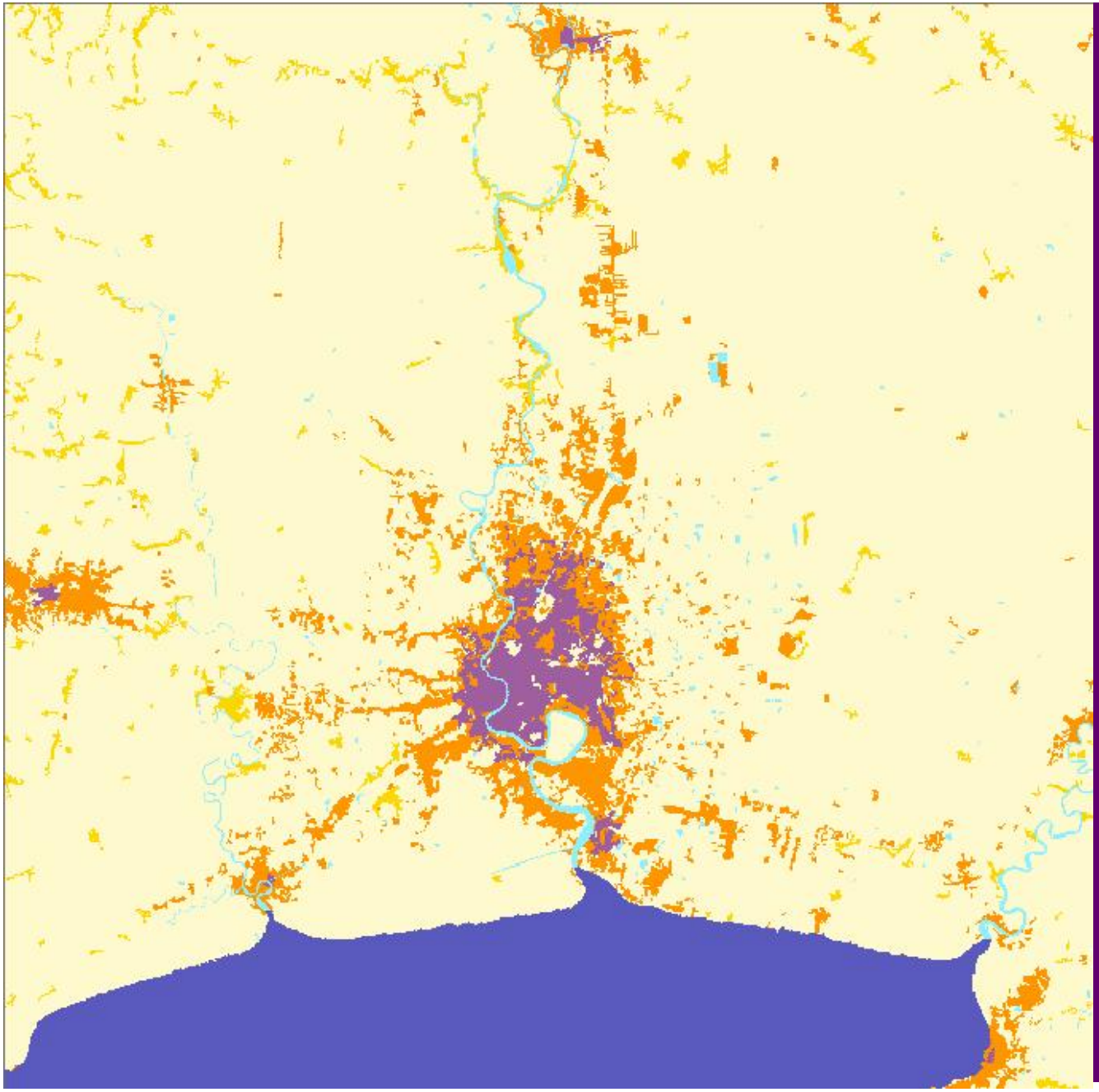

Clutter Database
Or
Landuse

Bangkok region
7 Classes

Urban, suburban,
rural, open,
sea, forest,
open in urban

Data supplied
by ISTAR

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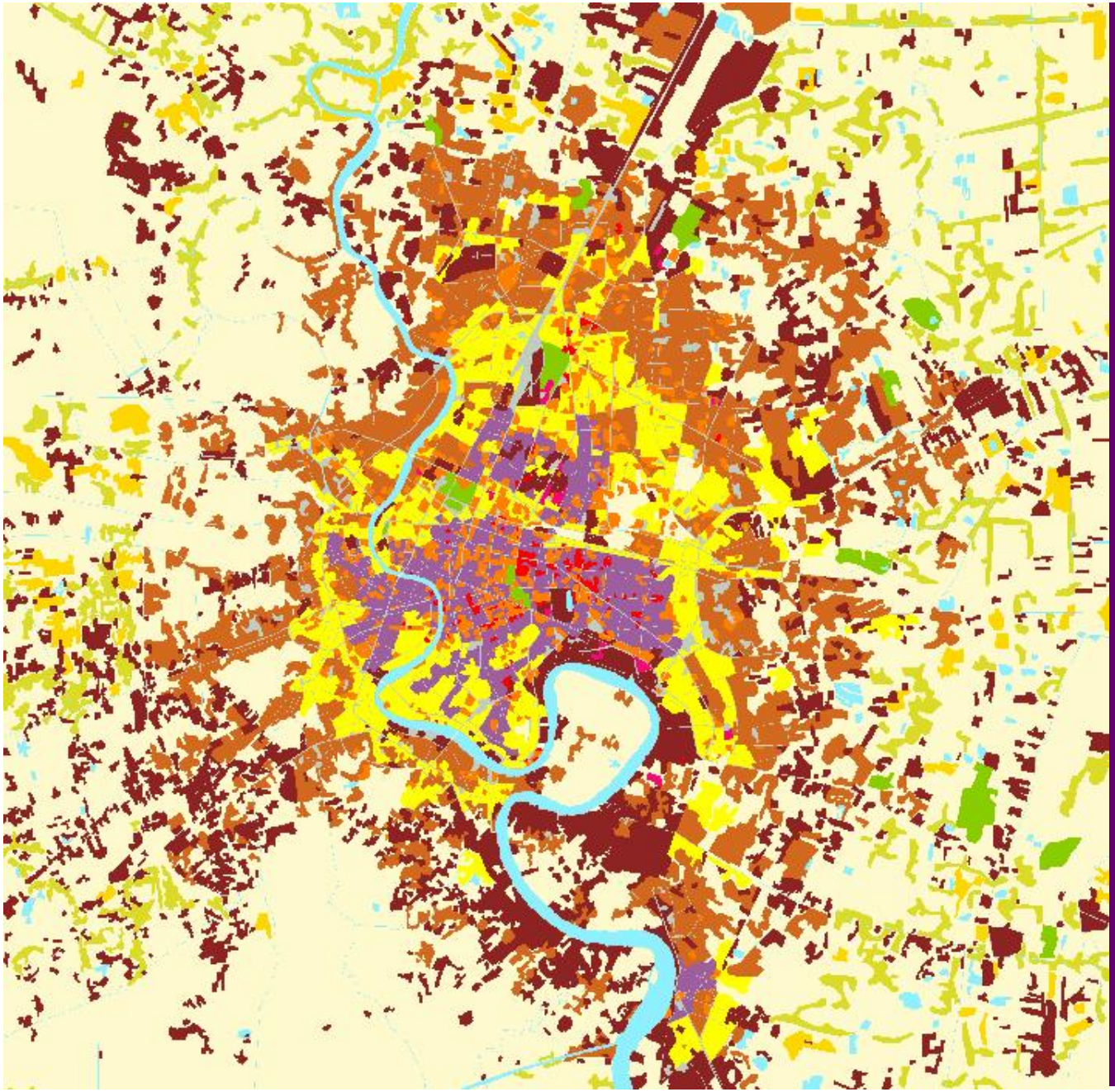

Clutter Database
Or
Landuse

Bangkok region
Urban Package
17 Classes

Includes:
Dense Urban,
Dense Urban High,
Dense Block Build

Data supplied
by ISTAR

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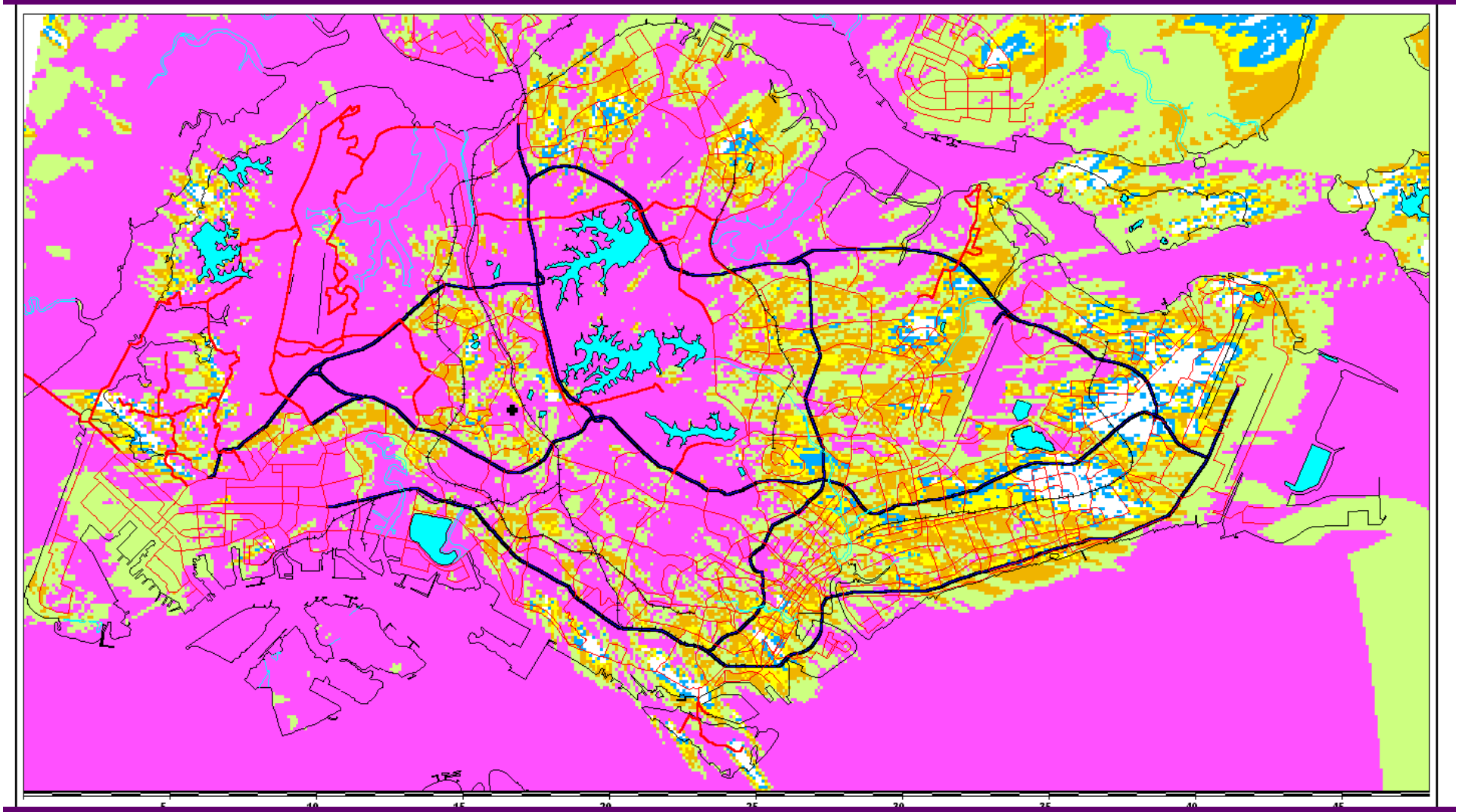
Singapore Mobile DTT, Bukit Batok; Main Station 40kW ERP



Prediction using Urban package 50m resolution (clutter 20m resolution)

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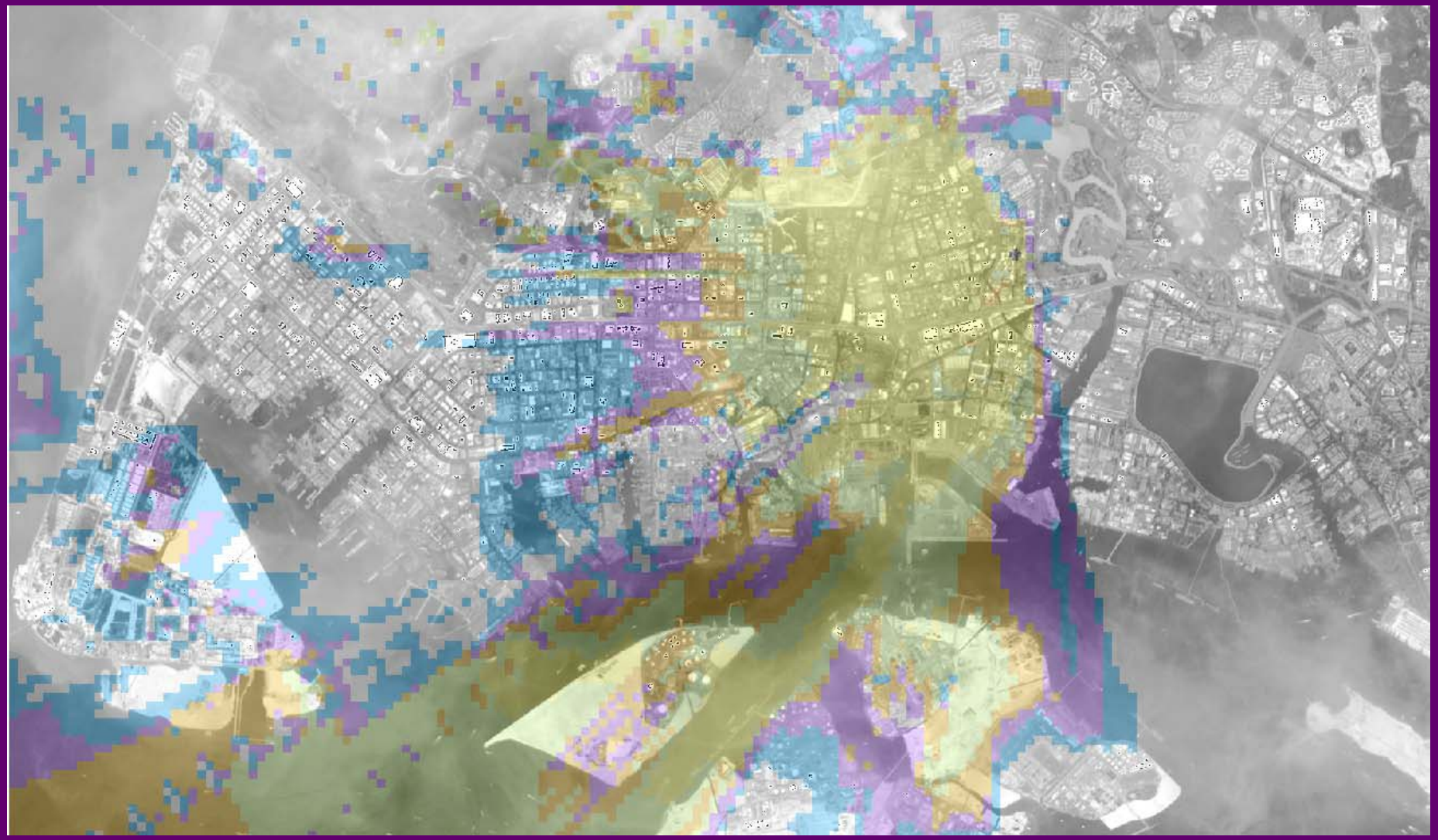
JURONG (On Channel Gapfiller) 250W ERP



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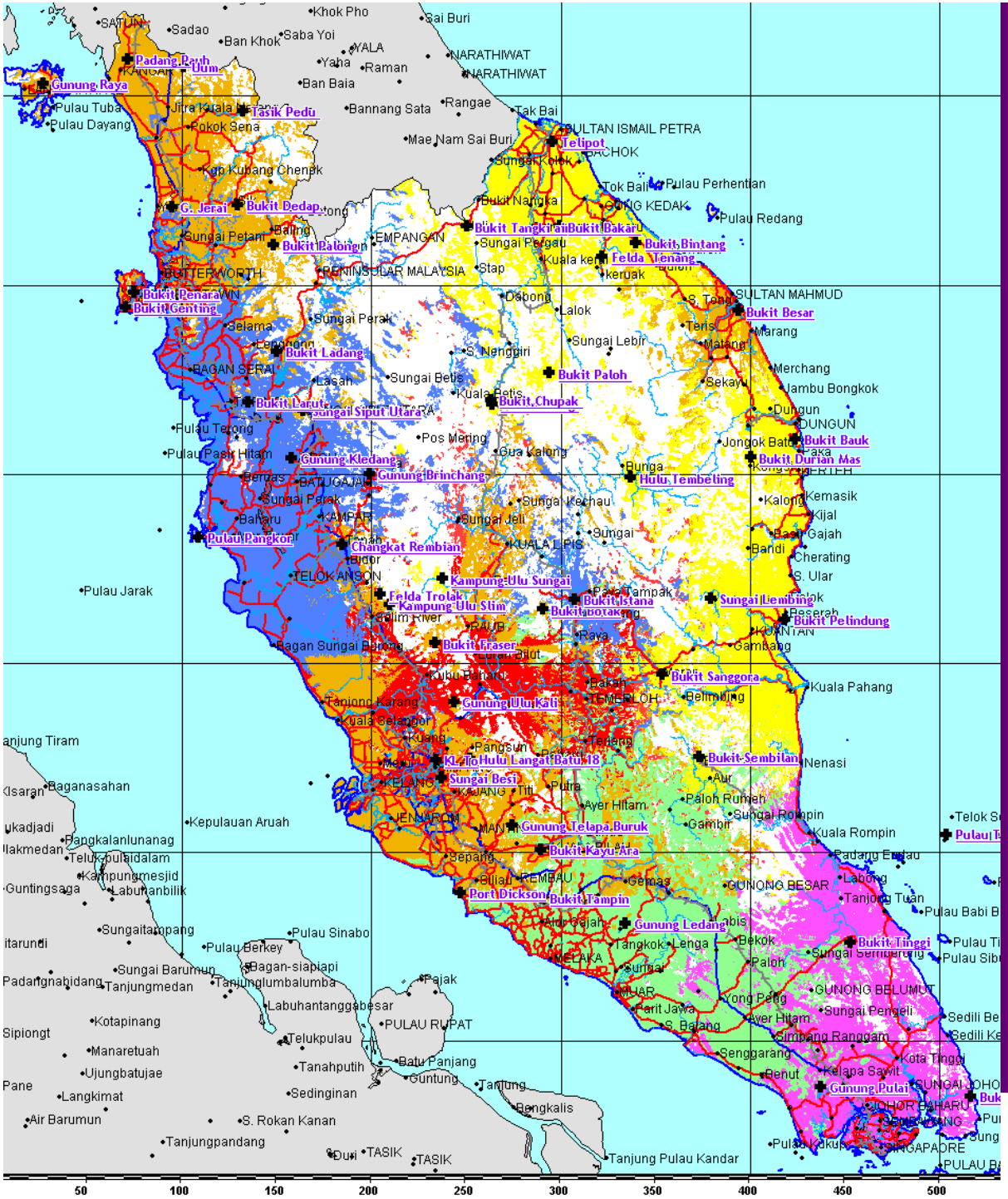
Types of DTT Networks (1)

- MFN (Multi-frequency Networks)
  - Each transmitter in the network operates on a different frequency
  - Overlaps between transmitters possible
  - Region programming (down to individual stations possible)
  - Ideal for conversion of existing analogue services
    - If transmitter is a conversion of an existing analogue it is already compatible existing services

Types of DTT Networks (2)

- SFN (Single Frequency Network)
  - All transmitters use the same frequency
  - Can be used as a regional network (dependant on geographic size)
  - Low power assignments (transmitters can added)
  - Mobile DVB-T / DVB-H networks
  - Interference potential to neighbouring countries could be potentially much higher



Network Coverage West Malaysia

Using a mixture of SFNs and MFNs

Colours Represent Different UHF channels

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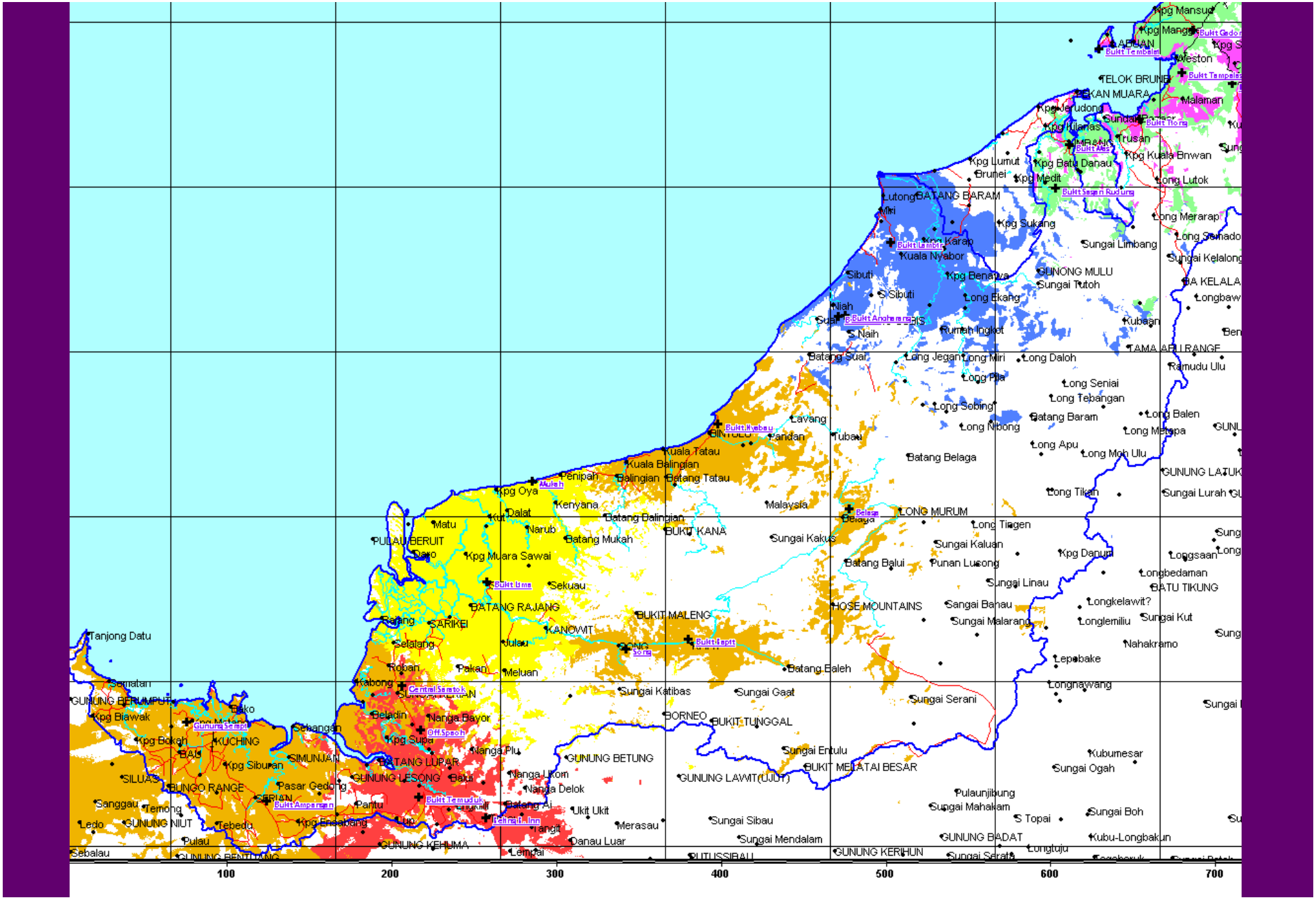

Sarawak Multiplex Coverage MFN/SFN

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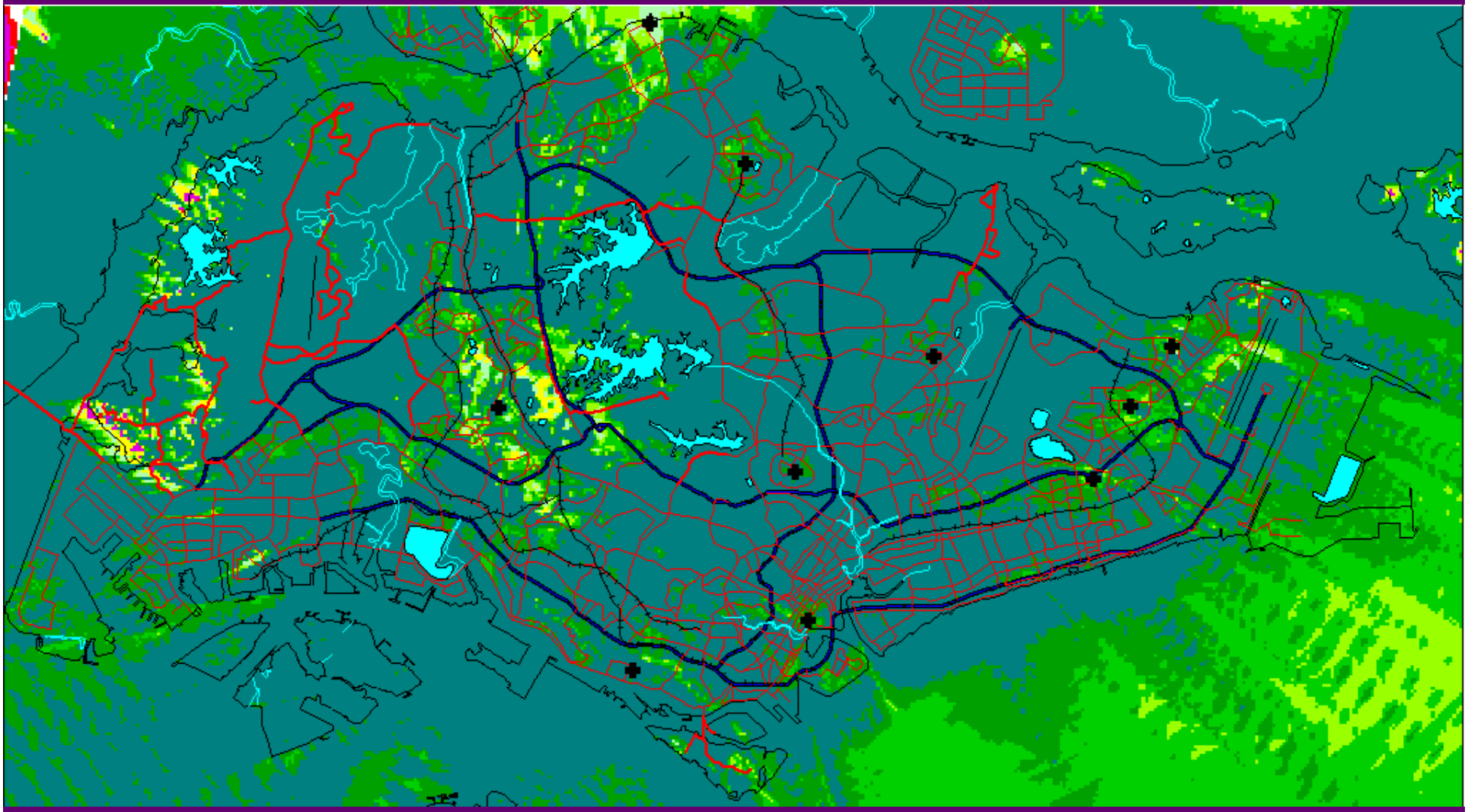
Dense SFN Mobile DVB-T 2K 16QAM ½ rate ¼ Guard Interval



Margin in dB’s

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