The Digital Video Broadcasting System:

The magic of the COFDM
(Coded Orthogonal Frequency Division Multiplex)

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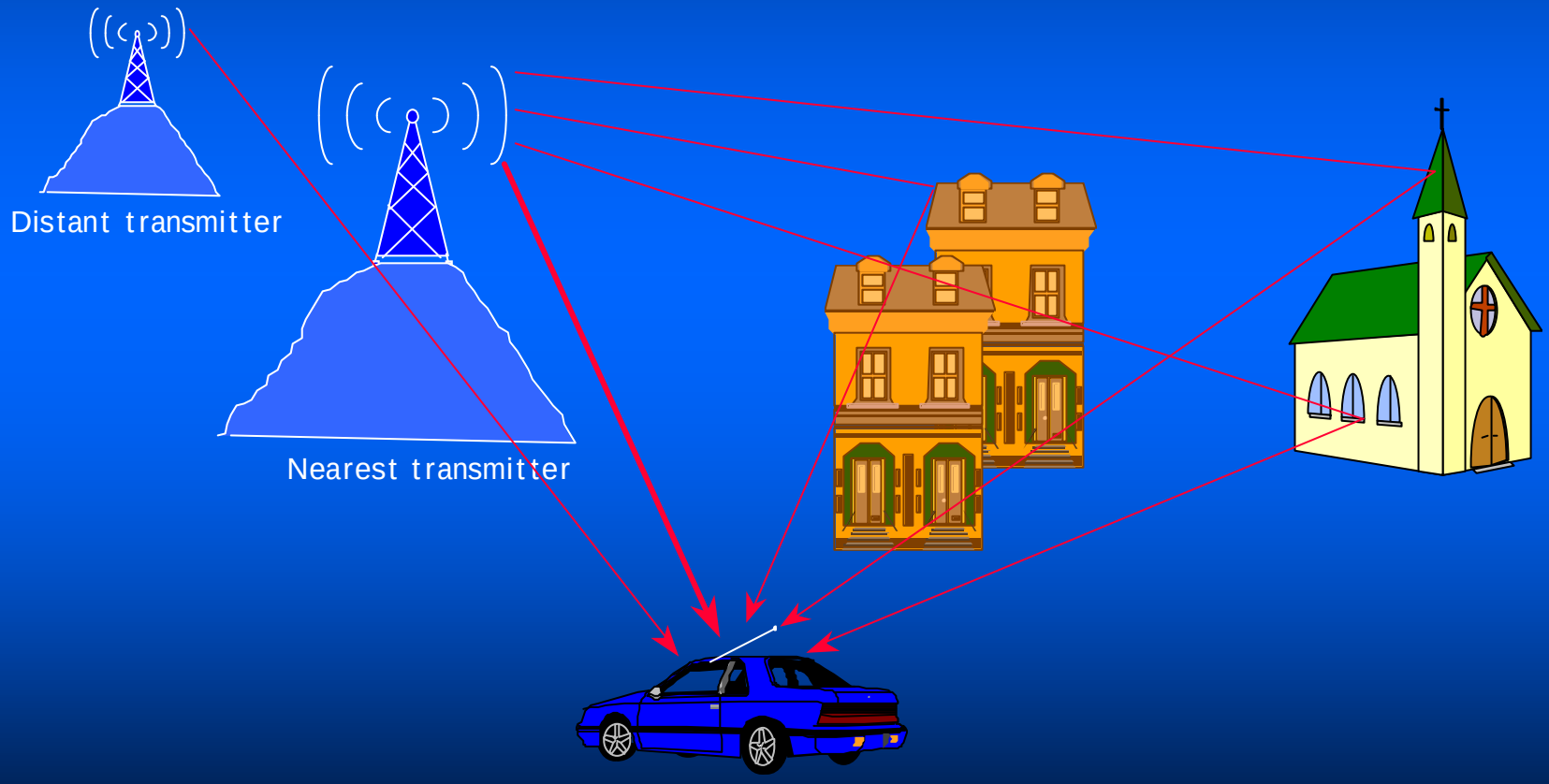
DIGITAL TERRESTRIAL BROADCAST

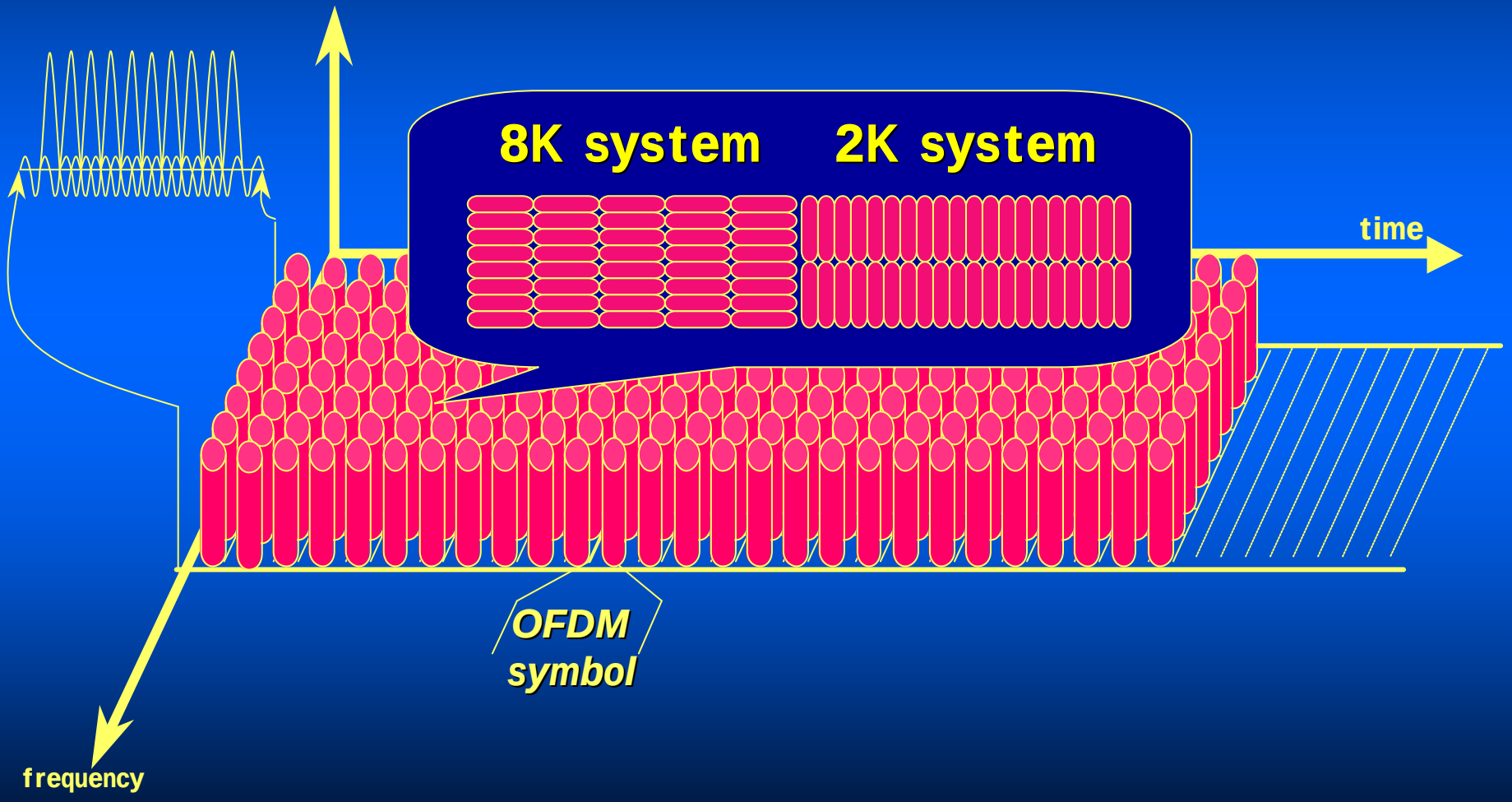
Among the available Digital Broadcasting standards, three are based on the Coded Orthogonal Frequency Division Multiplex modulation.... Why ?



Terrestrial Broadcast induces multi-pathes and Doppler effects (if Mobile) : COFDM is THE response to cope with these impairments !

COFDM : HOW ?

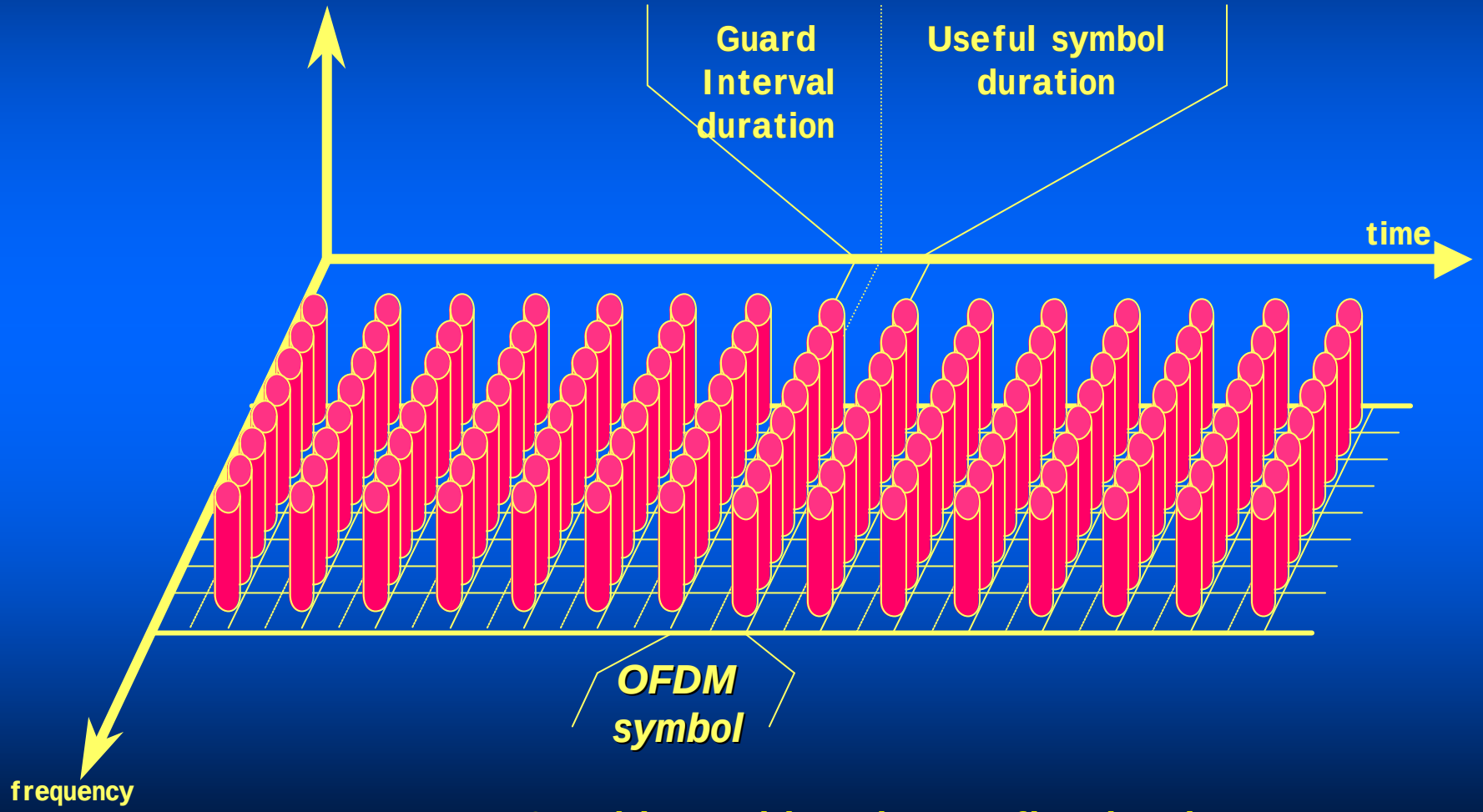
- 1 - Organise the channel as a “time-frequency” cells partition



Make sub-carriers orthogonal (df=1/dt) to avoid “inter-carriers” interference

COFDM : HOW ?

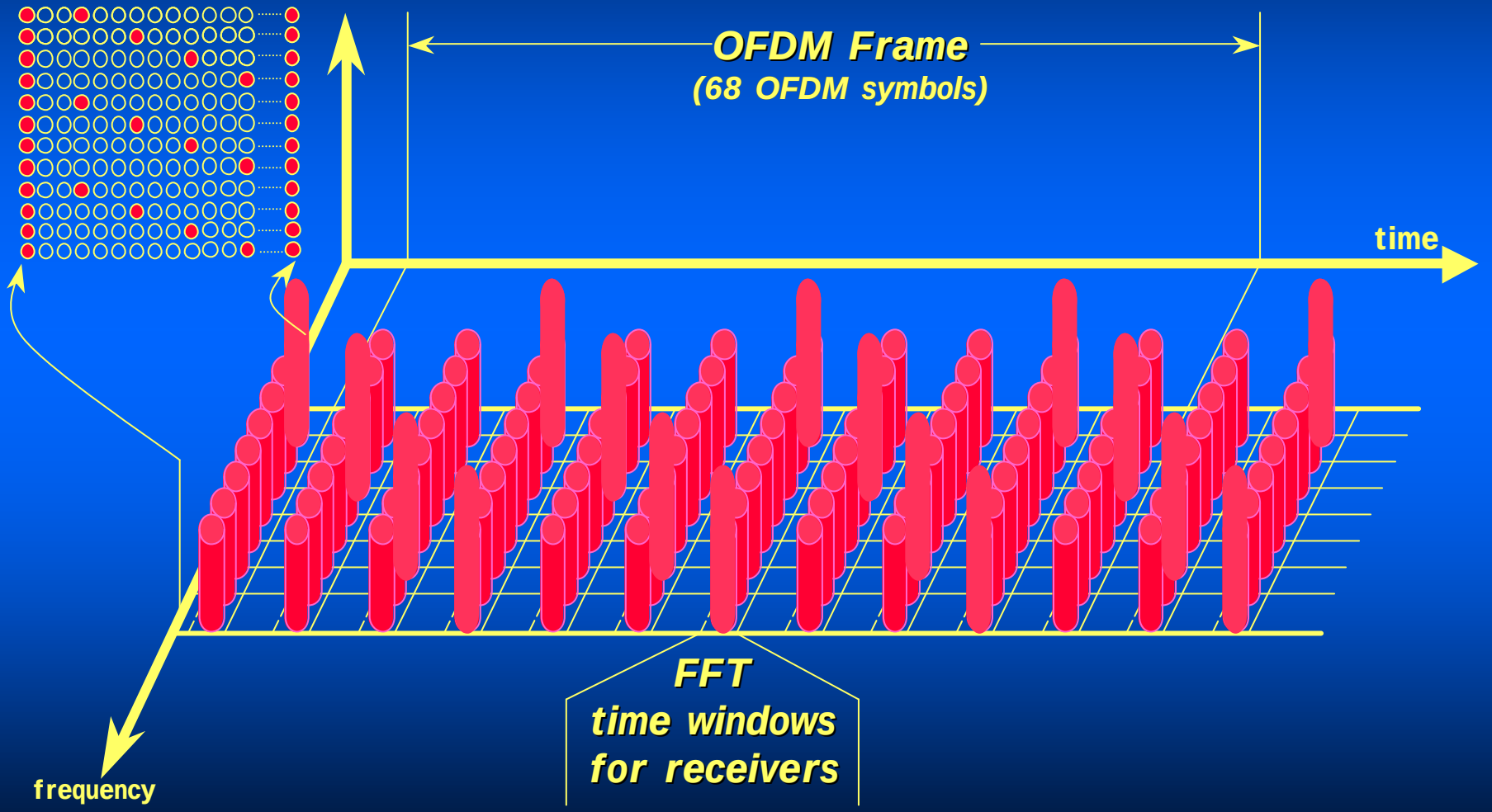
- 2 - Insert Guard Interval to avoid “inter-symbol” interference



BUT : Guard interval introduces a first loss in transport capacity

COFDM : HOW ?

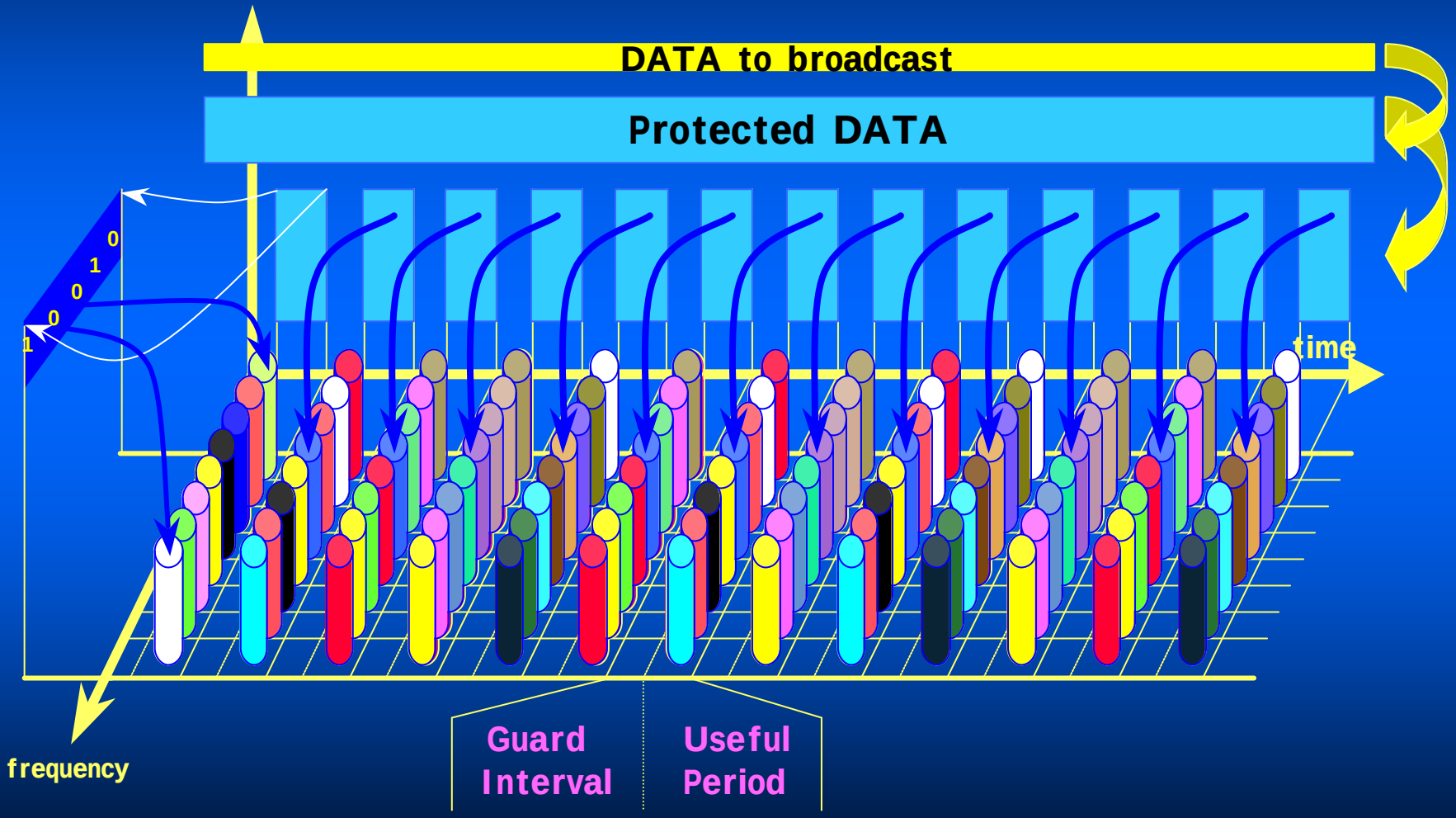
- 3 - Insert “Synchronization Pilots” to help Receivers to lock onto the useful signal



BUT : Synchronization markers introduce a second loss in transport capacity

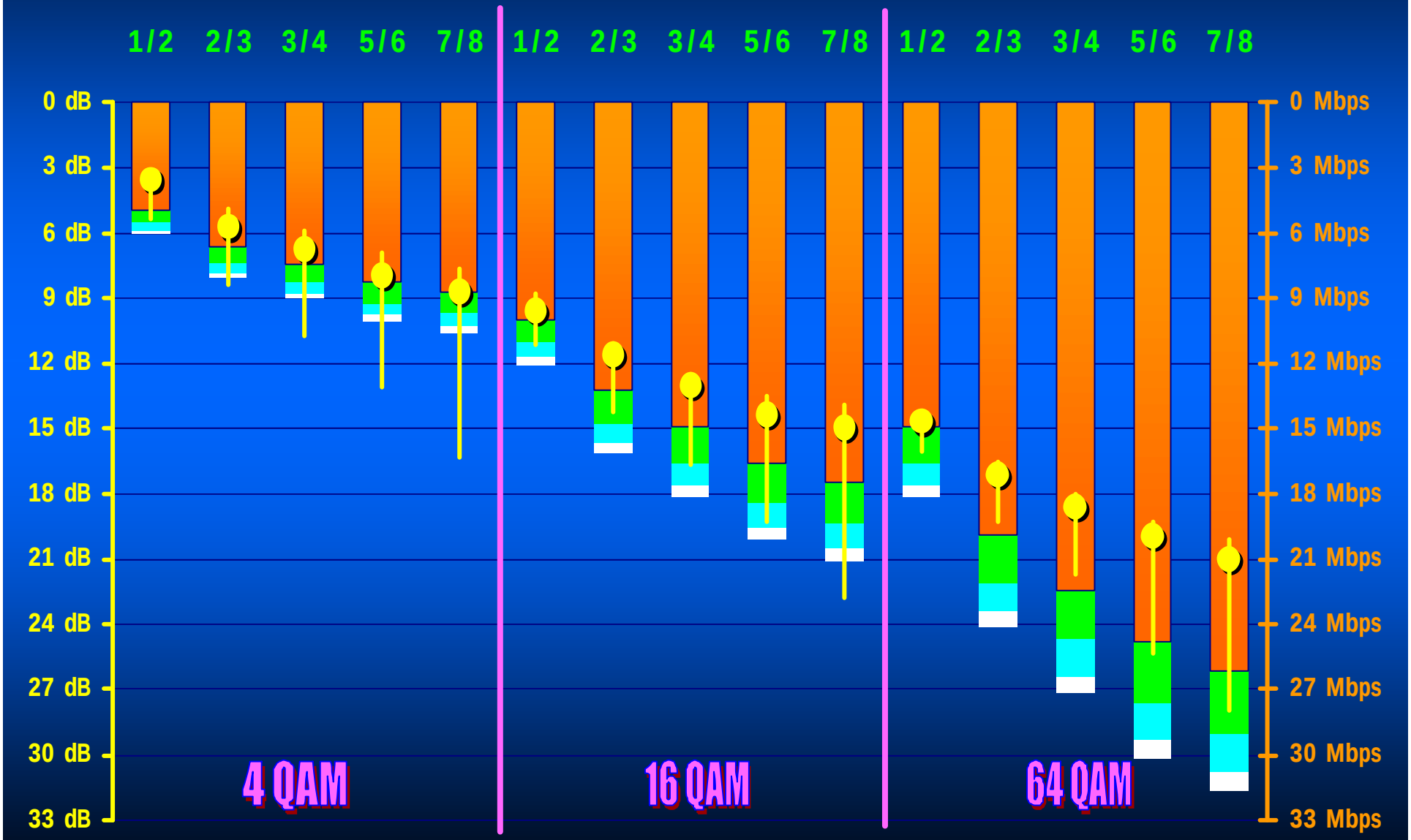
COFDM : HOW ?

- 4 - Map protected payload bits onto OFDM symbols with frequency interleaving



Create frequency diversity to improve robustness against selective fading

DVB-T modes : the trade-off between Bitrate and Robustness



The Digital Video Broadcasting System:

The Magic of Single Frequency Network (SFN) Operation

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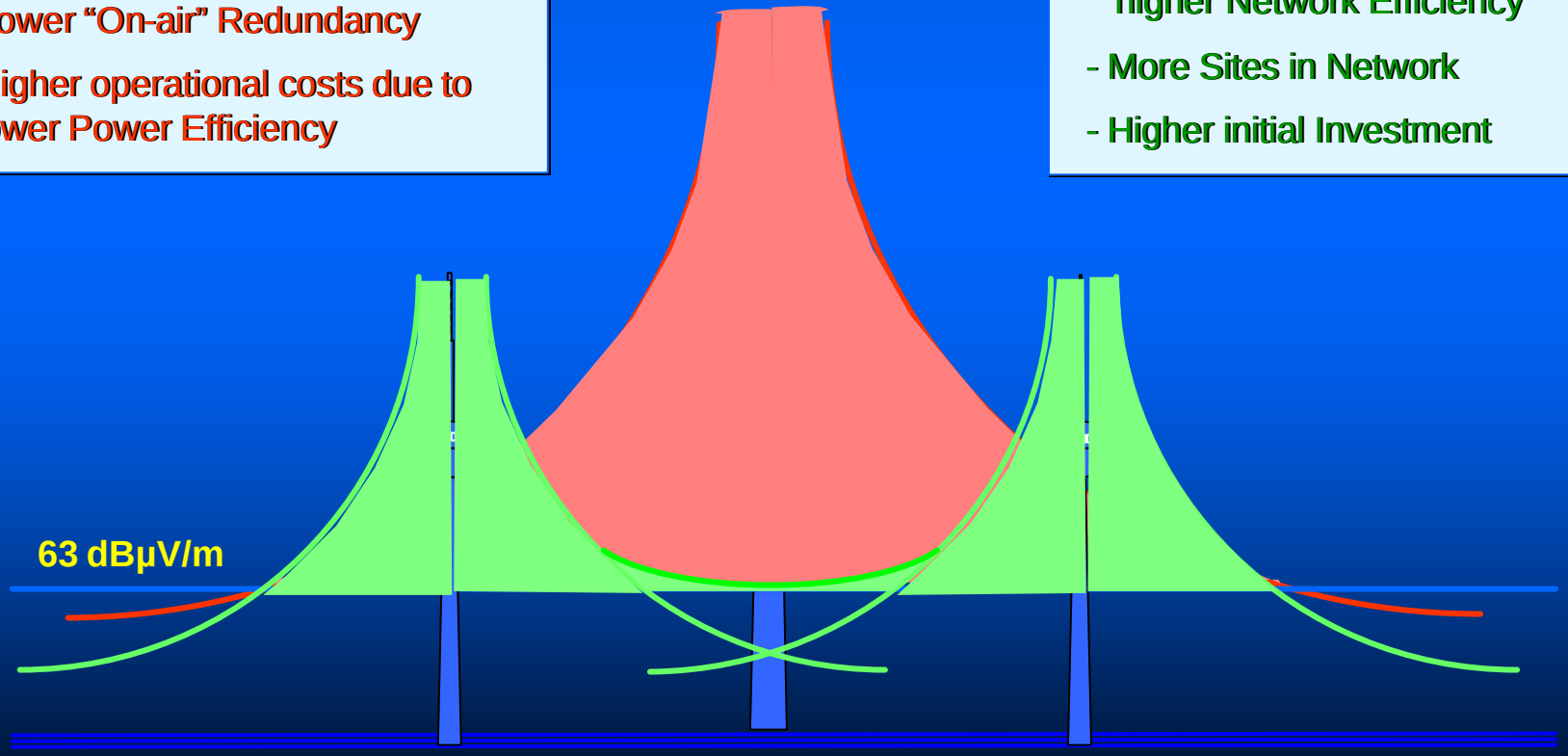
Spectrum & Power Efficiency : the network point of view

High Power Transmitters

+ Less Sites in Network
+ Lower initial Investment
- Lower "On-air" Redundancy
- Higher operational costs due to lower Power Efficiency

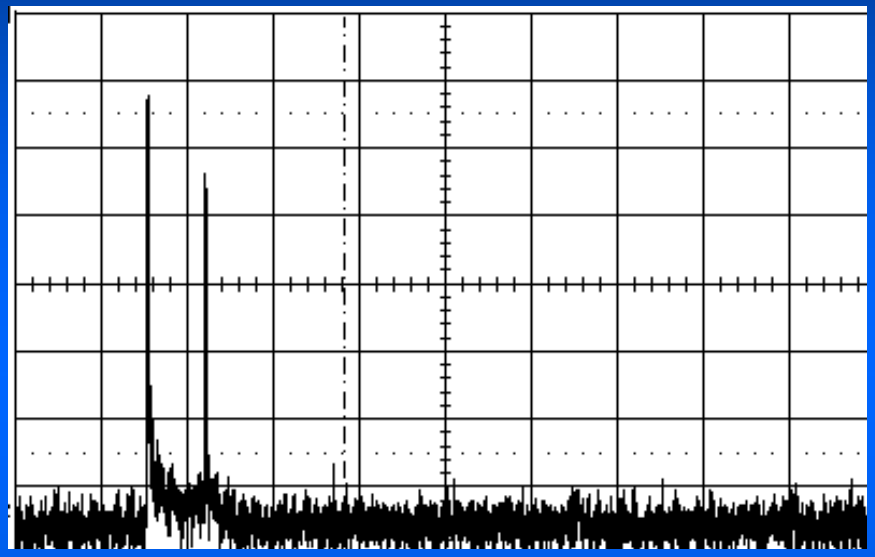
Low Power Transmitters

+ Higher "On-air" Redundancy
+ lower operational costs due to higher Network Efficiency
- More Sites in Network
- Higher initial Investment

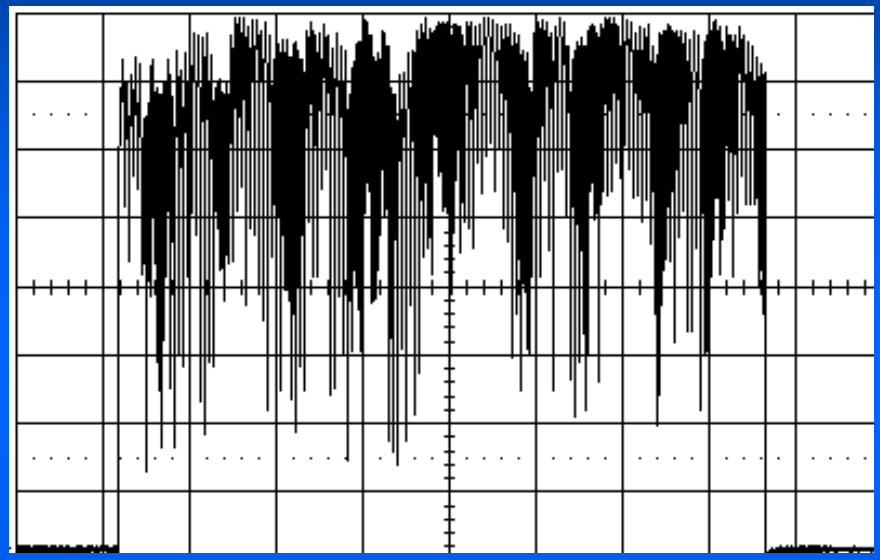


SFN, the receivers point of view ...

Channel Impulse Response



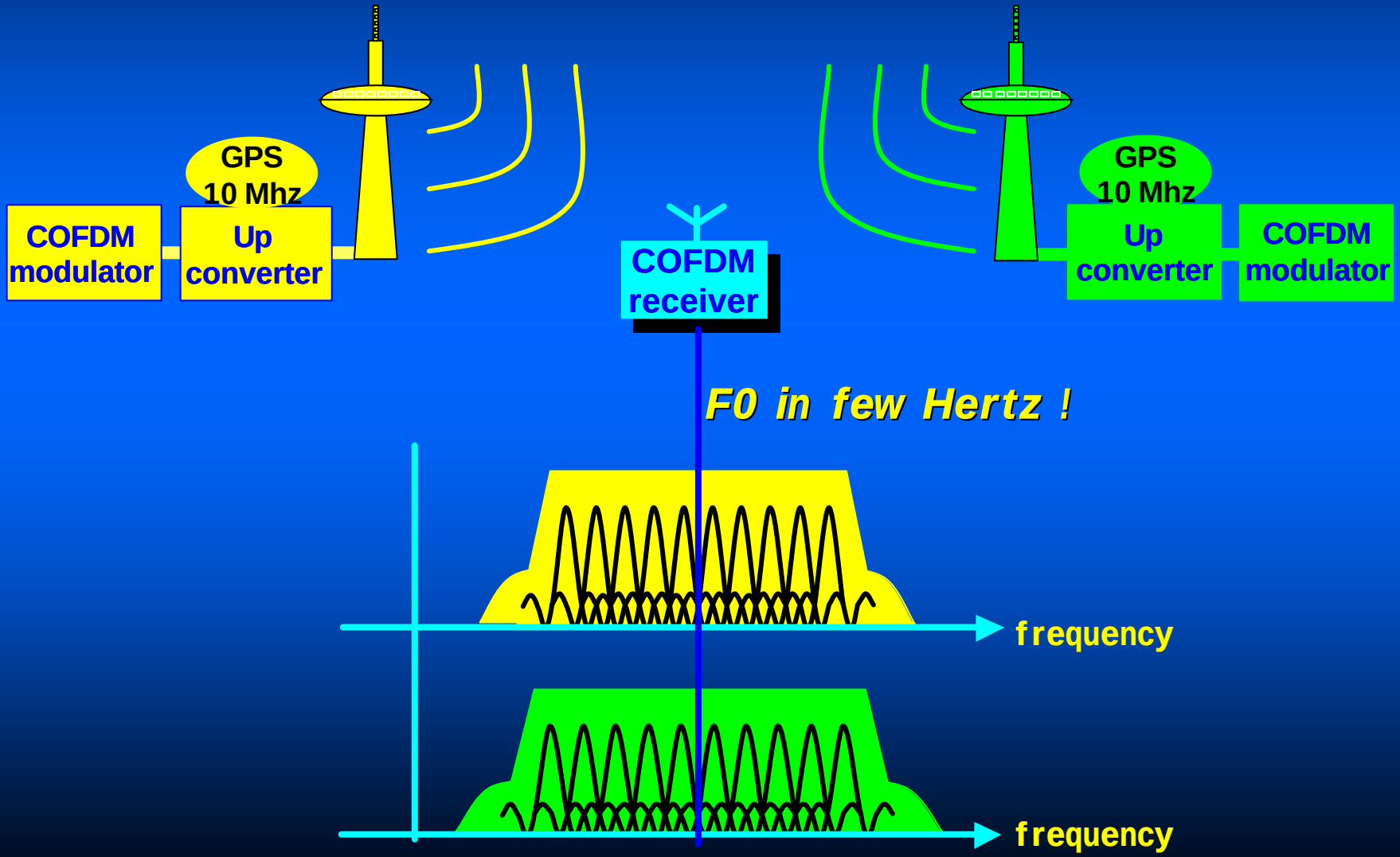
Channel Spectrum



To make receivers working with SFN signals, all transmitters involved in the Single Frequency Network shall comply the "SFN Golden Rules" :

To radiate . on the SAME FREQUENCY,
. at the SAME TIME,
. the SAME DATA BIT(s).

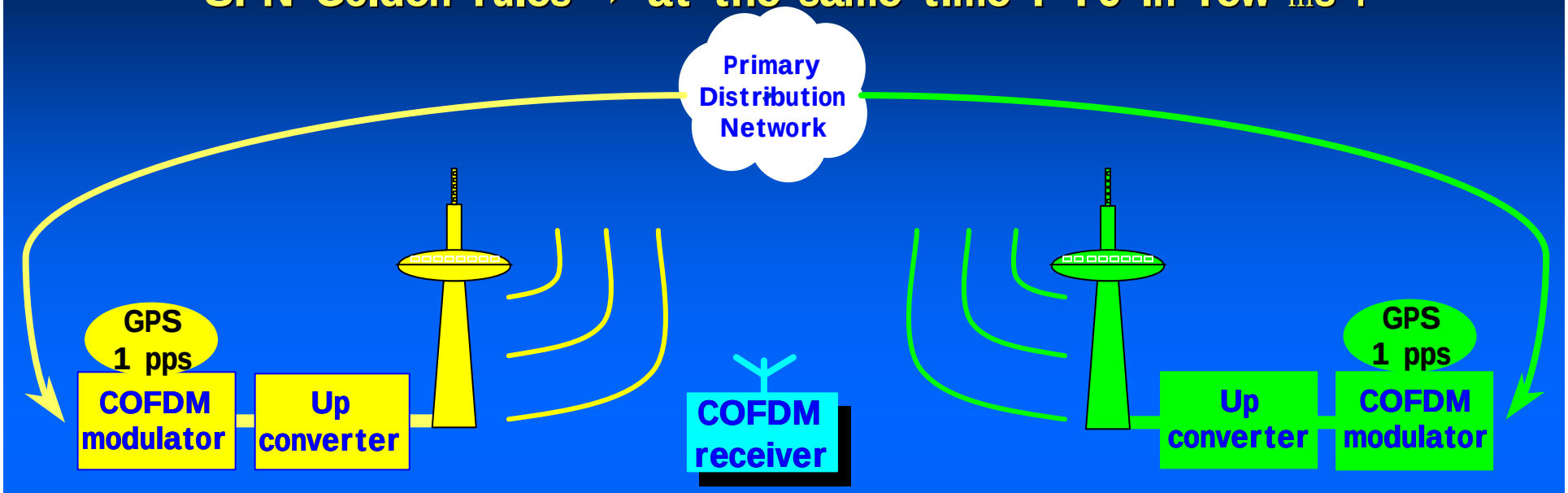
SFN Golden rules ⇨ on the same frequency

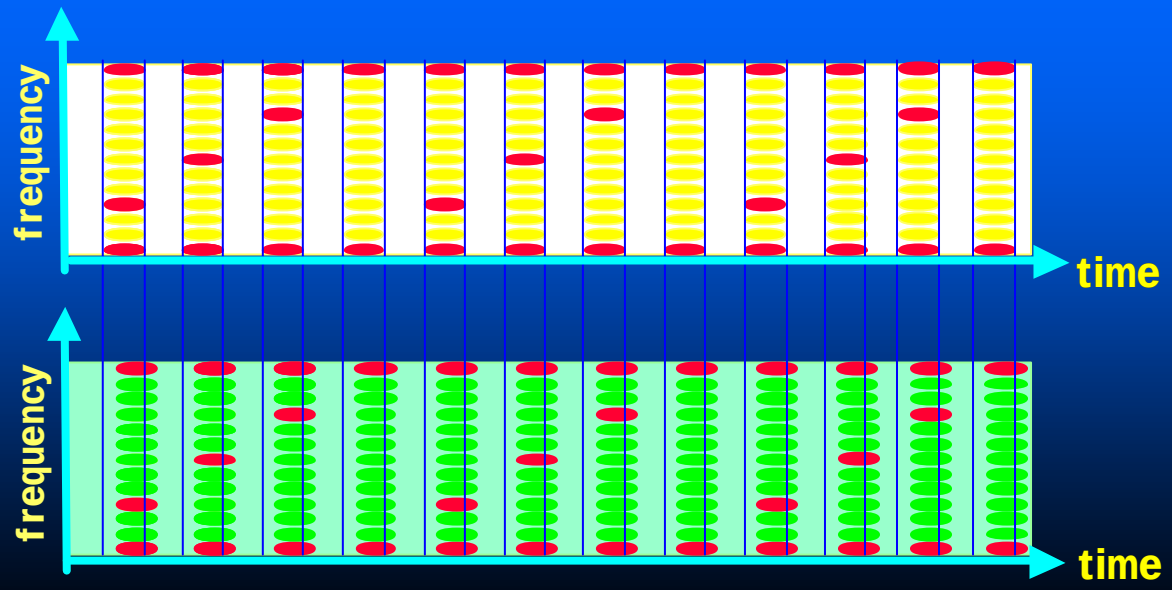


SFN : Frequency domain constraints

	DVB-T (8 MHz)		DAB-T (1,5 MHz)			
Modes	8K	2K	I	IV	II	III
Subcarriers / symbols	6817	1705	1536	768	384	192
. Used for system	769	193	-	-	-	-
. Used to carry data	6048	1512	1536	768	384	192
Bits / symbols						
. D - QPSK	-	-	3072	1536	768	384
. 4 - QAM (QPSK)	12 096	3 024	-	-	-	-
. 16 - QAM	24 192	6 048	-	-	-	-
. 64 - QAM	36 288	9 072	-	-	-	-
Inter-Carrier spacing	1 116 Hz	4 465 Hz	1 kHz	2 kHz	4 kHz	8 kHz
Absolute precision	~ 1 Hz	~ 4 Hz	~ 10 Hz	~ 20 Hz	~ 40 Hz	~ 80 Hz

SFN Golden rules ⇨ at the same time : T0 in few ms !





SFN : Time domain constraints

Modes	DVB-T (8 MHz) 8K	DVB-T (8 MHz) 2K	DAB-T (1,5 MHz) I	DAB-T (1,5 MHz) IV	DAB-T (1,5 MHz) II	DAB-T (1,5 MHz) III	Maximum distance between Tx
Symbols / frames	68	68	78	78	78	155	
. Used for system	-	-	2	2	2	2	
. Used to carry data	68	68	76	76	76	153	
Symbols duration	896 us	224 us	1000 us	500 us	250 us	125 us	
Guard Interval durations		7 us					~ 3 kms
		14 us					~ 6 kms
	28 us	28 us				31 us	~12 kms
	56 us	56 us			62 us		~24 kms
	112 us			123 us			~48 kms
	224 us		248 us				~96 kms
Delivery Time Accuracy	**2..22 us**	**0..5 us**	**24 us**	**12 us**	**6 us**	**3 us**	

The Digital Video Broadcasting System:

DVB-T Hierarchical modulation

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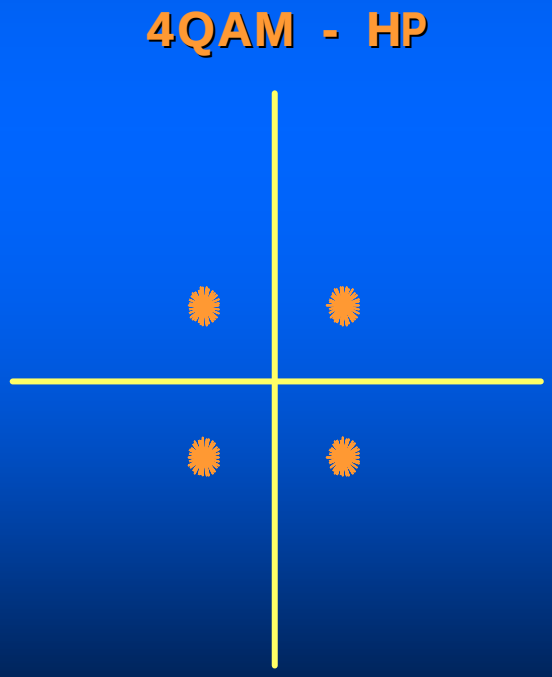
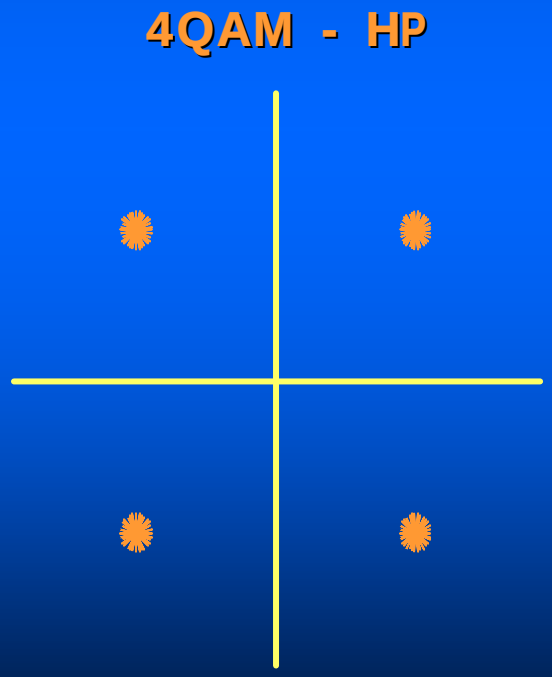
DVB-T Hierarchical constellations : another way to use one RF channel

A basic 4 QAM named HP (High Priority) is used as a core modulation.....

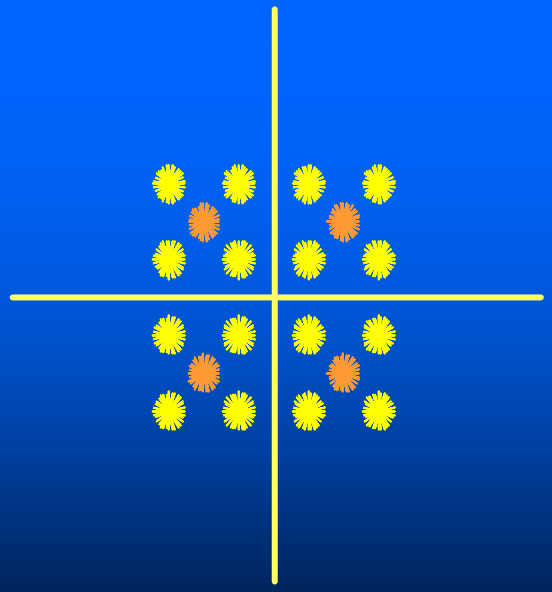




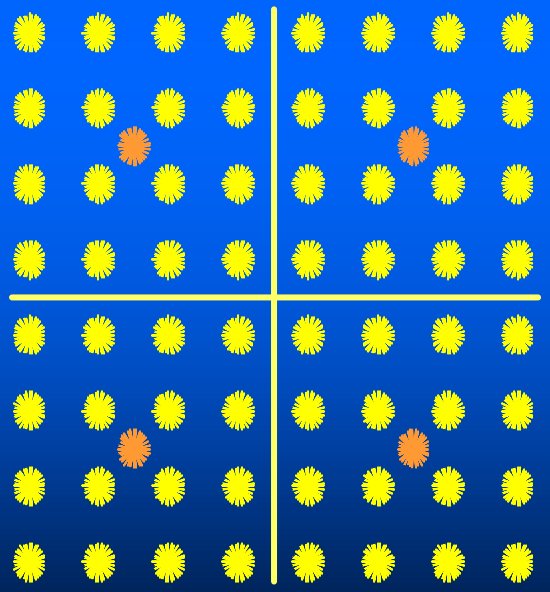
DVB-T Hierarchical constellations : another way to use one RF channel

Then, a Low Priority stream (LP) “over-modulates” the HP one to constitute a....

HIERARCHICAL 16 QAM
made of
4QAM (LP) over 4QAM (HP)



HIERARCHICAL 64 QAM
made of
16QAM (LP) over 4QAM (HP)



DVB-T : Hierarchical modulation for what ?

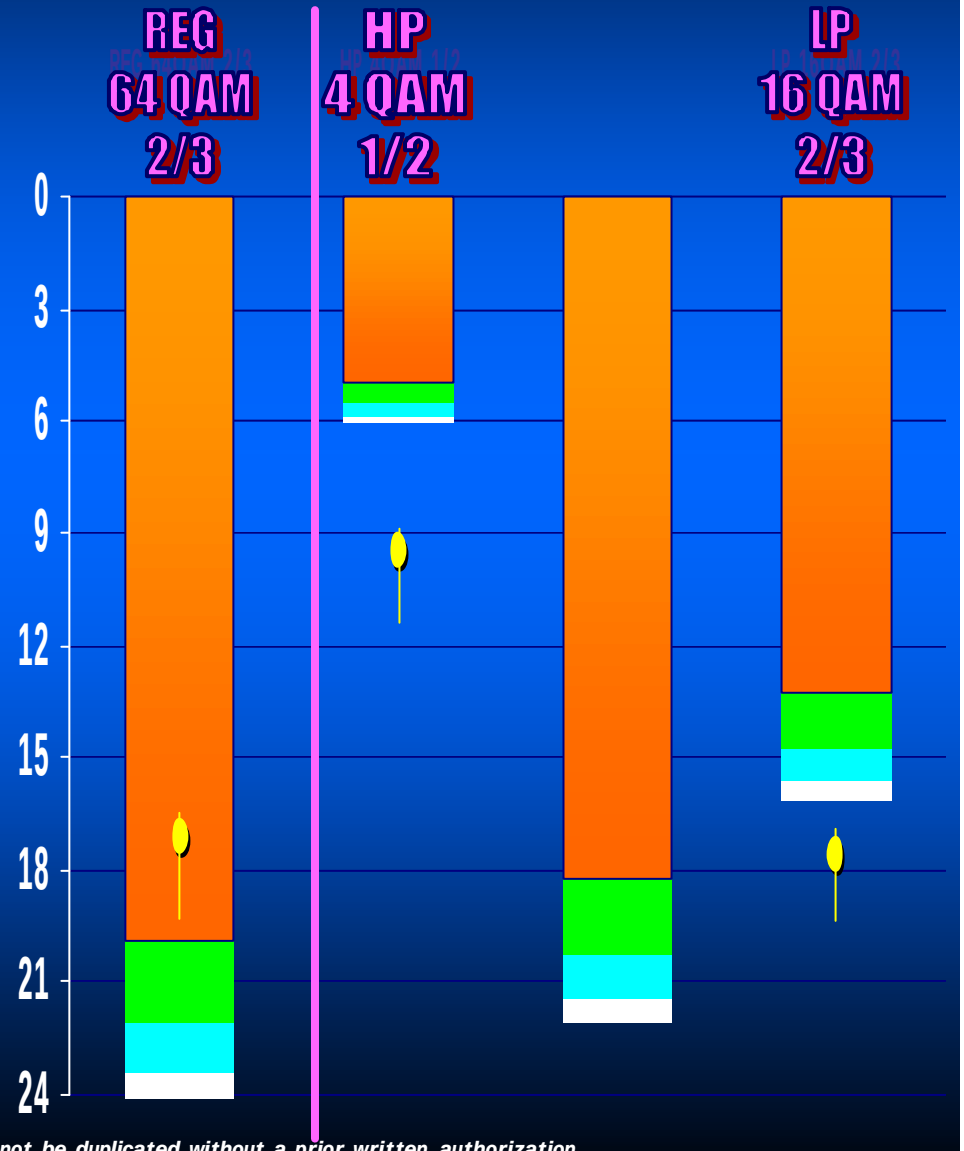
To define modulation parameters, the network planning follows “usually” these rules :

- to reach a given bitrate, Physical Modulation & Coding rate are determined,
- 2K / 8K format is selected relative to the transmission cell sizes,
- Guard Interval value is chosen relative to the nature of the terrain,

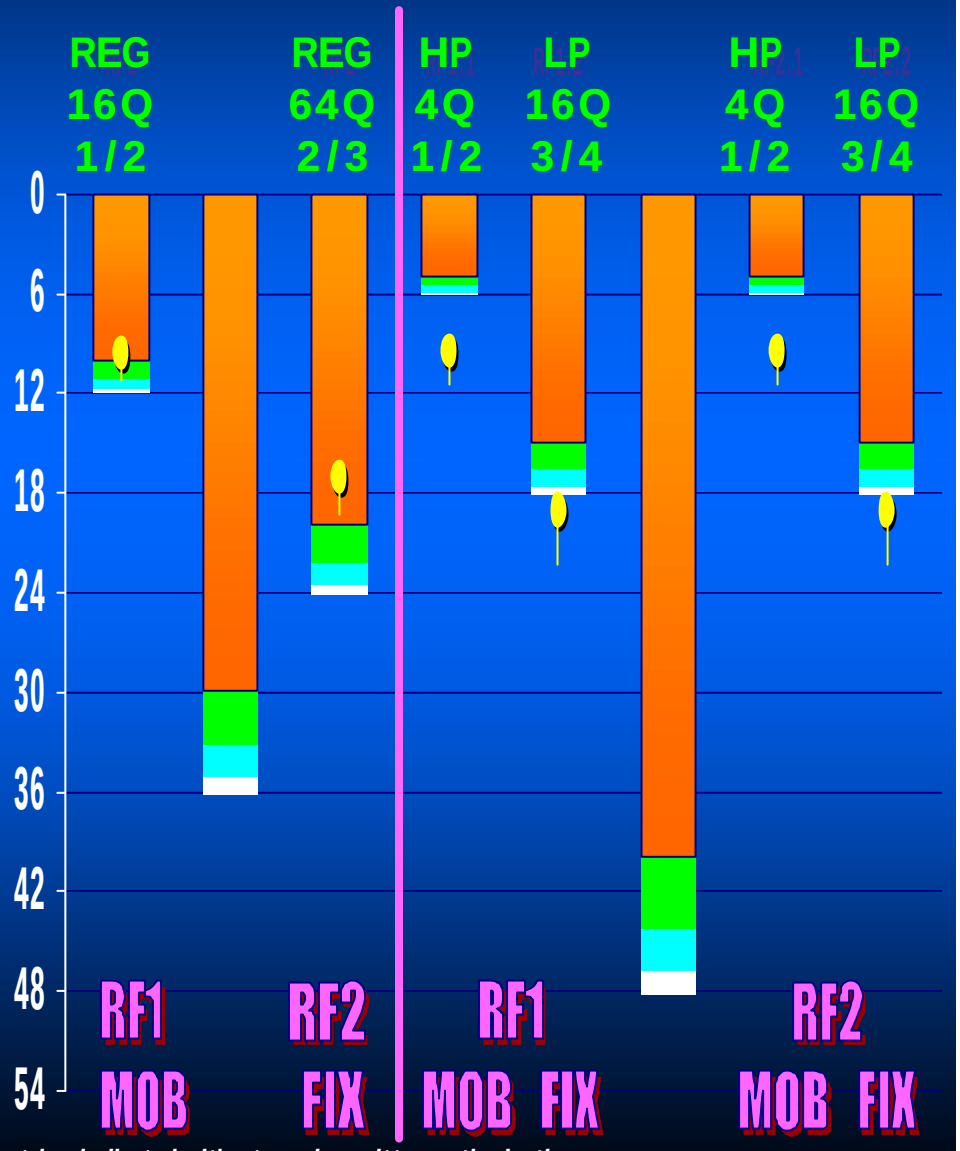
The Hierarchical Modulation feature offers a further trade-off :

to broadcast TWO services on ONE radio channel

Hierarchical Modulation : Stationary vs Portable receivers



Hierarchical Modulation : Mobile vs Static reception



The Digital Video Broadcasting System:

Use of DVB-T with Mobile Receivers

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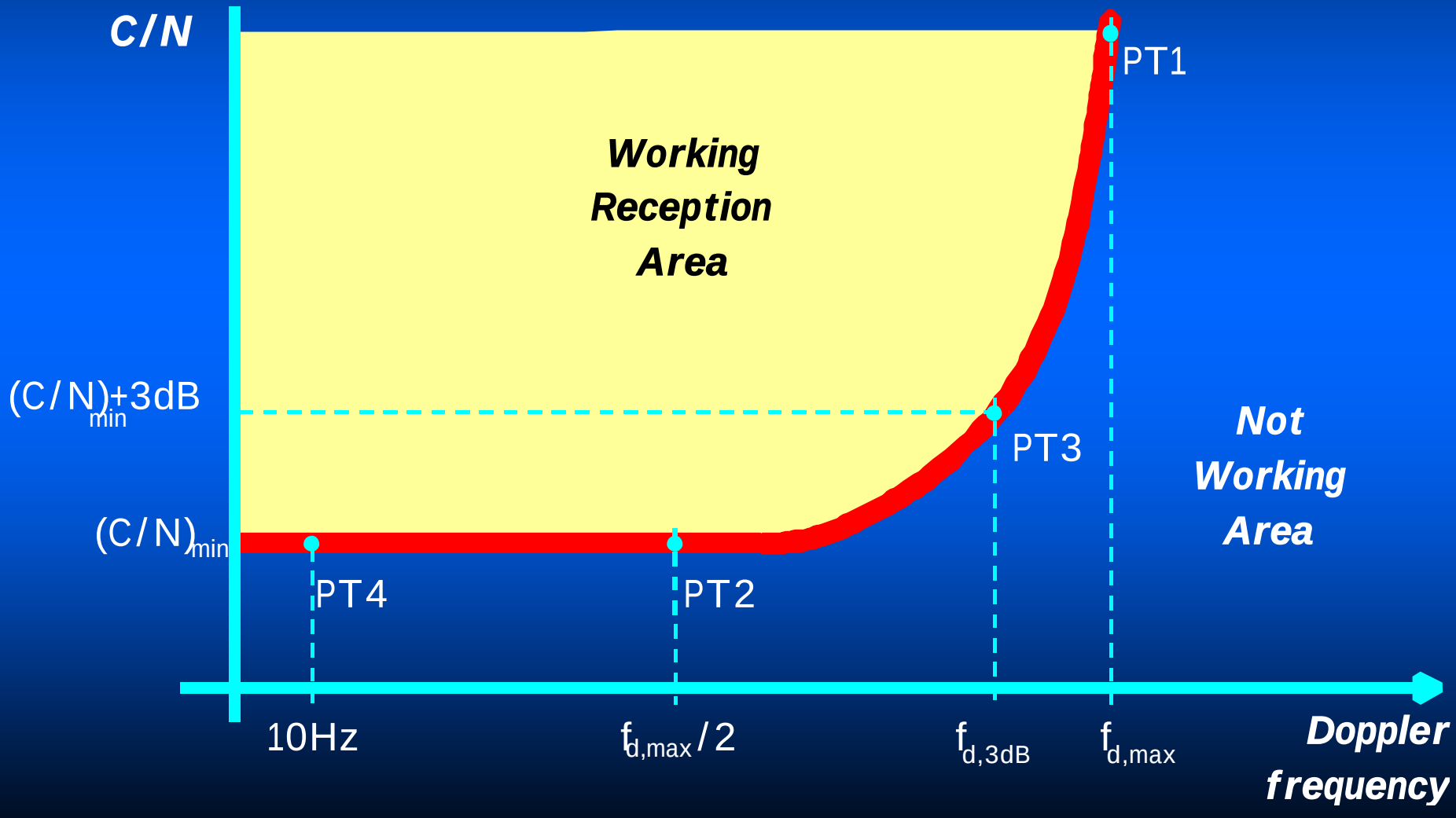
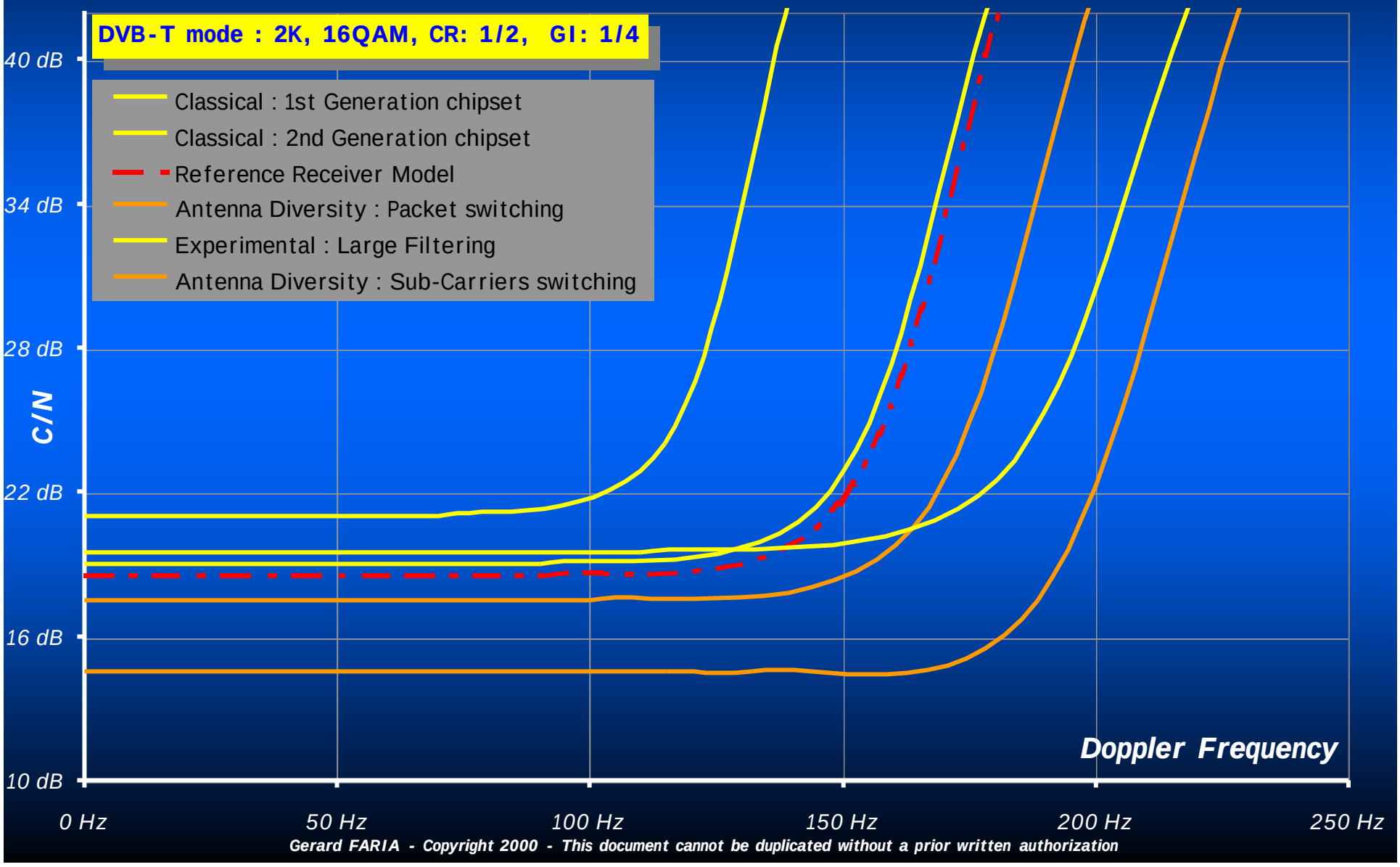
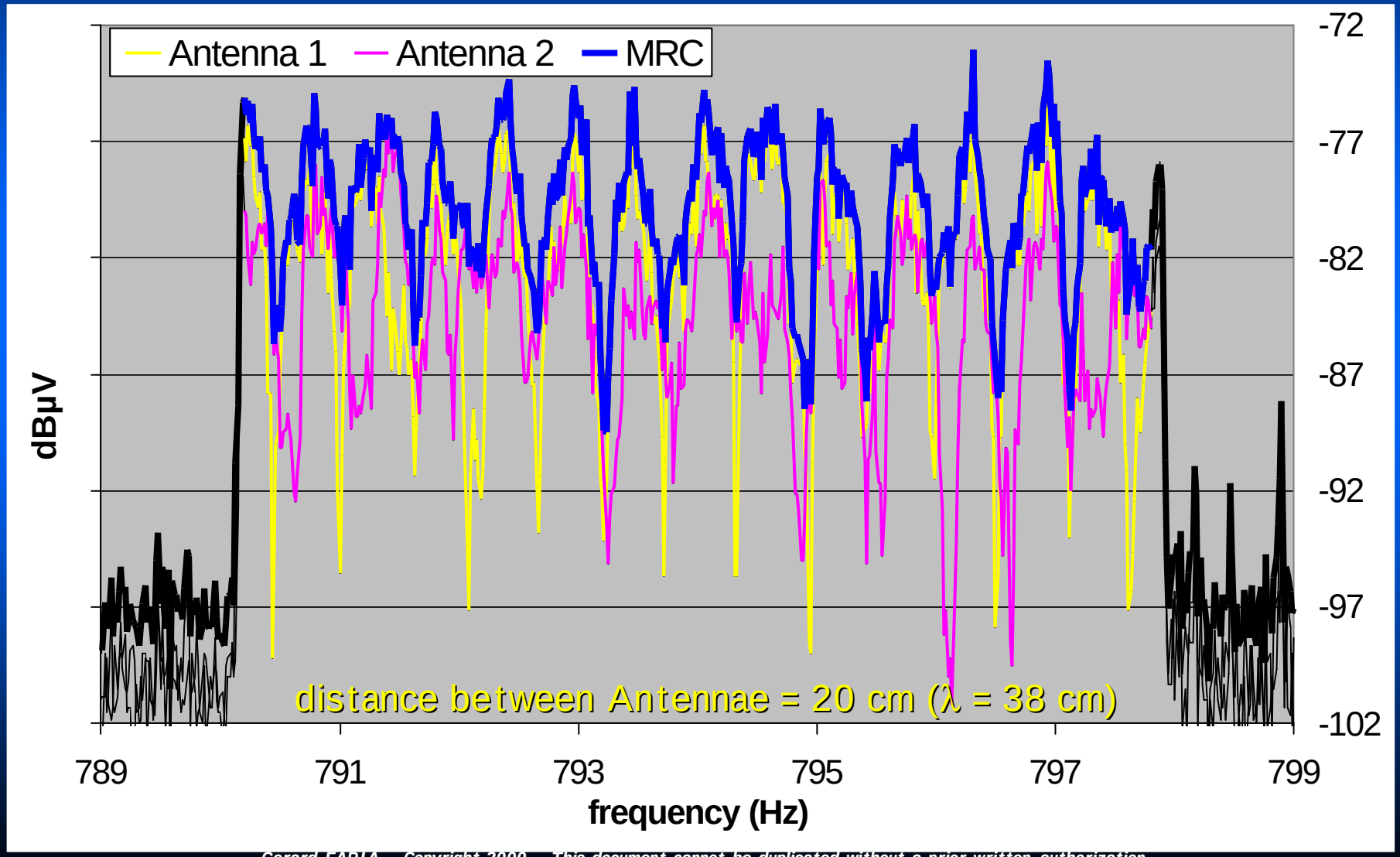
Mobile Receivers behaviour characteristic



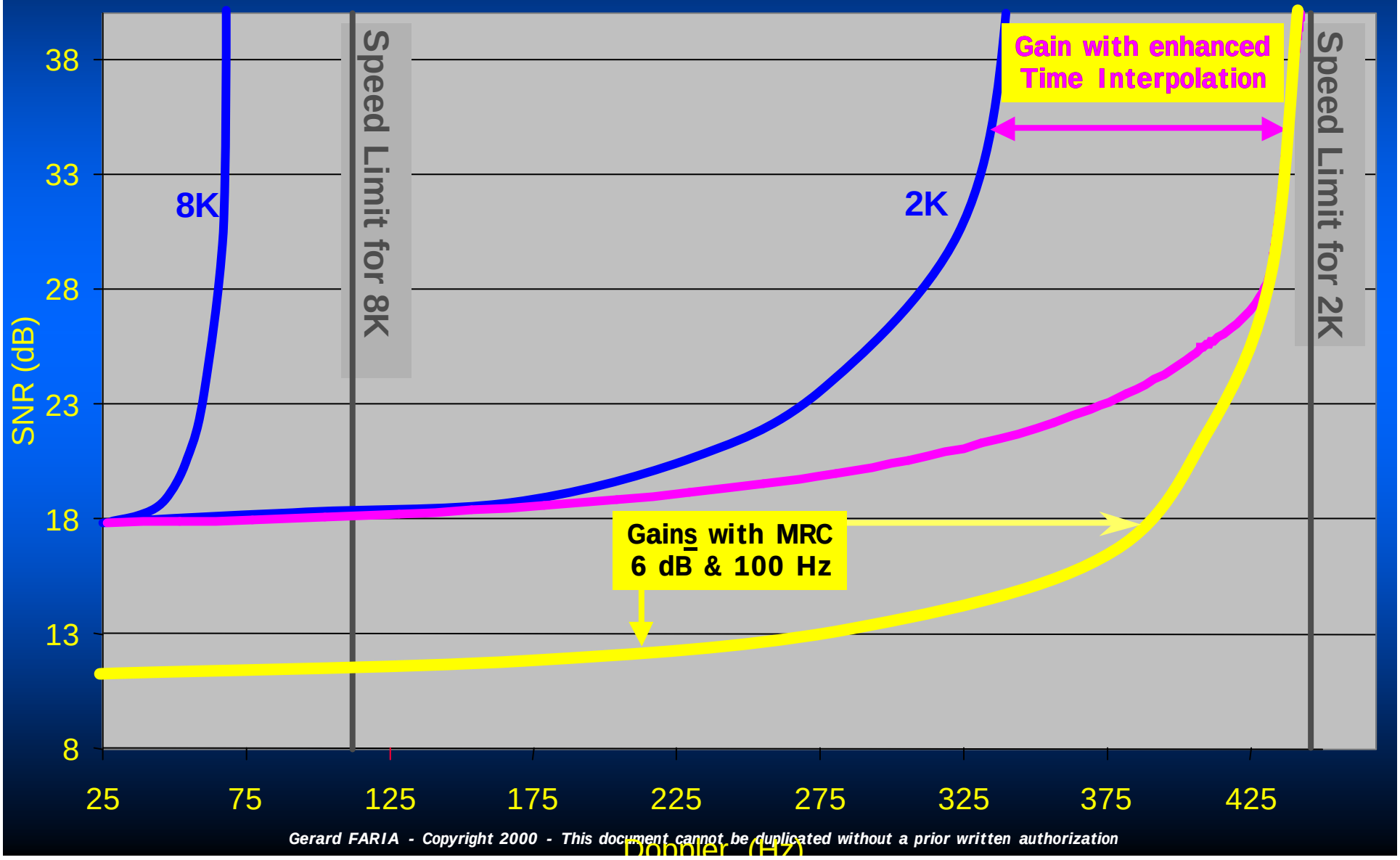
Receiver 's characteristics Dispersion



Field tests : recorded spectra (dense urban environment)

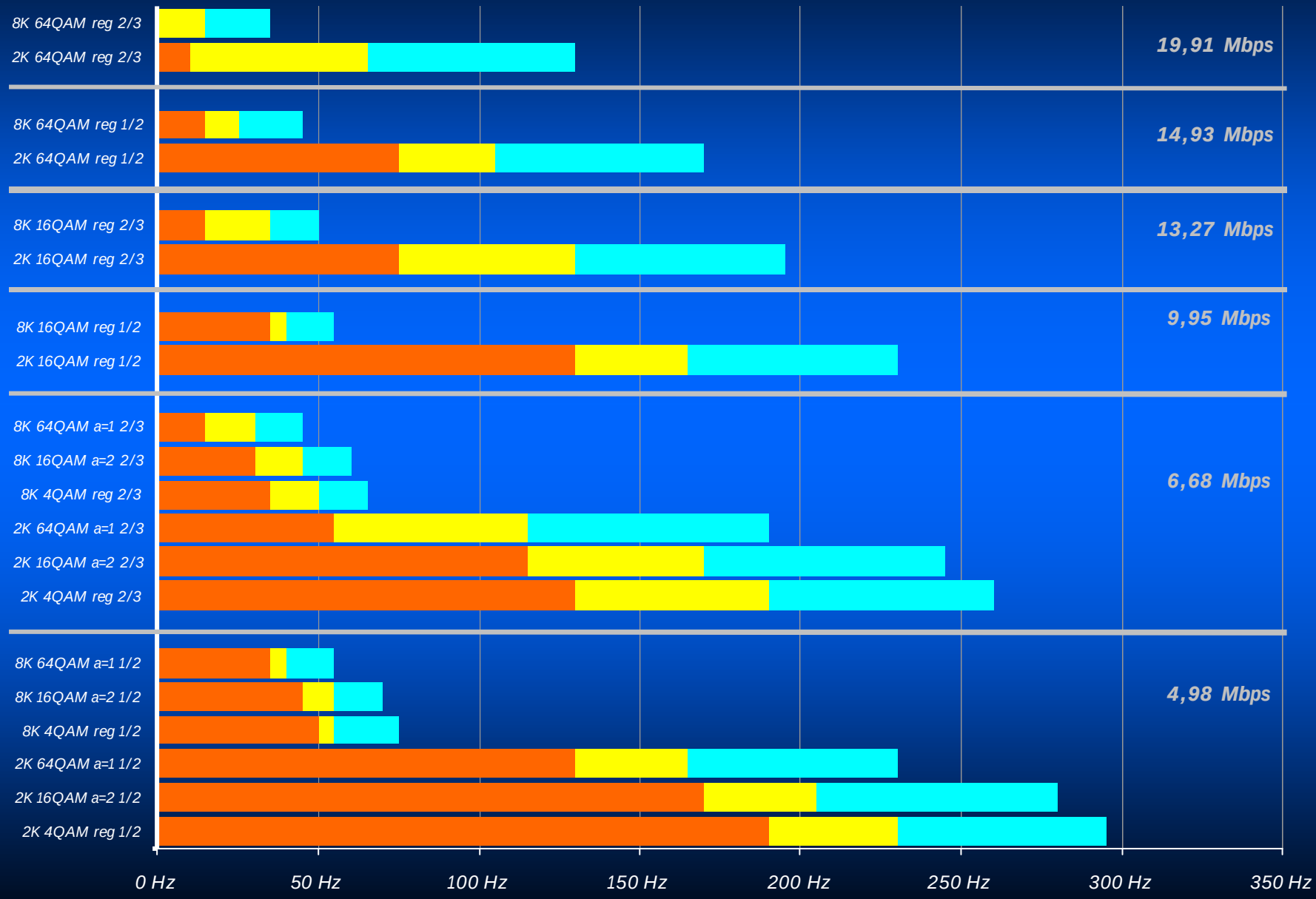


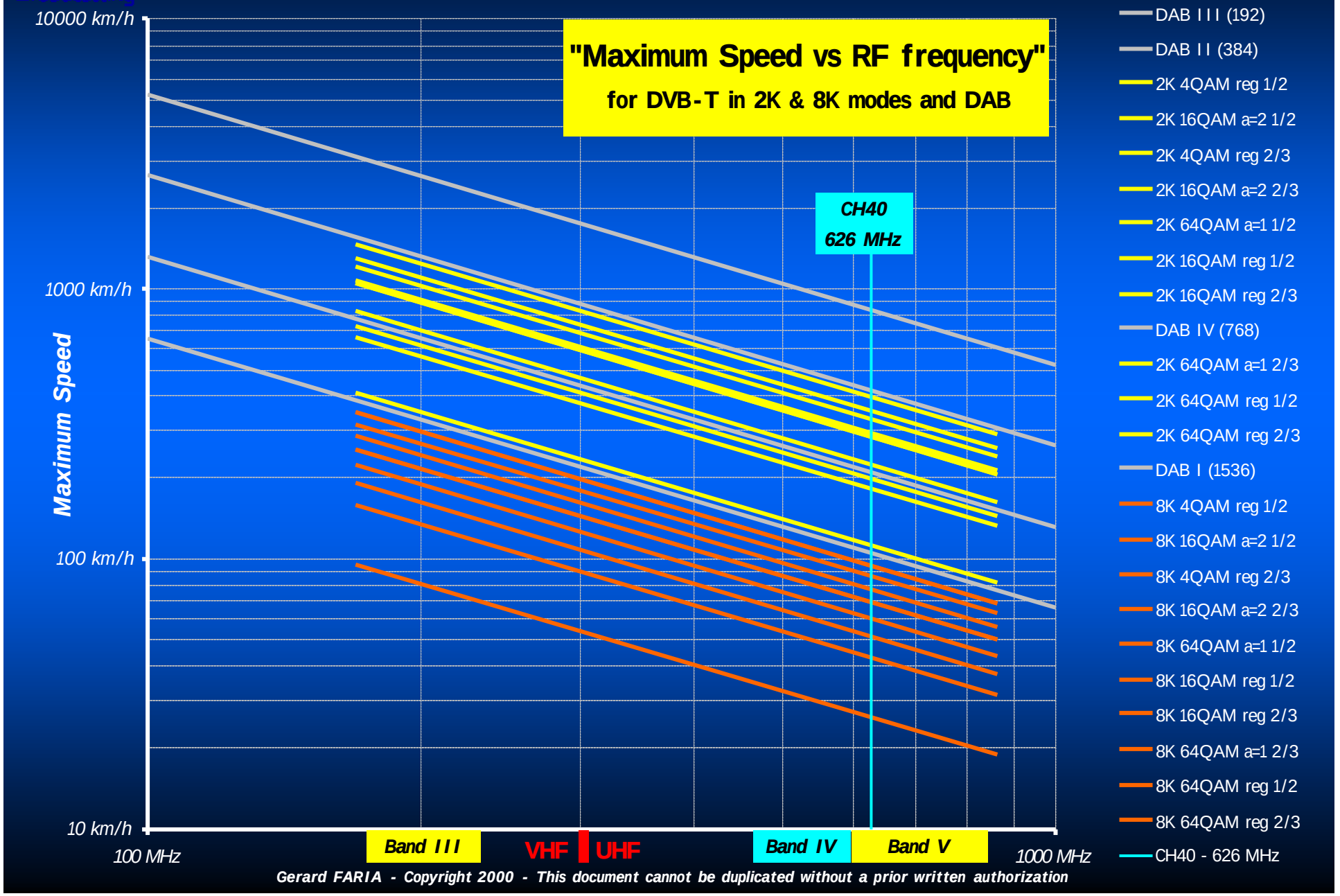
Signal to Noise Ratio vs Doppler



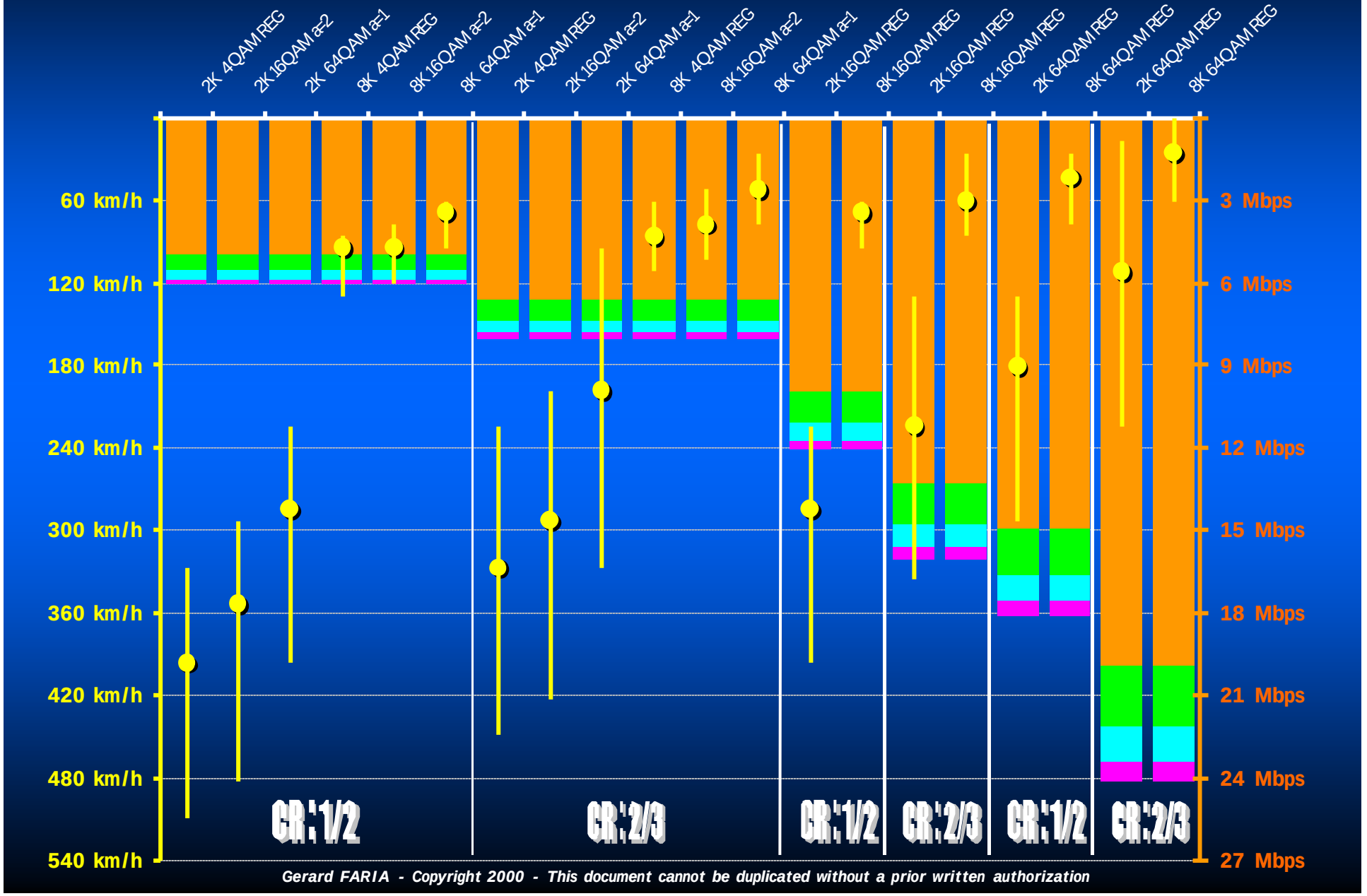
ITU seminar - The Digital Video Broadcast
Kiev - 13th November 2000

« Maximum Doppler Frequency » vs DVB-T Modes & Channel Profiles





« Maximum Speed » using CH40-626 MHz
vs
DVB-T Modes using GI:1/4



Mobile DVB-T demonstrated at IBC 98

Courtesy of BBC

THANK YOU FOR YOUR ATTENTION

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