DVB-T and DVB-T2 Comparison and Coverage

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Featuring GatesAir's

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DVB-T and DVB-T2
Comparison and Coverage

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Welcome

With the growing interest in DVB-T2 as the first planned digital rollout, many customers would like to understand not only the differences but the real world benefits that DVB-T2 can provide over a DVB-T system.

DVB-T & DVB-T2 standards are similar to each other as both use COFDM (Coded Orthogonal Frequency Division Multiplex) modulation but DVB-T2 is distinguished by a number of technical enhancements.

The primary requirements of DVB-T2 were to increase the data carrying capacity by up to 30% over DVB-T and also to improve the flexibility of operation and robustness of reception.

What are the main differences?

Are there real world examples?

What are the main differences between DVB-T and DVB-T2 ?

1st. Forward Error Correction (FEC)

DVB-T2 uses LDPC (Low density parity-check) codes and BCH (Bose-Chaudhuri-Hocquengham) to protect against high noise levels and interference.

DVB-T uses Convolutional coding and Reed-Solomon to protect against high noise levels and interference.

LDPC and BCH does this more efficiently than Convolutional coding and Reed-Solomon.

DVB-T2 includes additional codes rates 3/5 and 4/5, and removed 7/8 code rate.

What are the main differences between DVB-T and DVB-T2 Continued ?

2nd. Modulation Modes

DVB-T2 has an additional mode: 256QAM.

The addition of 256 QAM allows for an increased number of bits per data cell. This and the improved FEC (forward error correction) greatly improves the DVB-T2 capacity.

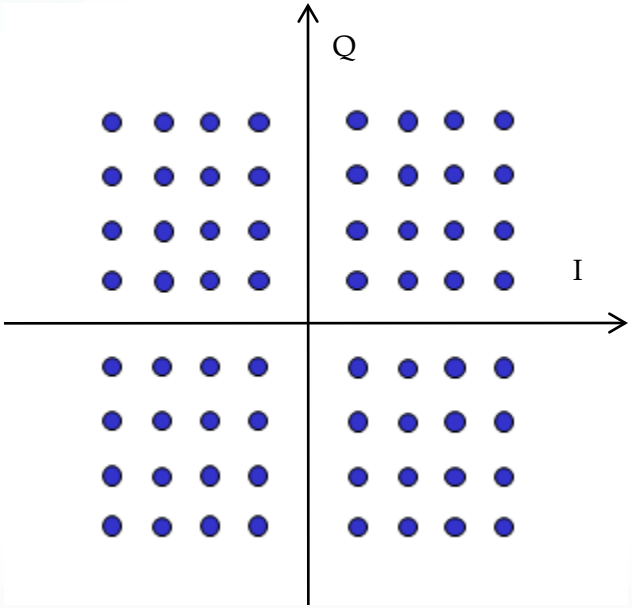
3rd . Rotated Constellations

The next change to the DVB-T2 modes is the use of rotated constellations, this significantly improves robustness of the modulation against loss of data by ensuring that the lost data from one channel component (I & Q component data) can be recovered from the other.

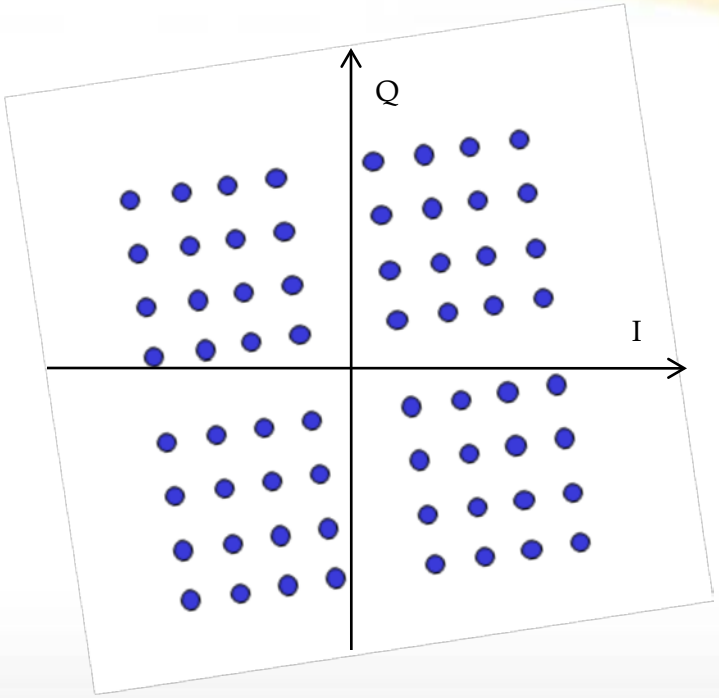
This improves signal robustness against external multipath distortion from geography, buildings and weather.

What are the main differences between DVB-T and DVB-T2 Continued ?

DVB-T 64QAM



DVB-T 2 Rotated 64QAM



Degrees =	QPSK	16 QAM	64 QAM	256 QAM
	29°	16.8°	8.6°	atan 1/16 ~ 3.57°

What are the main differences between DVB-T and DVB-T2 Continued ?

4th. Guard Interval

DVB-T2 added three additional guard intervals

19/256 19/128 And 1/128

Additional Guard intervals add to the flexibility and helps maximize the data payload of DVB-T2. (note a shorter guard interval , such as 1/128, increases payload but decreases maximum distance in SFN mode)

5th. DFT (Discrete Fourier Transform) Size (also known as FFT , Fast Fourier Transform)

DVB-T used 2k & 8k sizes

DVB-T2 has additional flexibility with 1k, 2k, 4k, 8k, 16k & 32k (additional FFT's of 16k and 32k significantly increase payloads)

What are the main differences between DVB-T and DVB-T2 Continued ?

This refers to the number of carriers per a given bandwidth for an 8 MHz Channel , the normal carrier mode bandwidth is 7.61 MHz. The extended carrier mode bandwidth is 7.71 MHz this increases capacity by 2%.

Normal Mode (only)	Normal Mode	Extended Mode
1k = 853 carriers	8k = 6817 carriers	6913 carriers
2k = 1705 carriers	16k = 13,633 carriers	13, 921 carriers
4k = 3409 carriers	32k = 27,265 carriers	27,841 carriers

For SFN (Single frequency network) we can calculate the distance between transmitters or between direct and multipath signals by using the guard interval and the Mode (Normal or Extended band width)

What are the main differences between DVB-T and DVB-T2 Continued ?

Example: (Guard interval (Gi) = 1/16, 8k Mode, 7.61MHz band width)

Bandwidth Hz / # of carriers = carrier spacing (cs)

$7.61*10^6$ / 6817 = 1.116 kHz

1/carrier spacing (cs) = Total Symbol Duration(Tu)

1/1.116kHz = 896 us

Tu * Gi = Guard interval in micro seconds (Gius)

895.8us * (1/16) = 56us

Now the distance between SFN (Single frequency network) transmitters or between direct and multipath signals is calculated by:

Guard interval * Velocity of light (Vo) = The distance in km

56us * $300*10^3$ = **16.8 km**

What are the main differences between DVB-T and DVB-T2 Continued ?

For Single Frequency Networks (SFN)

The Maximum guard interval in DVB-T mode is 224us this gives a maximum distance between transmitters of 67.2 km.

The maximum guard interval in DVB-T2 mode is 532us this give a maximum distance between transmitters of 159.5 km.

Guard-interval in Micro Seconds							
	Guard-interval fraction						
FFT	**1/128**	**1/32**	**1/16**	**19/256**	**1/8**	**19/128**	**1/4**
32k	28.0 us	112.0 us	223.9 us	265.9 us	447.8 us	531.8 us	N/A
16k	14.0 us	56.0 us	112.0 us	133.0 us	223.9 us	265.9 us	447.9 us
8k	7.0 us	28.0 us	56.0 us	66.5 us	112.0 us	133.0 us	223.9 us

Maximum Distance Between Transmitters in (km) for a single frequency network (SFN)							
	Guard-interval fraction						
FFT	**1/128**	**1/32**	**1/16**	**19/256**	**1/8**	**19/128**	**1/4**
32k	8.4 km	33.6 km	67.2 km	79.8 km	134.4 km	159.5 km	N/A
16k	4.2 km	16.8 km	33.6 km	39.9 km	67.2 km	79.8 km	134.4 km
8k	2.1 km	8.4 km	16.8 km	19.9 km	33.6 km	39.9 km	67.2 km

What are the main differences between DVB-T and DVB-T2 Continued ?

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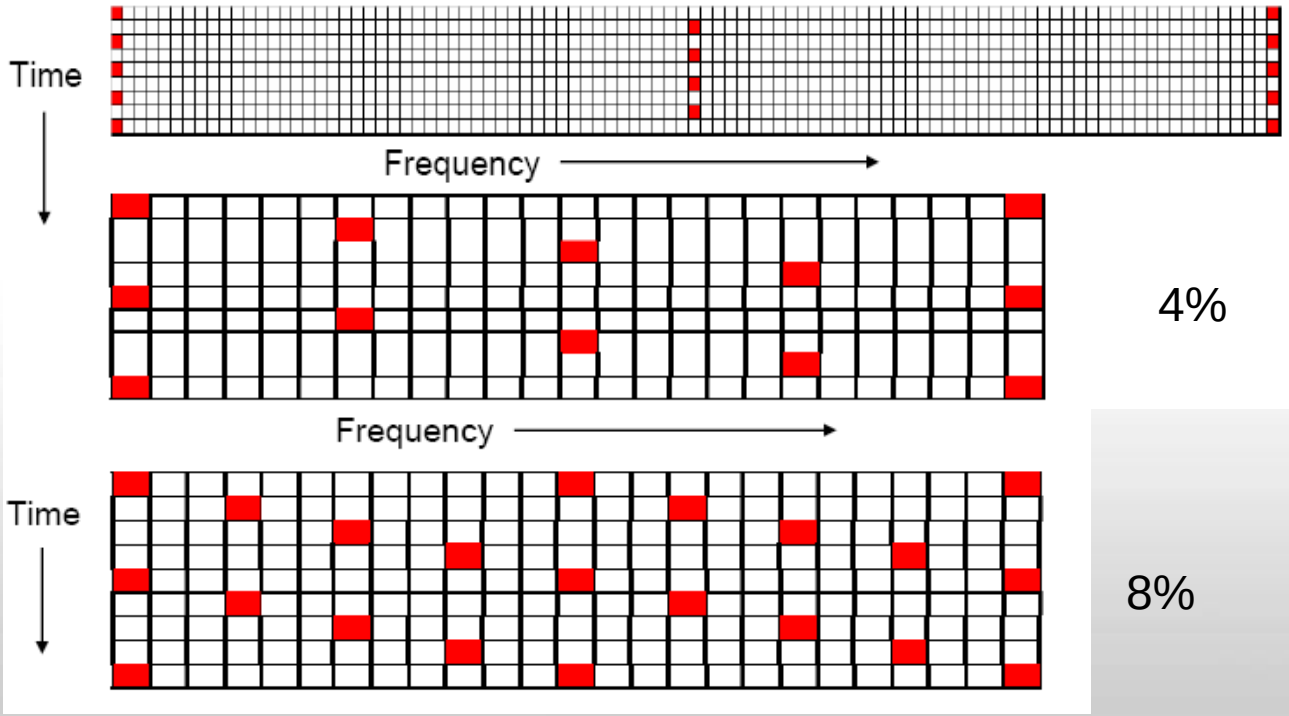
6th. Scattered Pilot

DVB-T used 8% of the total cells (carriers) for scattered pilots

DVB-T2 has additional flexibility with 1%, 2%, 4% & 8% of total cells (carriers) for scattered pilots, this allows for less overhead and increased data efficiency.

Scattered pilots are data cells (carriers) of a known amplitude and phase. The receivers use these to compensate for effects of channel distortions in frequency and time.



What are the main differences between DVB-T and DVB-T2 Continued ?

HARRIS

7th . Pilot Patterns

DVB-T2 also incorporates the use of 8 different pilot patterns (PP). The chart below shows the PP used for corresponding DFT & Guard interval.

Guard interval

DFT Size	1/128	1/32	1/16	19/256	1/8	19/128	1/4
32k	PP7	PP4 PP6	PP2 PP8 PP4	PP2 PP8 PP4	PP2 PP8	PP2 PP8	N/A
16k	PP7	PP7 PP4 PP6	PP2 PP8 PP4 PP5	PP2 PP8 PP4 PP5	PP2 PP3 PP8	PP2 PP3 PP8	PP1 PP8
8k	PP7	PP7 PP4 PP6	PP8 PP4 PP5	PP8 PP4 PP6	PP2 PP3 PP8	PP2 PP3 PP8	PP1 PP8
4k &2k	N/A	PP7 PP4 PP6	PP4 PP5	N/A	PP2 PP3	N/A	PP1
1k	N/A	N/A	PP4 PP5	N/A	PP2 PP3	N/A	PP1

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SISO Mode (Single in Single Out)

The goal of the pilot patterns are to minimize the pattern overhead for a given fractional guard interval increasing payload capacity.

What are the main differences between DVB-T and DVB-T2 Continued ?

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8th . Continual Pilots

DVB-T uses 2.6% of the total

DBV-T2 uses 0.35% of the total, increasing payload capacity.

9th Physical Layer Pipes

DVB-T2 uses single and multiple physical layer pipes (PLP). A PLP contains a single transport stream and all services in a single transport stream are in a single PLP. Multiple PLPs still have one transport stream per PLP, the advantage is each PLP can have different modulations and coding modes.

PLP0	PLP1
256 QAM	64 QAM
2/3 code rate	1/2 code rate

The higher the bit rate the higher the carrier to noise ratio the less robust the signal

What are the main differences between DVB-T and DVB-T2?

Summary of Differences:

	DVB-T	DVB-T2
Forware error correction (FEC) & Code Rates	Convolutional Coding + Reed Solomon 1/2, 2/3, 3/4, 5/6, & 7/8	LDPC + BCH 1/2, **3/5**, 23, 3/4, **4/5**, & 5/6
Modulation	QPSK, 16QAM, & 64QAM	QPSK, 16QAM, 64QAM & 256QAM
Rotated constellation Mode	N/A	Rotated or None rotated modes
Guard intervals	1/4, 1/8, 1/16, & 1/32	1/4, **19/256**, 1/8, **19/128**, 1/16, 1/32, & **1/128**
Discrete Fourier Transform (DFT size)	2k & 8k	**1k**, 2k, **4k**, 8k, **16k, & 32k**
Scattered Pilots	8% of total	**1%, 2%, 4%,** or 8%
Pilot Patterns	N/A	8 Patterns Avalible
Continual Pilots	2.6% of total	.35% of total
		Single or Multiple PLP

How does these differences affect DVB-T2 & coverage

Capacity (Bit Rate Mbps)

The maximum capacity of DVB-T is approximately 31.67 Mbps

The maximum capacity of DVB-T2 is approximately 50.34 Mbps

CNR (Carrier to Noise Ratio)

The carrier to noise ratio is controlled by the modulation mode and the code rate.

With DVB-T2 there has been significant improvements in CNR.

One point to remember with DVB-T and DVB-T2 the lower the transport stream bit rate the lower the CNR, this equals a more robust signal. As you increase the transport stream bit rate the CNR increases. This equals a less robust single.

This means a lower quality signal goes father than a higher quality signal.

Compared to DVB-T, DVB-T2 offers a higher transport stream bit rate with a comparable CNR.

SNR (Signal to Noise Ratio) Continued

The chart below shows the CNR for DVB-T (8MHz Channel)

Modulation	Code rate	Required S/N for BER=$2x10^{-4}$ after Viterbi QEF after Reed-Solomon		
		Gaussian channel	Ricean channel	Rayleigh channel
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
16-QAM	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
64-QAM	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

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Gaussian Channel
- directional antenna used
- direct reception

Ricean Channel
- directional antenna used
- multi path reception

Rayleigh Channel
- non-directional antenna
- multi path reception

SNR (Signal/Carrier to Noise Ratio) Continued

The chart below shows the CNR for DVB-T2 (LDPC Long Block Length: 64800 bits)

			Required $(C/N)_0$ (dB) for BER = 1×10^{-7} after LDPC decoding			
Constel-lation	Code rate	Spectral Efficiency (see note 2)	Gaussian Channel (AWGN)	Ricean channel (F_1)	Rayleigh channel (P_1)	0 dB echo channel @ 90 % GI
QPSK	1/2	*0,99*	*1,0*	*1,2*	*2,0*	*1,7*
QPSK	3/5	*1,19*	*2,3*	*2,5*	*3,6*	*3,2*
QPSK	2/3	*1,33*	*3,1*	*3,4*	*4,9*	*4,5*
QPSK	3/4	*1,49*	*4,1*	*4,4*	*6,2*	*5,7*
QPSK	4/5	*1,59*	*4,7*	*5,1*	*7,1*	*6,6*
QPSK	5/6	*1,66*	*5,2*	*5,6*	*7,9*	*7,5*
16-QAM	1/2	*1,99*	*6,0*	*6,2*	*7,5*	*7,2*
16-QAM	3/5	*2,39*	*7,6*	*7,8*	*9,3*	*9,0*
16-QAM	2/3	*2,66*	*8,9*	*9,1*	*10,8*	*10,4*
16-QAM	3/4	*2,99*	*10,0*	*10,4*	*12,4*	*12,1*
16-QAM	4/5	*3,19*	*10,8*	*11,2*	*13,6*	*13,4*
16-QAM	5/6	*3,32*	*11,4*	*11,8*	*14,5*	*14,4*
64-QAM	1/2	*2,98*	*9,9*	*10,2*	*11,9*	*11,8*
64-QAM	3/5	*3,58*	*12,0*	*12,3*	*14,0*	*13,9*
64-QAM	2/3	*3,99*	*13,5*	*13,8*	*15,6*	*15,5*
64-QAM	3/4	*4,48*	*15,1*	*15,4*	*17,7*	*17,6*
64-QAM	4/5	*4,78*	*16,1*	*16,6*	*19,2*	*19,2*
64-QAM	5/6	*4,99*	*16,8*	*17,2*	*20,2*	*20,4*
256-QAM	1/2	*3,98*	*13,2*	*13,6*	*15,6*	*15,7*
256-QAM	3/5	*4,78*	*16,1*	*16,3*	*18,3*	*18,4*
256-QAM	2/3	*5,31*	*17,8*	*18,1*	*20,1*	*20,3*
256-QAM	3/4	*5,98*	*20,0*	*20,3*	*22,6*	*22,7*
256-QAM	4/5	*6,38*	*21,3*	*21,7*	*24,3*	*24,5*
256-QAM	5/6	*6,65*	*22,0*	*22,4*	*25,4*	*25,8*

NOTE 1: Figures in italics are approximate values.
NOTE 2: Spectral efficiency does not take into account loss due to signalling / synchronization / sounding and Guard interval.
NOTE 3: The BER targets are discussed above.
NOTE 4: The expected implementation loss due to real channel estimation needs to be added to the above figures (see clause 14.4). This value will be significantly less than the corresponding figure for DVB-T in some cases, due to better optimisation of the boosting and pattern densities for DVB-T2.
NOTE 5: Entries shaded blue are results from a single implementation. All other results are confirmed by multiple implementations.

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Gaussian Channel
- directional antenna used
- direct reception

Ricean Channel
- directional antenna used
- multi path reception

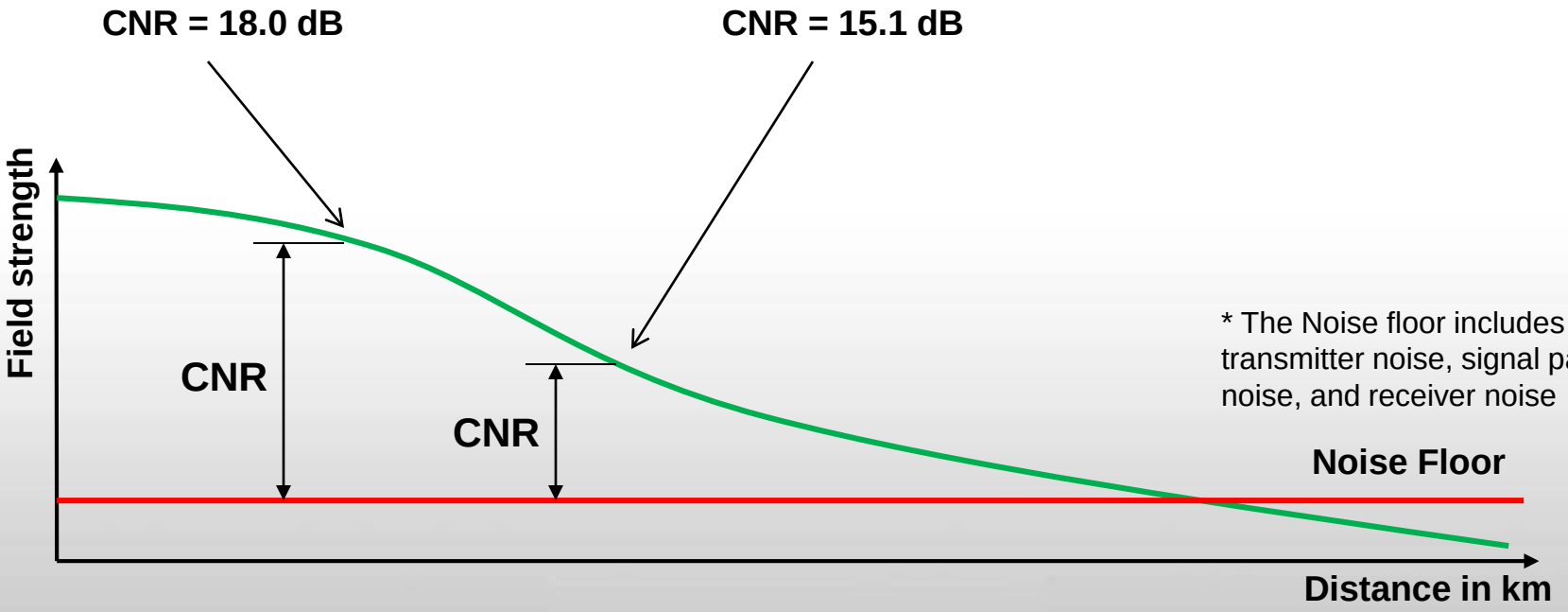
Rayleigh Channel
- non-directional antenna
- multi path reception

How does these differences affect DVB-T2 & coverage

Theoretical Comparison

DVB-T	DVB-T2
64 QAM	64 QAM
3/4 Code rate	3/4 Code Rate
Gaussian Channel	Gaussian Channel

Δ 3.1 dB



* The Noise floor includes transmitter noise, signal path noise, and receiver noise

Karaganda, Kazakhstan Field Measurements

Harris conducted field strength measurements of DVB-T & DVB-T2

This test was conducted in Karaganda, Kazakhstan by Harris Corporation in cooperation with KATZELRADIO of Kazakhstan.

The measurement were taken using a Harris 1kW UAX transmitter with dual exciters one with DVB-T one with DVB-T2, the transmit antenna was a Omni directional pattern Superturnstile antenna with a gain of approximately 9.1dBd at 183 meters above ground level.

The test was conducted at channel 49 (698 MHz), with an ERP of approximately 4.53 kW average.

Karaganda, Kazakhstan Field Measurements

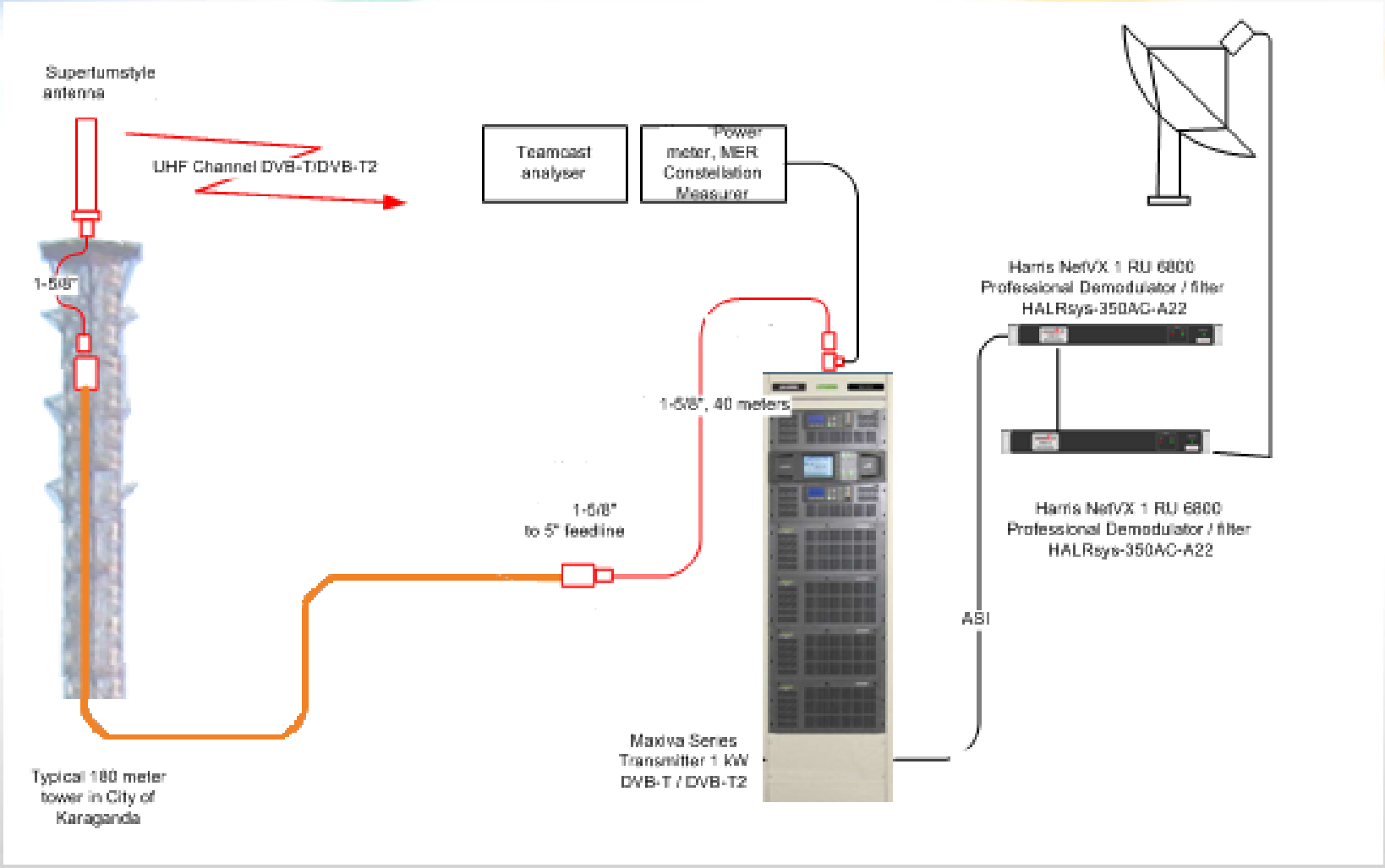
The following tables show the DVB-T & DVB-T2 system parameter s

Parameter	DVB-T	DVB-T2, VV03	DVB-T2, VV14
Number of Carriers	6817	27841	6913
Guard Interval	1/32	1/128	1/128
Carrier Modulation	64 QAM	256 QAM	64 QAM
Code Rate	3/4	2/3	3/4
Total Data Rate [Mbps]	27.14	40.22	32.54
C/N (Rice) [dB]	18.6	18.1	15.7

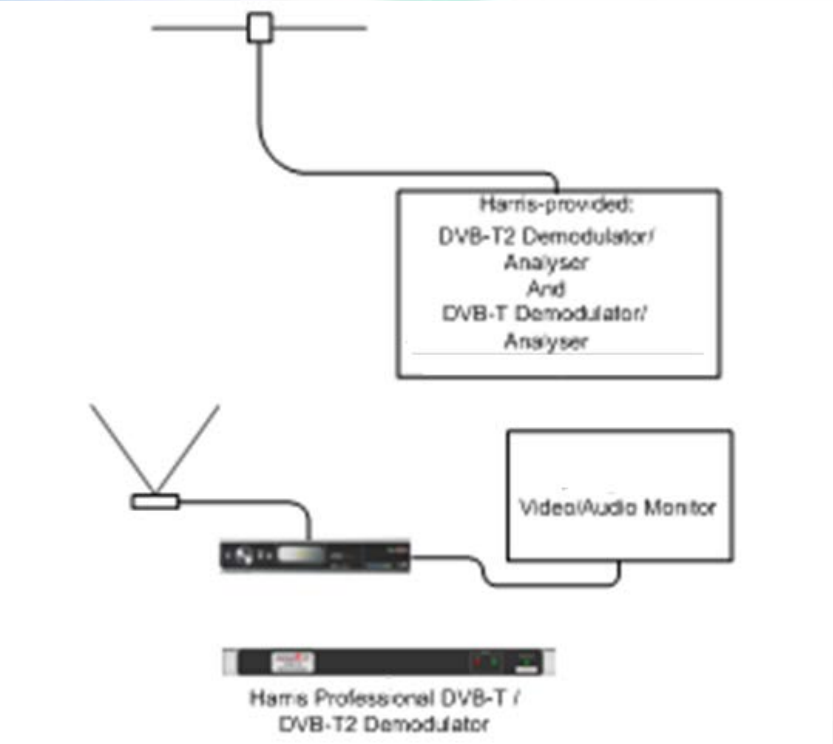
The transport stream data used the following parameters.

Transmitter mode	DVB-T, 64-QAM	DVB-T2, 256-QAM	DVB-T2, 64-QAM
Max.TS data rate	27.1 Mbit/s	40.2 Mbit/s	32.2 Mbit/s
Used TS data rate	27.0 Mbit/s	38.7 Mbit/s	32.0 Mbit/s
Transport stream standard	MPEG-2	MPEG-2	MPEG-2
Number of TV channels	5	9	6
Average data rate per channel	4.3 Mbit/s	4.3 Mbit/s	4.3 Mbit/s

Karaganda, Kazakhstan Field Measurements



Karaganda, Kazakhstan Field Measurements



Field strength measurements were taken at 10m above ground level using one dipole antenna for both DVB-T & DVB-T2.

The second antenna was a yagi at 8m above ground level for the two STB DVB-T & DVB-T2 receivers.

Karaganda, Kazakhstan Field Measurements

Parameter	DVB-T	DVB-T2_VV14
Frequency	698 MHz	698 MHz
FFT Size	8K	8K
Carrier Modulation	64 QAM	64 QAM
Code Rate	3/4	3/4
Guard Interval	1/32	1/128
Net Data Rate [Mbps]	27.14	32.54
C/N (Rice) [dB]	18.6	15.7

General RX Parameters	
Weather	clear/very windy
RX Antenna:	Dipol
Factor	26
Gain [dB]	1.16
Cable loss [dB]	3.3
RX Filter [dB]	0.7
Total loss [dB]	4

D 5.4Mbps

D 2.9dB

			DVB-T: 27.14 Mbps			DVB-T2: 32.54 Mbps		
Test	Site	Distance	Input signal	Field strength	MER	Input signal	Field strength	MER
		[km]	[dBm]	[dBuV/m]	[dB]	[dBm]	[dBuV/m]	[dB]
1	TV Tower	0	-34	103	32,4	-34	103	32,4
2	City Karaganda	1,8		not measured		-35	102	32,6
3	Camping bar	41	-56	81	30	-56	81	31,1
4	Road Almaty	55,7	-82	55	17,2	-84	53	20,1
5	Topar	34	-76	61	21	-76	61	24,8
6	Abay (centre)	25	-89	48	0	-89	48	18,4
7	Yalta	42	-94	43	0	-94	43	0

DVB-T
30dB

DVB-T
31.1dB

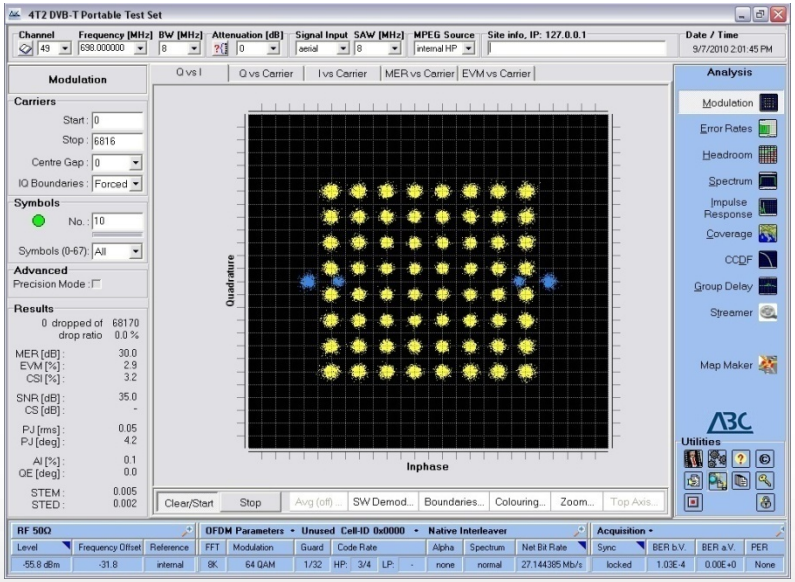
D 1.1dB

MER (modulation error rate) is a measure used to review the performance of the signal transmitted or received. MER is also closely related to CNR (Carrier to noise ratio).

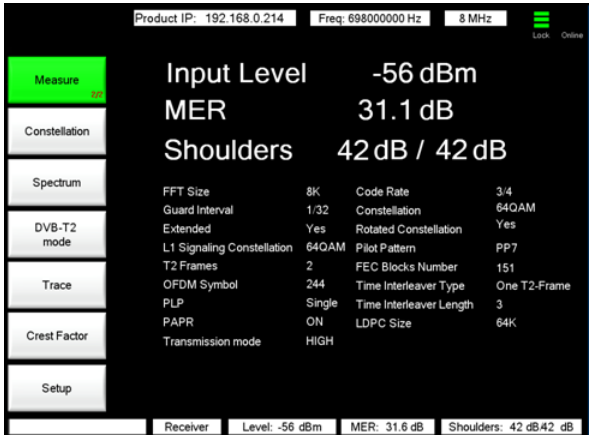
Karaganda, Kazakhstan Field Measurements

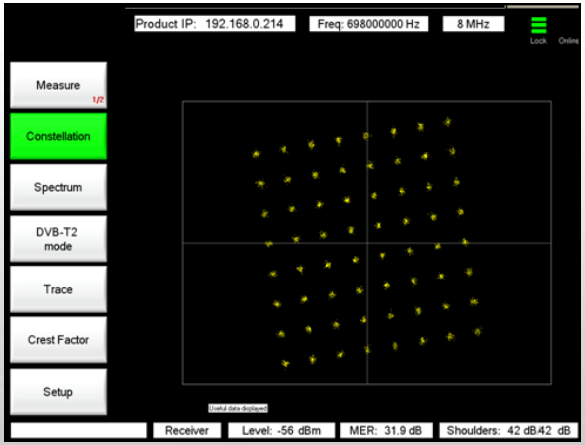
Road Almaty _Camping Bar Site

DVB-T: Distance 41km, MER = 30dB,
signal level = - 55.8 dBm



DVB-T2: Distance 41km, MER = 31.1dB,
signal level = - 56 dBm





Karaganda, Kazakhstan Field Measurements

Parameter	DVB-T2
Frequency	698 MHz
FFT Size	32K
Carrier Modulation	256 QAM
Code Rate	2/3
Guard Interval	1/128
net Rate [Mbps]	40.22
C/N (Rice) [dB]	18.1

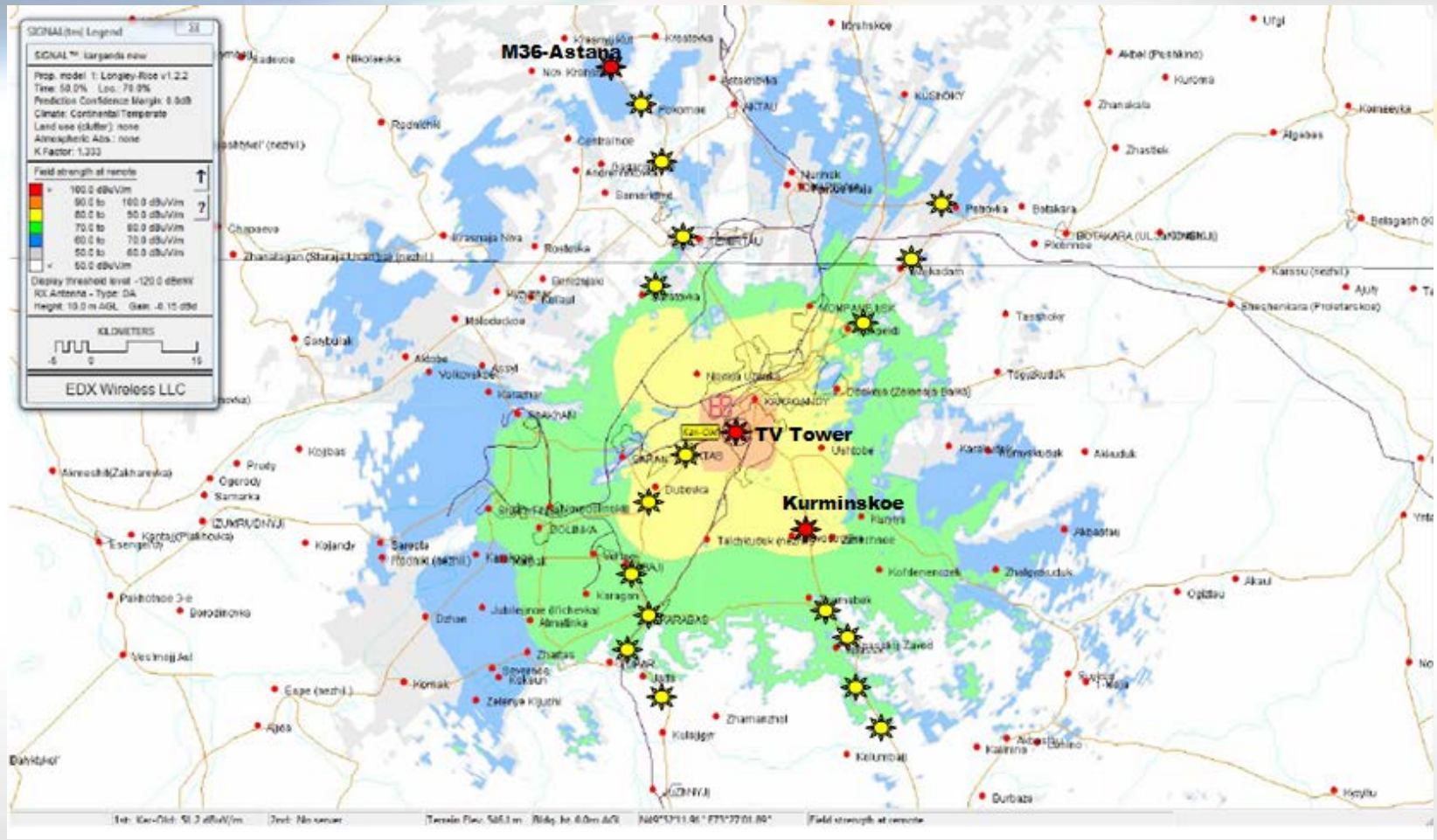
General RX Parameters	
Weather	clear
RX Antenna:	Dipol
Factor	26
Gain [dB]	1.16
Cable loss [dB]	3.3
RX Filter [dB]	0.7
Total loss [dB]	4

D 13.08Mbps higher data rate when compared to DVB-T at 64QAM

D 0.5dB CNR better when compared to DVB-T at 64QAM

Test #	Site	Site to TX distance	Input signal	Measured field strength	Simulated field strength	MER
		[km]	[dBm]	[dBµV/m]	[dBµV/m]	dB
1	KTR (TV Tower)	0	-34	103	>92	32,4
2	Kurminskoe	23	-48	89	84	33,1
3	M36 (monument)	34	-66	71	56-63	30
4	Uzbek cuisine (cafe)	36,2	-63	74	70	32,3
5	M36 - south 1	42,7	-63	74	63-70	31
6	M36 - south 2	56,4	-84	53	<50	24
7	M36 north - 1	21,5	-54	83	74-80	31,7
8	M36 north - 2	26,5	-55	82	56-62	32
9	M36 north - 3	37,8	-79	58	49-56	25
10	Pokornoe	48,3	-80	57	49-56	24,6
11	M36 - Astana	55,6	-64	73	56-63	31,4
12	Karabas	29,7	-76	61	77	26,1
13	Topar	35,5	-92	45	49	24
14	Abay (entrance)	22,3	-68	69	84	30,6
15	Petrovka	44	-87	50	49	24
16	Baikadam	32,4	-92	45	<50	0
17	Kokpekty	22,2	-77	60	63	25,6

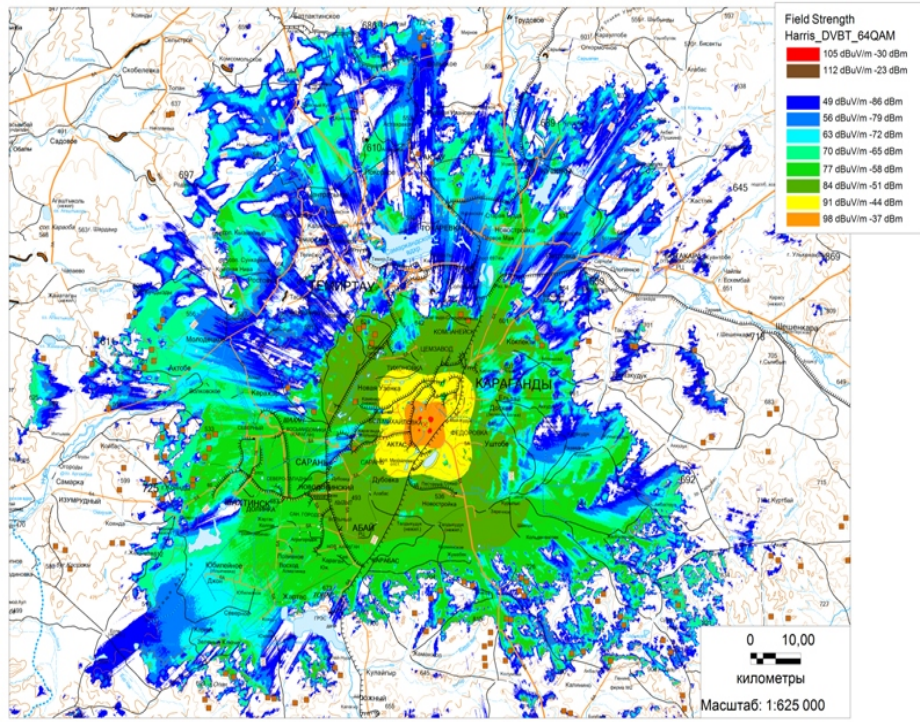
Karaganda, Kazakhstan Field Measurements

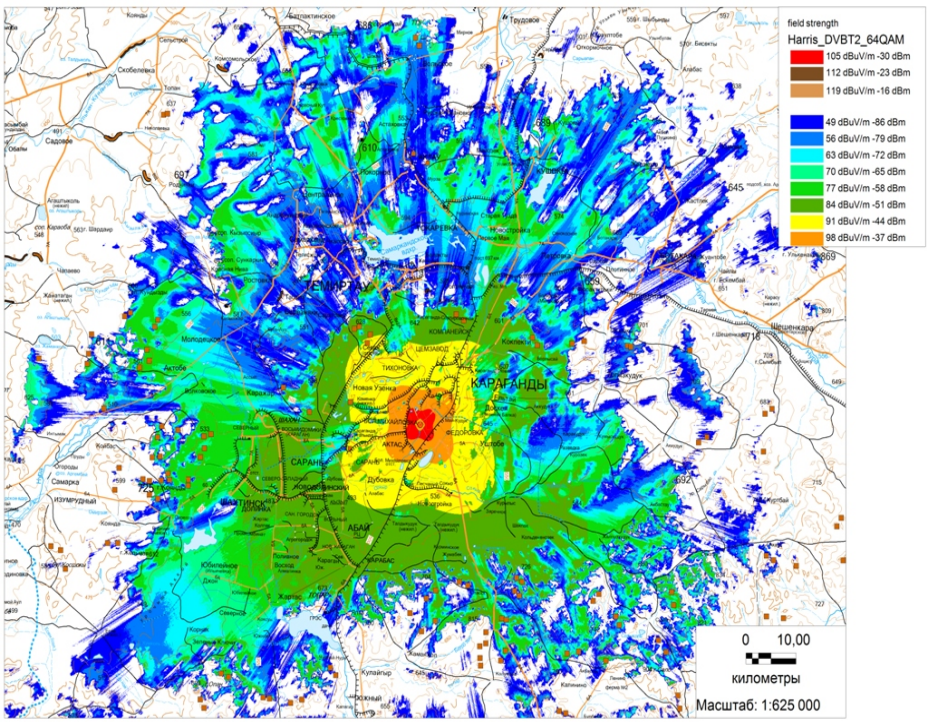


Software coverage estimation and field strength points used in previous 256QAM charts, Longley Rice study 50% of time, 70 % of locations

Karaganda, Kazakhstan Field Measurements

Coverage Plot Comparison



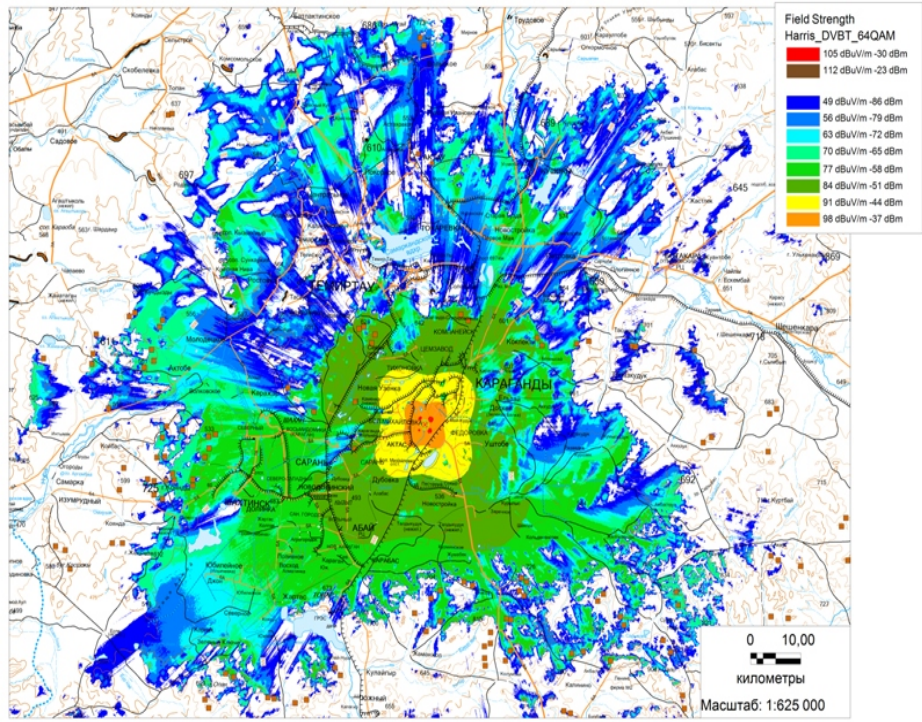


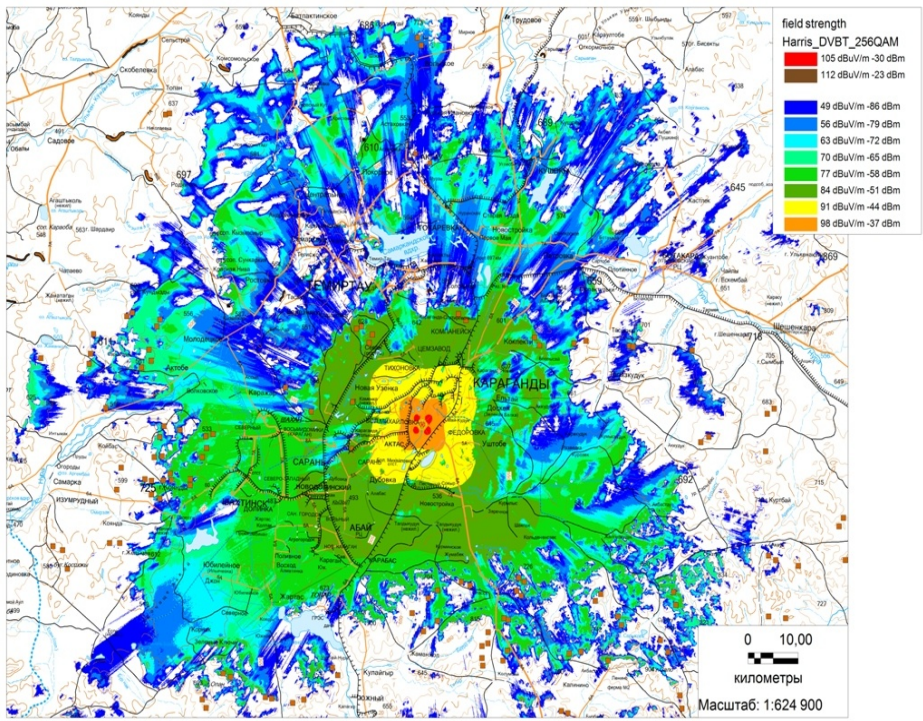
Software coverage estimation for DVB-T system, Modulation 64QAM, Data rate 27.14 Mbps

Software coverage estimation for DVB-T2 system, Modulation 64QAM, Data rate 32.54Mbps

Karaganda, Kazakhstan Field Measurements

Coverage Plot Comparison





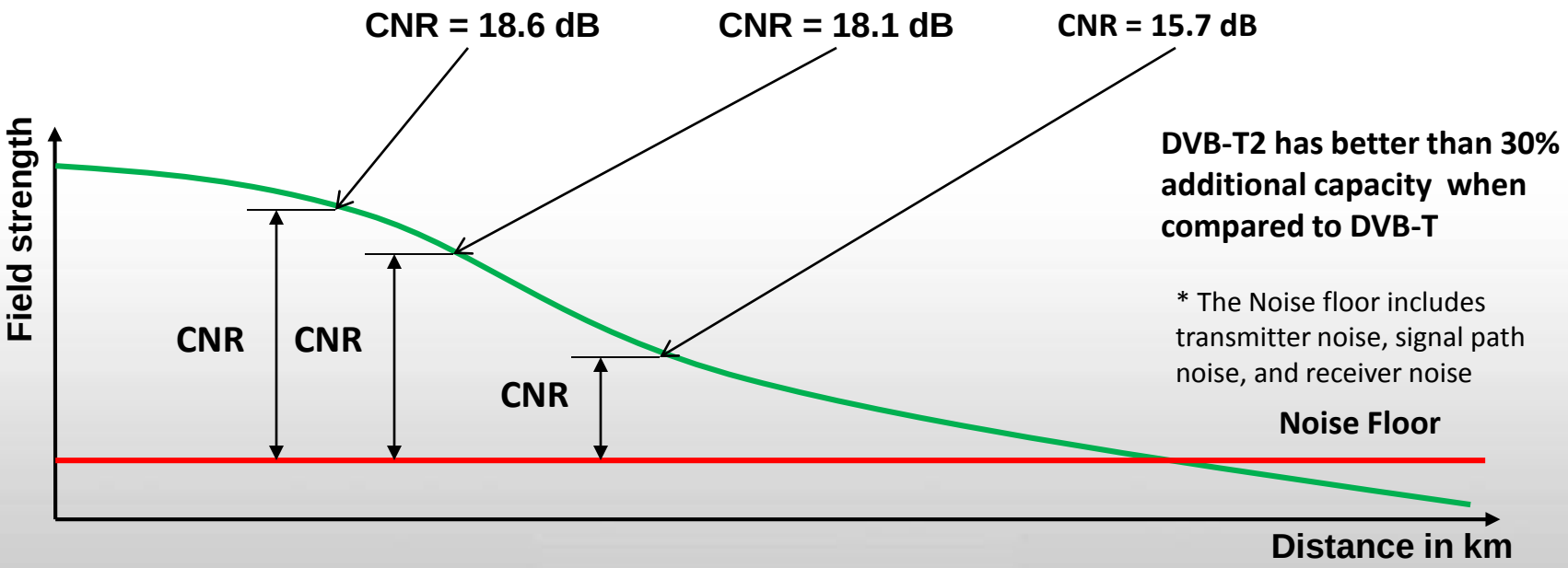
Software coverage estimation for DVB-T system, Modulation 64QAM, Data rate 27.14 Mbps

Software coverage estimation for DVB-T2 system, Modulation 256QAM, Data rate 40.22 Mbps

Conclusion

DVB-T2 significantly increases coverage & data rate over DVB-T This enables broadcasters to more efficiently use their spectrum & deliver more information to their customers.

	DVB-T	DVB-T2	DVB-T2
Carriers	6817	27841	6913
Guard Interval	1/32	1/128	1/128
Modulation	64 QAM	256 QAM	64 QAM
Code Rate	3/4	2/3	3/4
Data Rate	27.14 Mbps	40.22 Mbps	32.54 Mbps



Questions?