Communications Laboratory
China Delegation Presentation

Selecting Digital Television for Australia

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www.commslab.gov.au/lab/info/digtv

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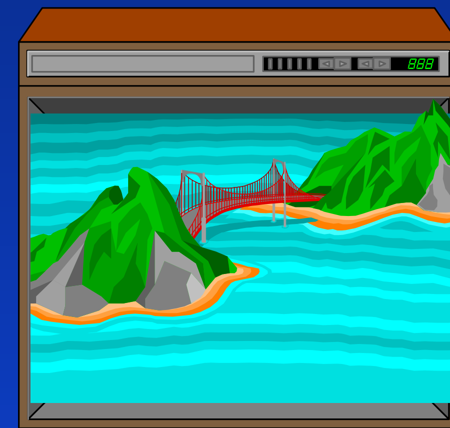
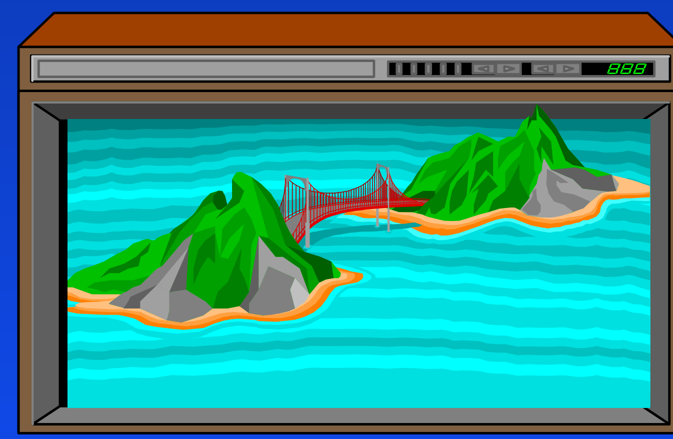
Digital Television

Why digital?

- Noise free pictures
- Higher resolution images
  Widescreen / HDTV
- No ghosting
- Multi-channel sound
- Other services.





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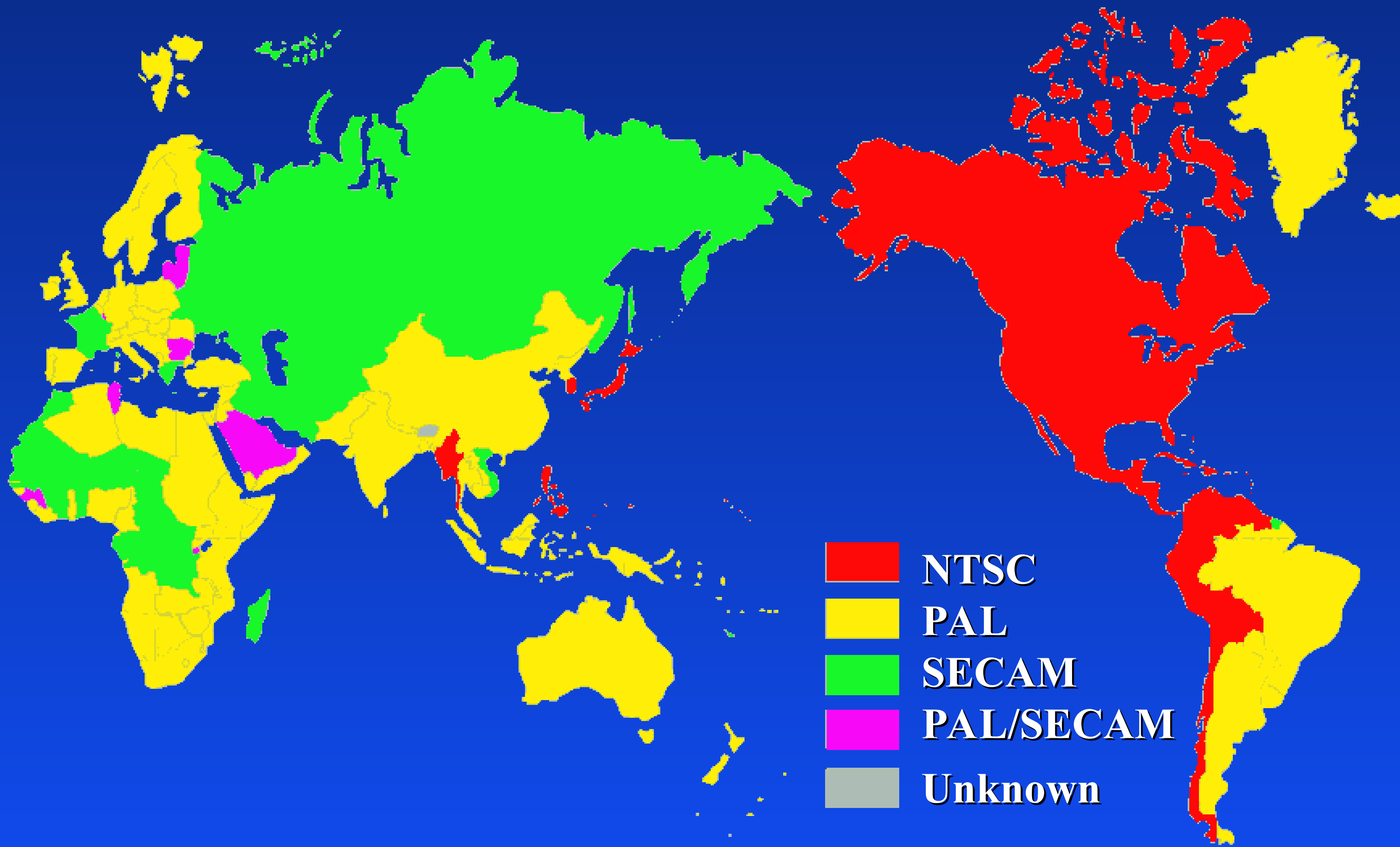
Broad Objectives of DTB

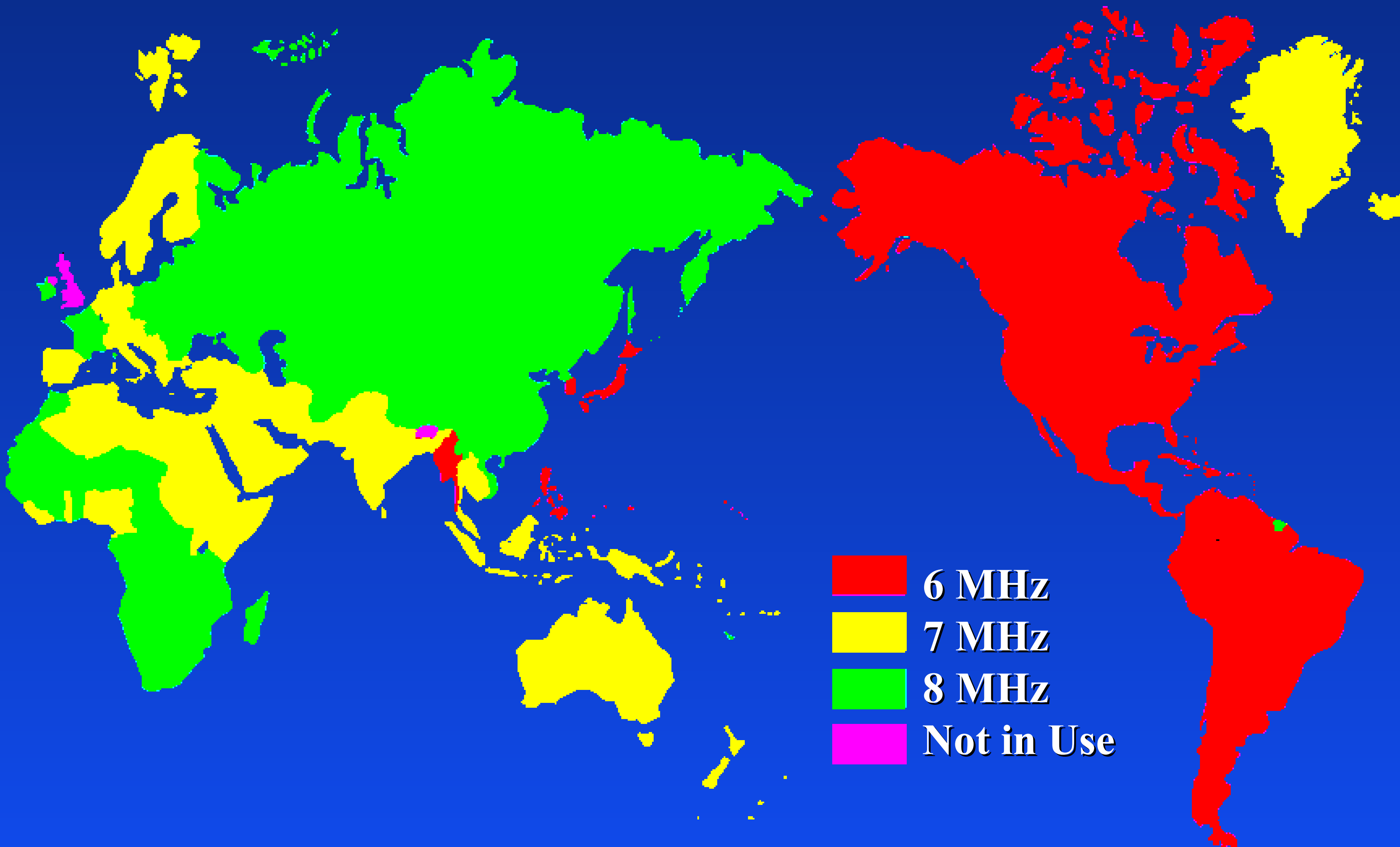
- Overcome limitations of the existing analog television system
- Improved picture
  - High quality (no interference)
  - Resolution (HDTV)
  - Format (16:9)
- Enhanced Audio services
- Data capacity available for other value added services

World TV Standards



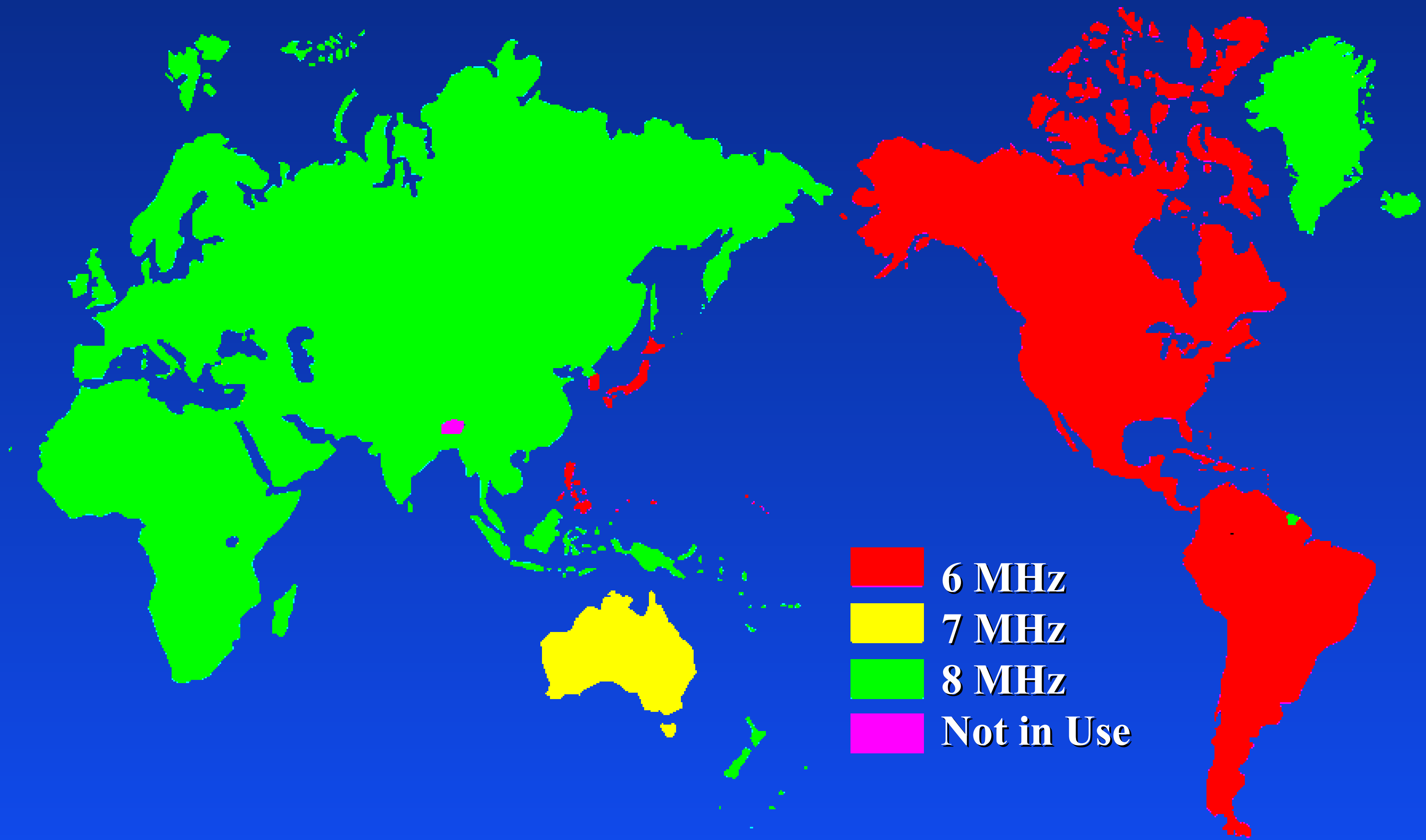
Australia like China is PAL

Transmission Bandwidth - VHF



Australia is 7 MHz, China is 8 MHz

Transmission Bandwidth - UHF



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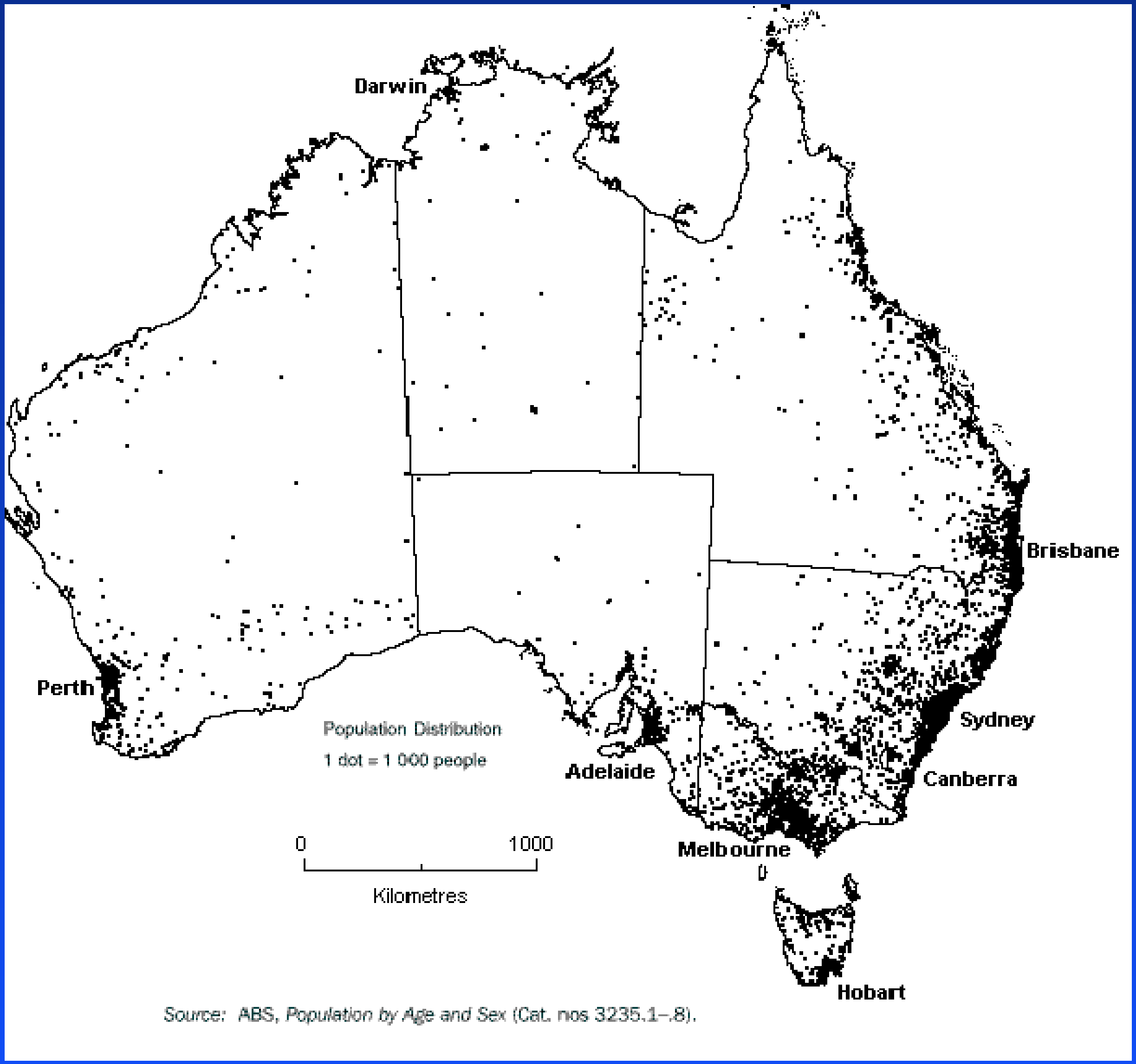
The Australian Broadcasting Environment

- The unique broadcasting environment of Australia has had a major influence on the way we have looked at digital television.
- What are the main defining aspects of the Australian television environment?

Australian Population Distribution



Uneven Population distribution

Wide areas where few people live

Noise Limited Transmission environment

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Free To Air Television (FTA)

- Important part of Australian entertainment
- Majority of Australian audience is watching
- No television receiving licences
- National broadcasters funded from taxation

Free To Air Broadcasters (Cont)

Total of 5 FTA broadcasters

- 2 national broadcasters (ABC & SBS)
- 3 commercial broadcasters (Seven, Nine & TEN networks)

- Commercial broadcasters have affiliated regional networks similar to US industry
- Limits on ownership of media outlets (including television) imposed by government

Pay TV - Cable, MDS & Satellite

- Only a small business in Australia
- Less then 400,000 subscribers
- Less than 7% of households

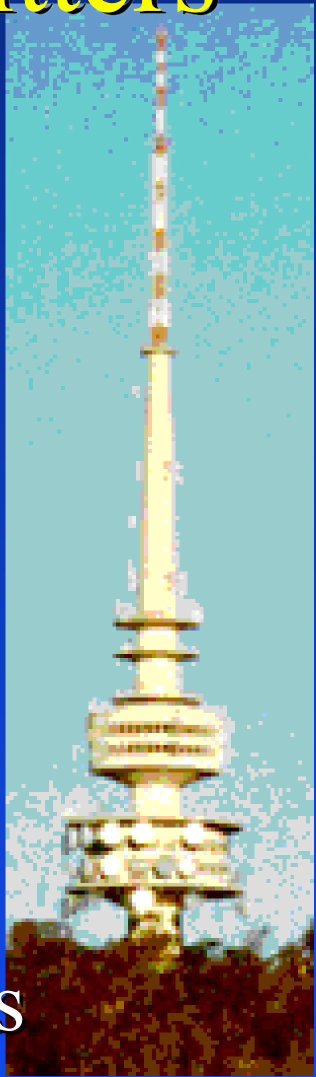
Indoor reception

- Around 30% of Australians watch FTA using indoor antennas

Program Quality Vs Quantity

- Australians have a low number of available television channels
- Television program budget is spread between fewer programs
- Australians used to watching high quality programming at high technical quality.

Australian Television Transmitters



- Use moderate power levels
- Typically
  - **VHF 100 kW EIRP**
  - **UHF 1 MW EIRP**
- Common antenna & feeder systems
- Most use combiner technology
- 10 rebroadcast sites for each main Tx
- Many of these are frequency transposers

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Receiver Bandwidth

- Australia has 7 MHz channels at VHF & UHF
- Receivers from Europe or America will require modifications to operate in the 7 MHz domain.
  - **VHF tuner**
  - **7 MHz IF filter**
  - **Synthesizer programming**
  - **Control software modifications**

Australian Television Environment

- We have a unique television environment
- This is why we have been keen to investigate digital transmission technology

Australia has been an early implementer before.

- B-MAC was introduced for remote area broadcasting in 1985.
- Australia is leading again with HDTV plans.

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Digital TV Systems Development

Australia has been following Digital TV & HDTV

- Europeans - Digital SDTV
  - 8 MHz on UHF
  - DVB-T (COFDM)
- Americans - Digital HDTV
  - 6 MHz VHF/UHF
  - ATSC (8-VSB)
- Japanese - Integrated Broadcasting
  - ISDB (BST-OFDM)

Australia's Involvement in DTV

- Testing MPEG 1 & 2 SW profiles in early 90s
- ITU-R study groups 10 & 11
- Initiated formation of ITU-R task group 11/3
- TG 11/3 fostered convergence of systems
  - Source coding the same
  - Modulation different
- 1993 ABA inquiry into planning & system implications of DTTB
- 1997 recommended HDTV

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HDTV - Why Do We Want It?

- HDTV has been coming for a long time & Australia has been following it for a long time
- Australia believes HDTV will be the FUTURE television viewing format.
- Any system we implement NOW must cater for HDTV in the FUTURE
- If HDTV is not designed in at the outset then you will be constrained by the lowest common denominator in the TV market.

MP@ML

MP@HL

All decoders sold in Australia will be MP@HL capable allowing all viewers access to HD resolution when it becomes available

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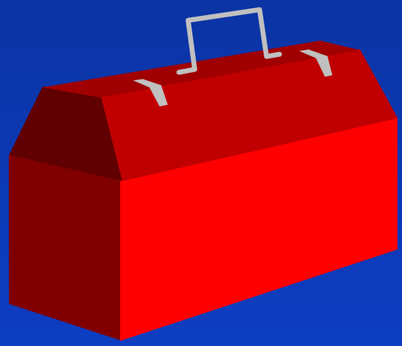
MPEG-2 - Formats ML & HL

- MPEG-2 defines profiles & levels
  - They describe sets of compression tools
- DTTB uses main profile.
- With a choice of levels
  - Higher levels include lower levels



Level	Max Resolution	Format
Low level (LL)	360 by 288	SIF
Main level (ML)	720 by 576	SDTV
High level (HL)	1920 by 1152	HDTV

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FACTS - Specialists Group

- Federation of Australian commercial television stations (FACTS) have formed the advanced television specialists group
  - Investigate all aspects of future television technology
  - Digital TV - transmission & distribution
  - HDTV technology
  - Digital encoding, interchange & distribution for current SDTV

The Benefits of Digital TV

The user will see the following benefits.

❶ More predictable/reliable reception

❷ A change in aspect ratio of pictures 4:3 ⇒ 16:9

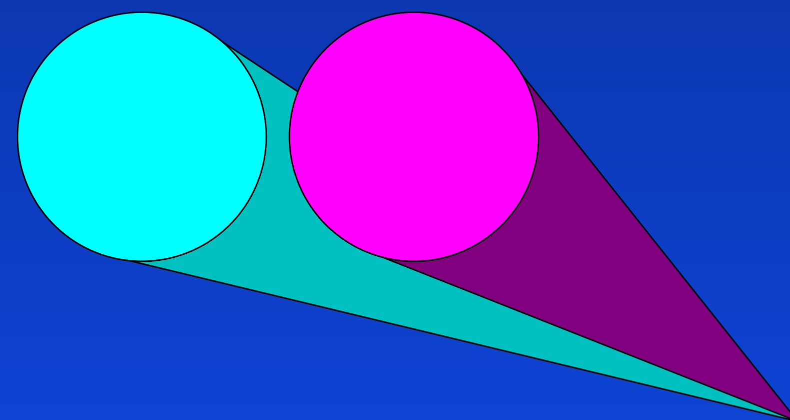
❸ Higher resolution pictures –
high definition for those with HD displays

❹ Multichannel digital surround sound technology.

❺ More capacity for additional services

Digital TV Transmission Technology

- The transmission system is a "data pipe"
- Transports data rates of around 20 Mb/s
- Transports data in individual containers called packets



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DTTB Transmission Systems

- 3 systems are being developed at present.

USA	ATSC	8-VSB	HDTV
Europe	DVB-T	COFDM	SDTV
Japan		ISDB	Band Segmented OFDM

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Only European and American systems are sufficiently developed to allow implementation by 2001

8-VSB - USA

ADVANCED TELEVISION SYSTEMS COMMITTEE

- Developed by the advance television systems committee - ATSC
- Developed for use in a 6 MHz channel
  - A 7 MHz variant is possible.
- Uses a single carrier with pilot tone
- 8 level amplitude modulation system
- Payload data rate of 19.3 Mb/s
- Relies on adaptive equalisation
- Existing AM technology highly developed

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COFDM - Europe

- Developed by the digital video broadcasting project group - DVB
- Uses similar technology to DRB
- Uses 1705 or 6817 carriers
- Variable carrier modulation types are defined allowing data rates of 5-27 Mb/s in 7 MHz
- Developed for 8 MHz channels
  - A 7 MHz variant has been produced and tested
- Can use Single Frequency Networks - SFNs
- New technology with scope for continued improvement & development

ISDB - Japan

- Japanese are developing integrated services digital broadcasting (ISDB)
- System integrates all forms of broadcasting services into one common data channel which can be passed by satellite, cable or terrestrial delivery systems
- Video services
  - Sound services
  - Bulk data services
  - Interactive data services

ISDB - Concept

- Proposed to use band segmented transmission - orthogonal frequency division multiplex (BST-OFDM)

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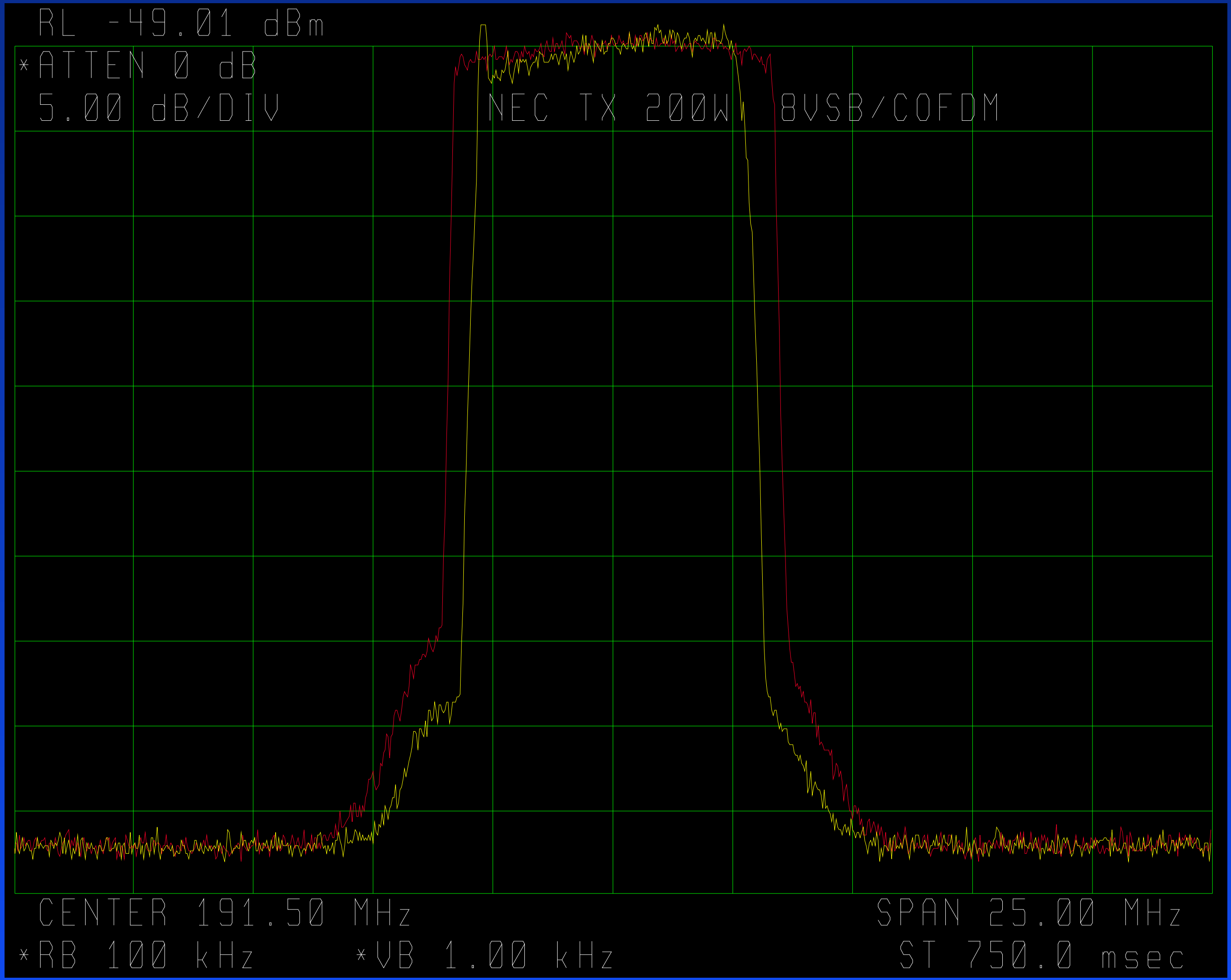
8-VSB & COFDM - Spectrum



8-VSB
COFDM

Channel 8 - VHF

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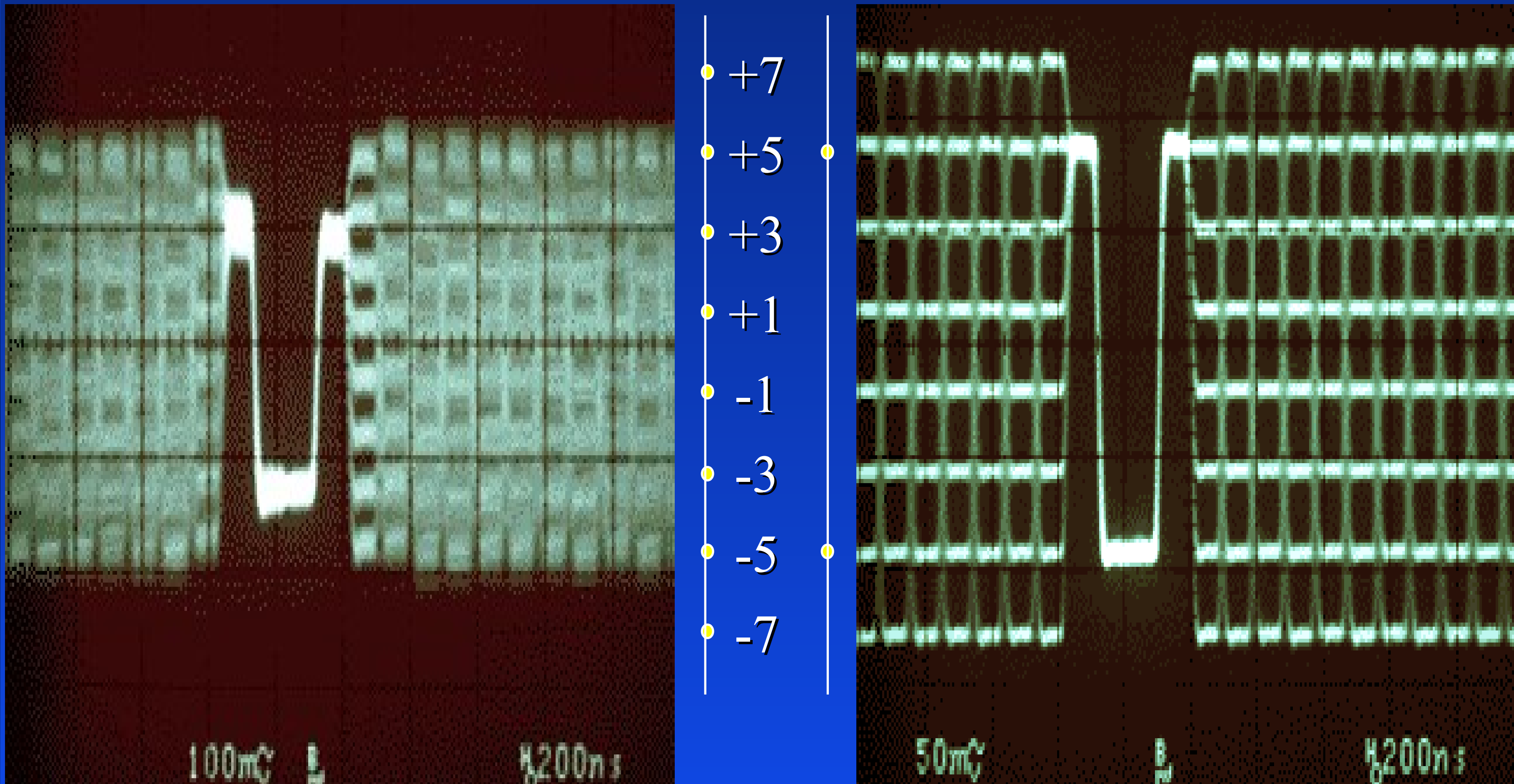
Digital Modulation - 8-AM



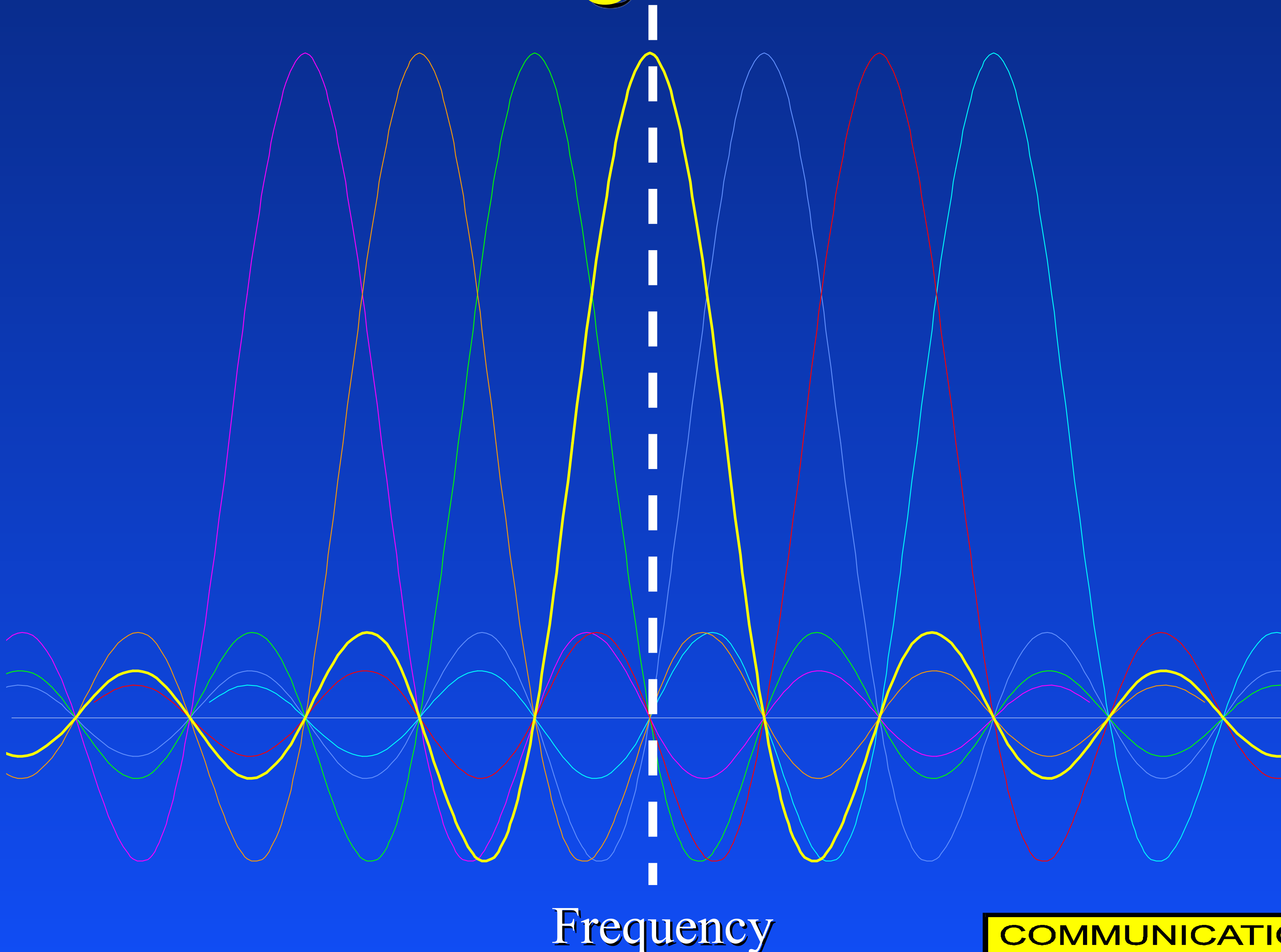
Before Equaliser

After Equaliser

8-VSB - Coaxial Direct Feed through Tuner on Channel 8 VHF

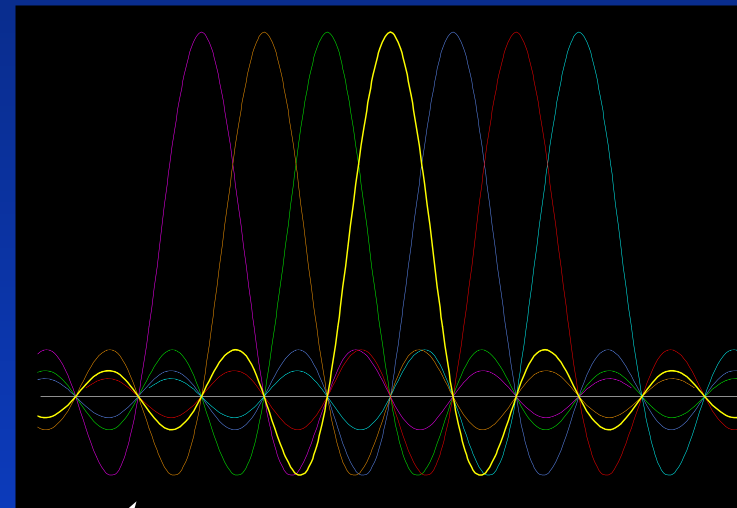
3 Bits/Symbol

COFDM - Orthogonal Carriers

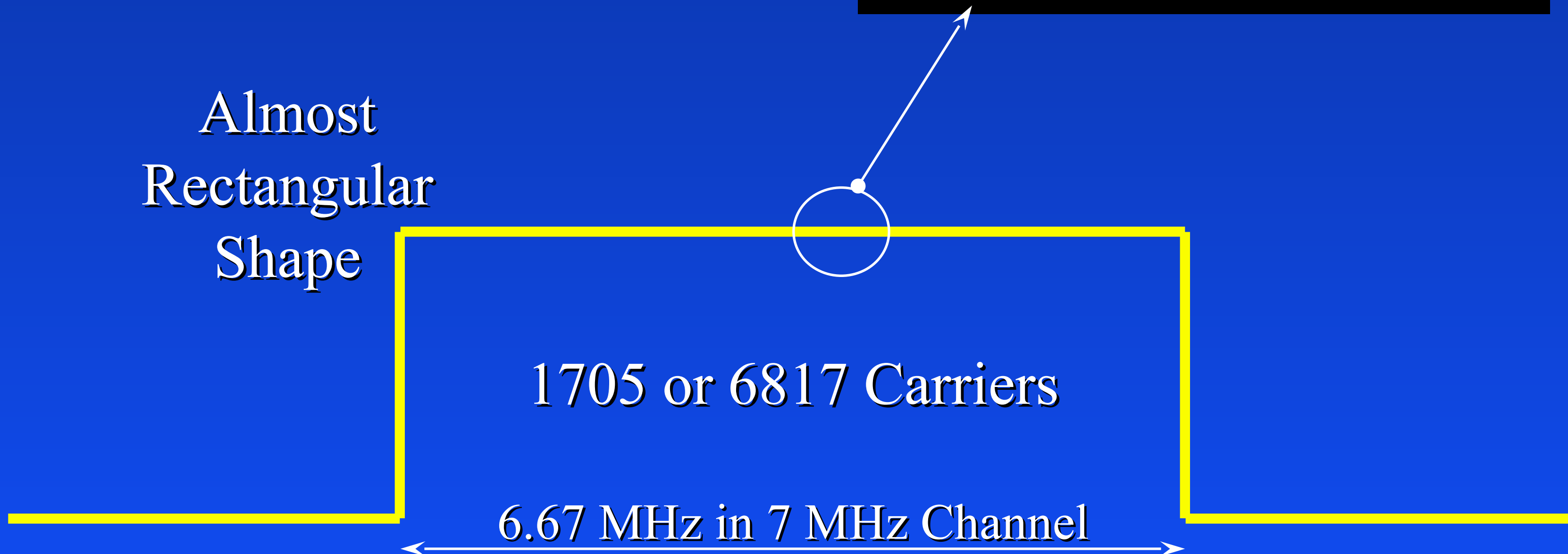


Spectrum of COFDM DTTB

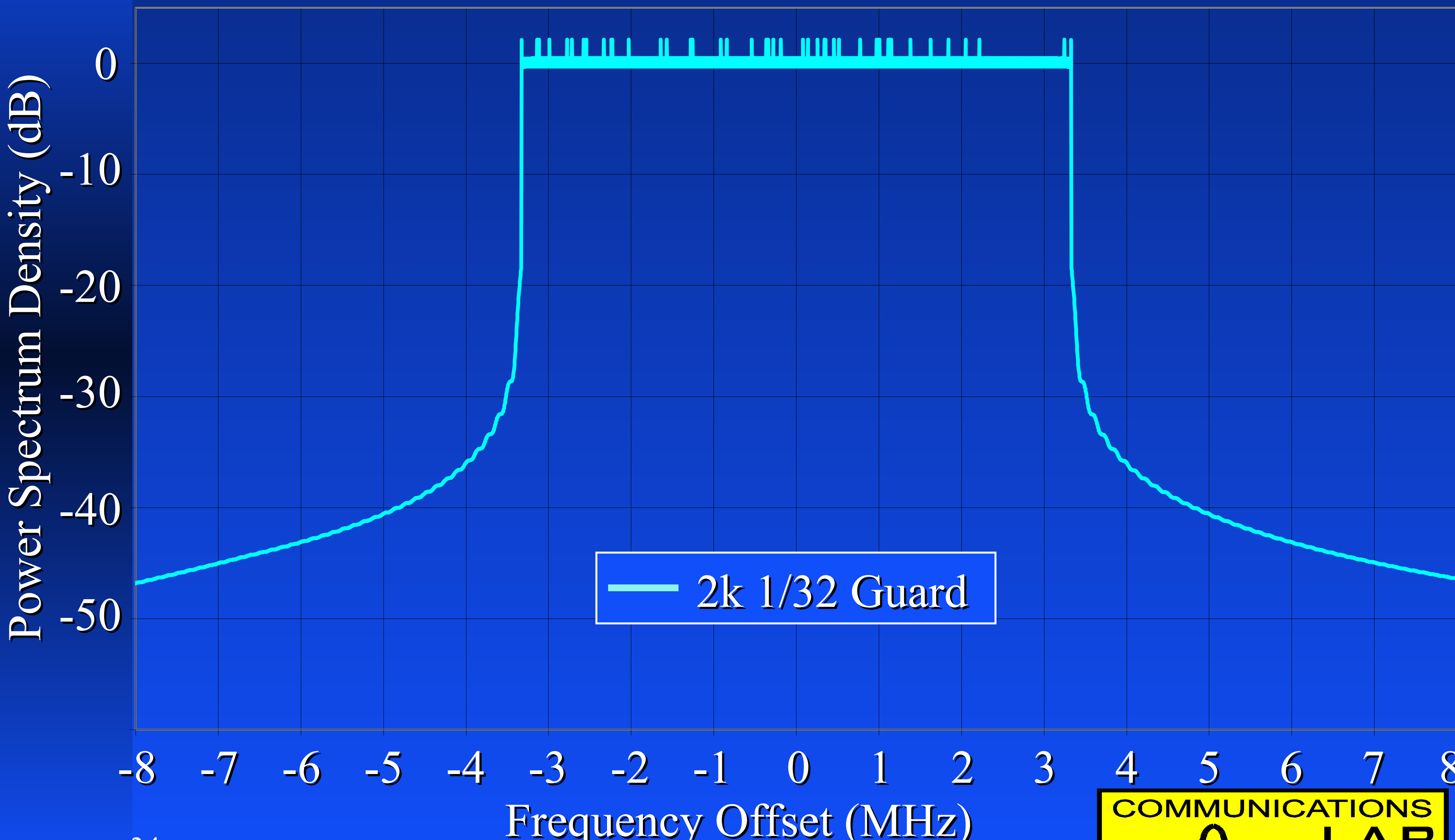
Carrier Spacing
2k Mode 3.91 kHz
8k Mode 0.98 kHz



Almost
Rectangular
Shape



7 MHz COFDM Modulator Spectrum



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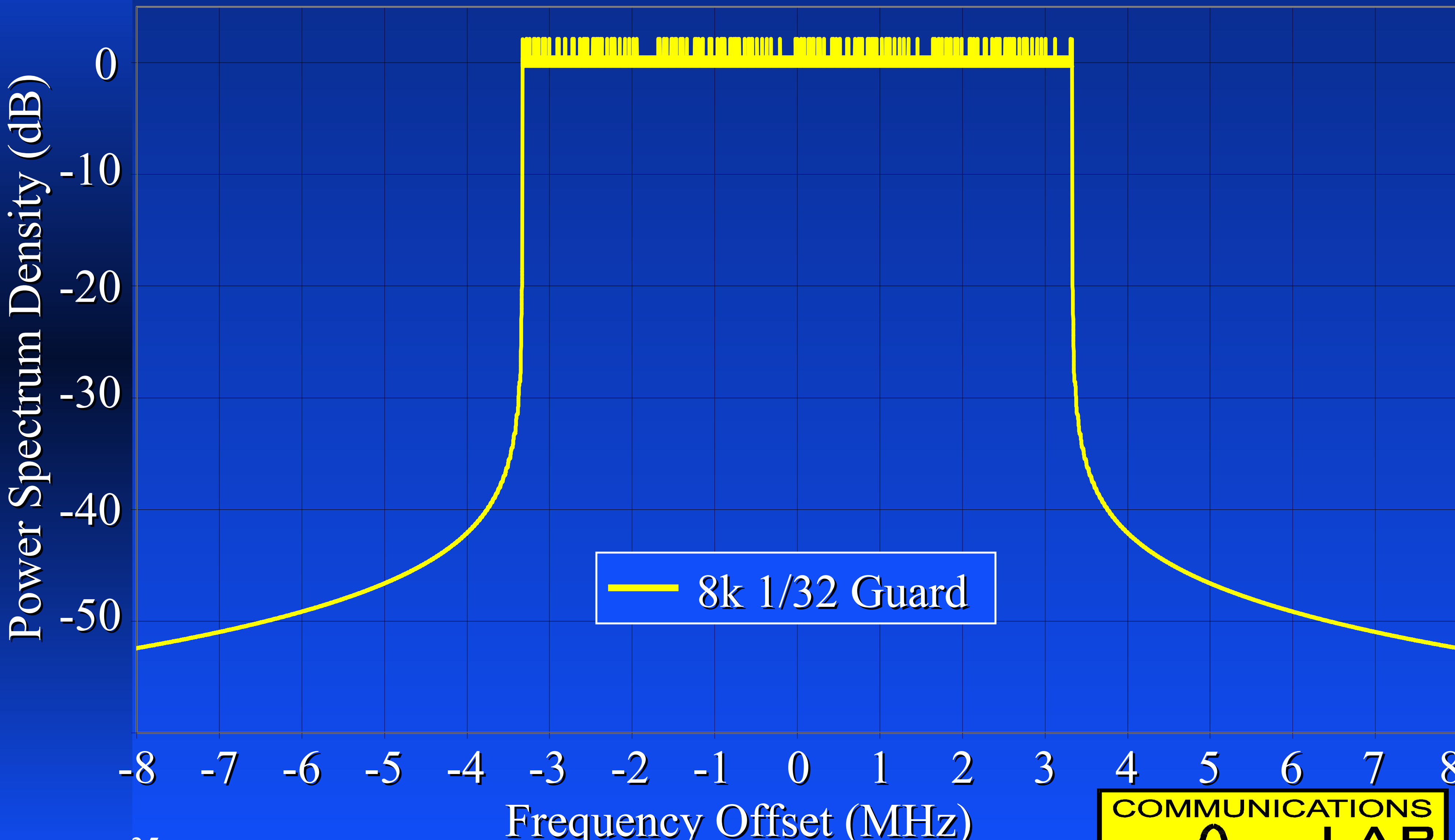
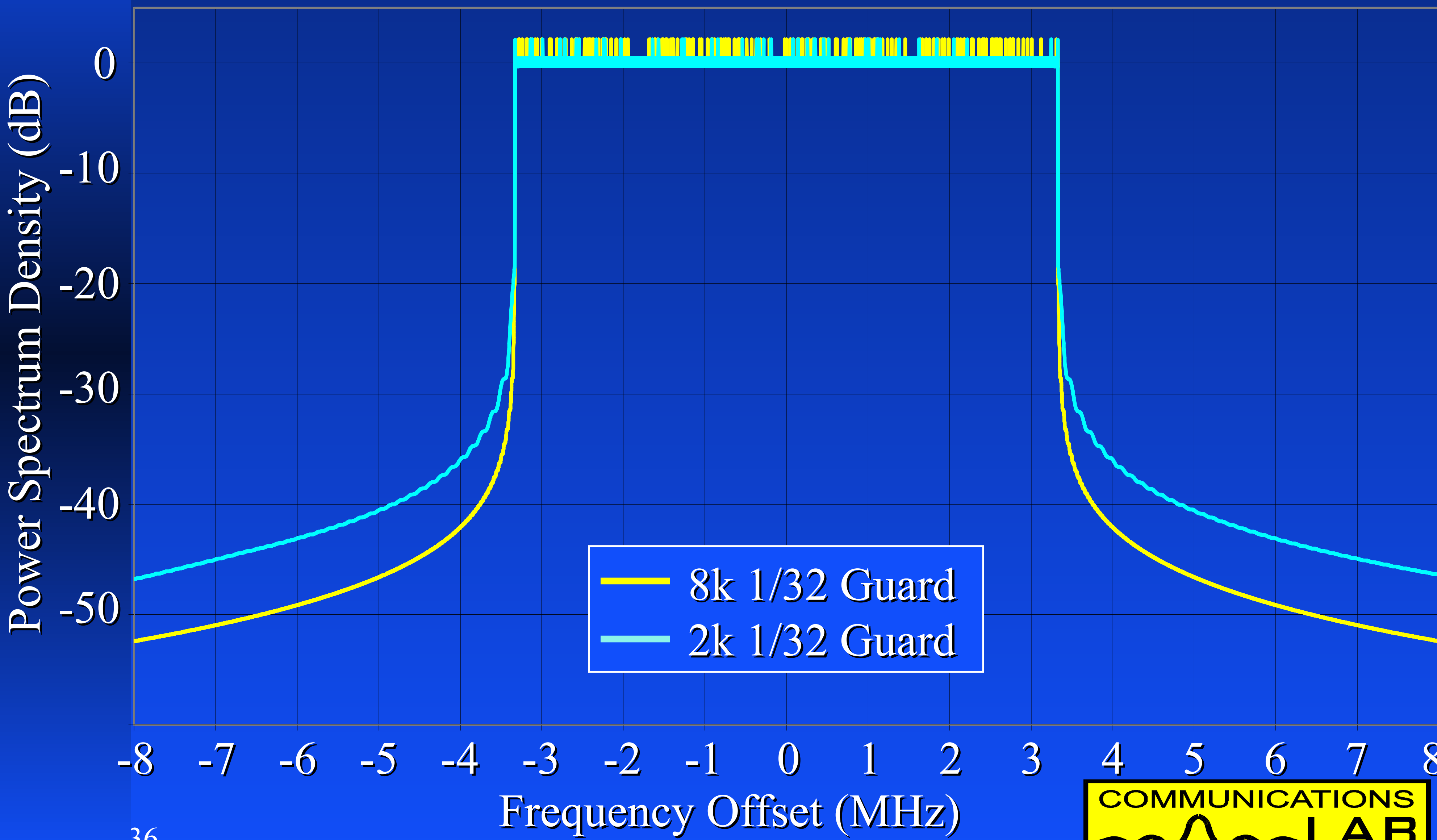
7 MHz COFDM Modulator Spectrum



7 MHz COFDM Modulator Spectrum



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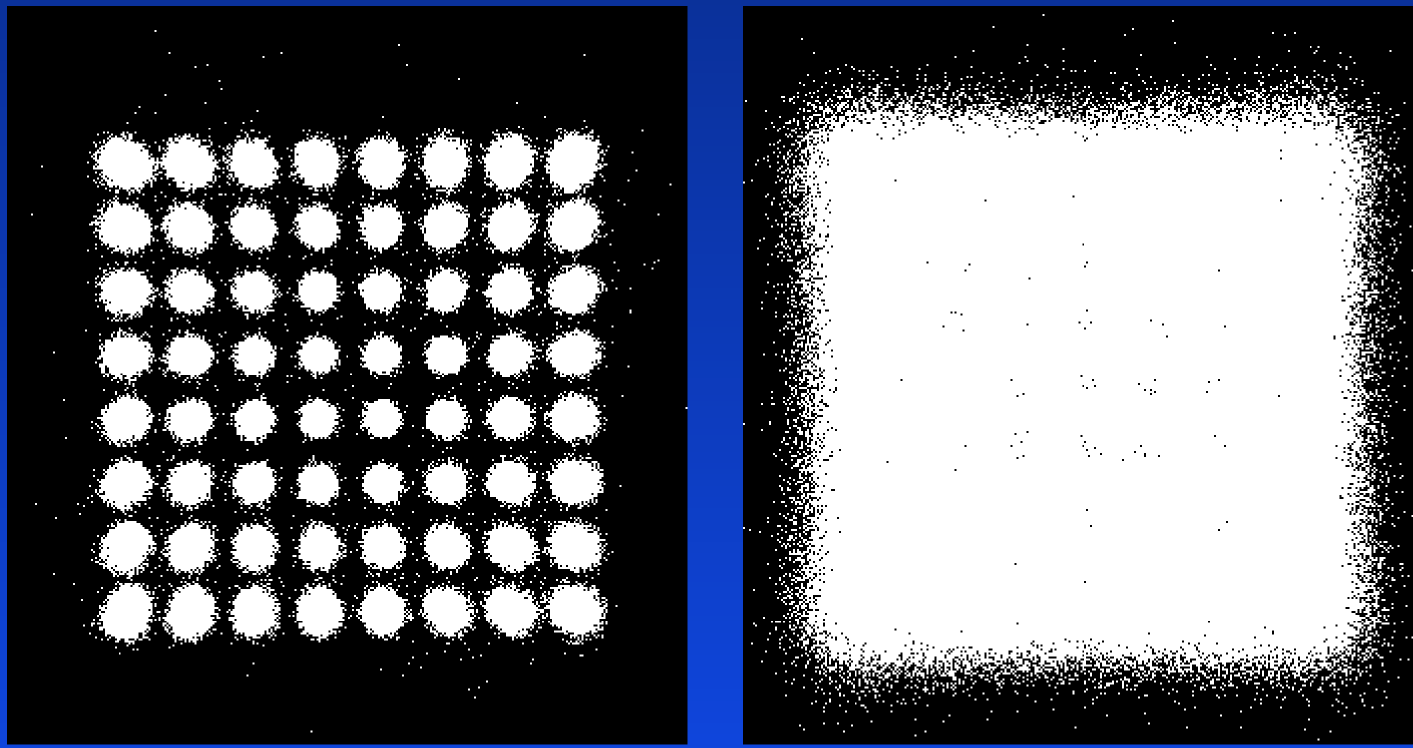
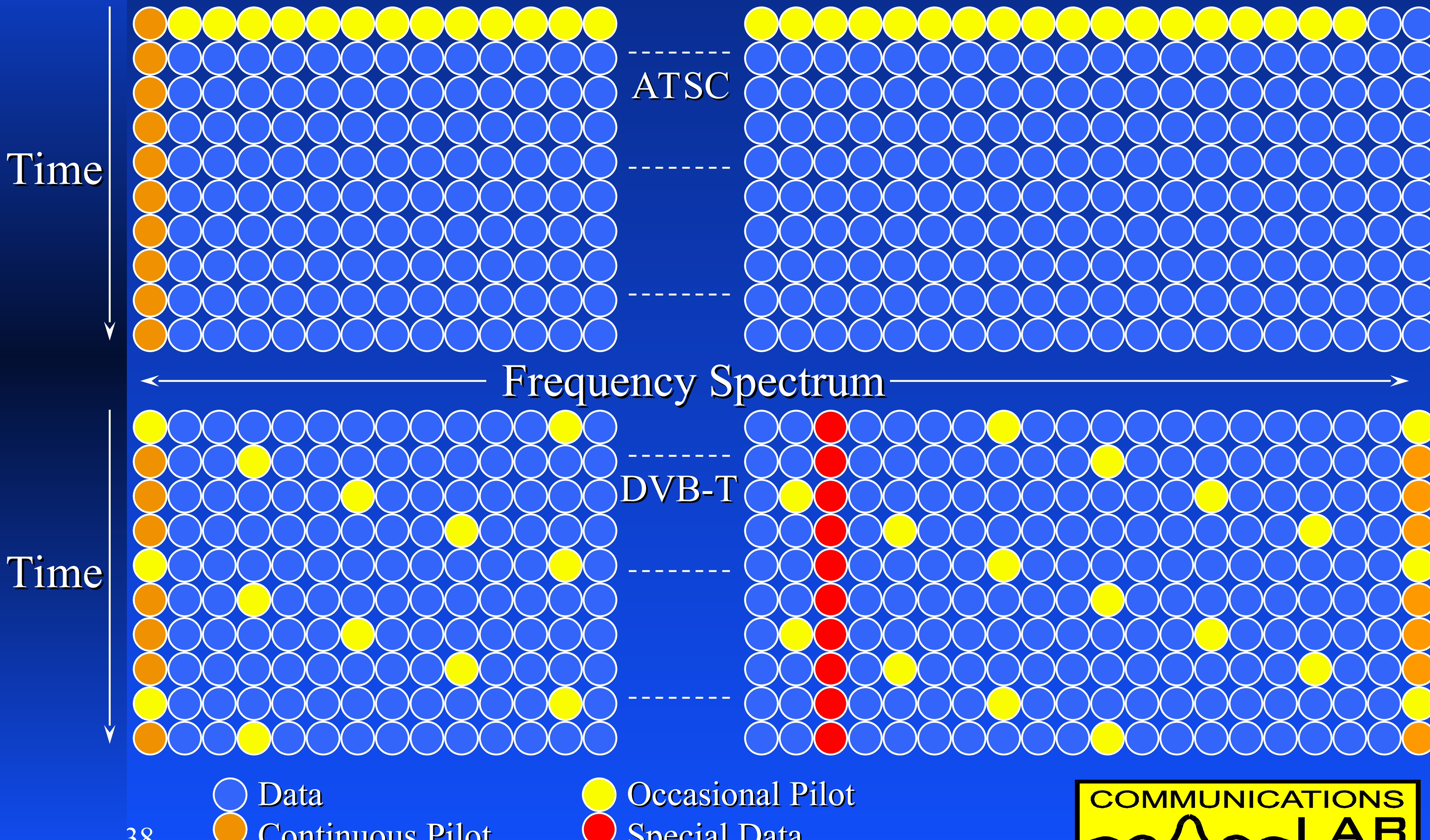
64-QAM - Perfect & Failure



Channel Estimation & Equalisation



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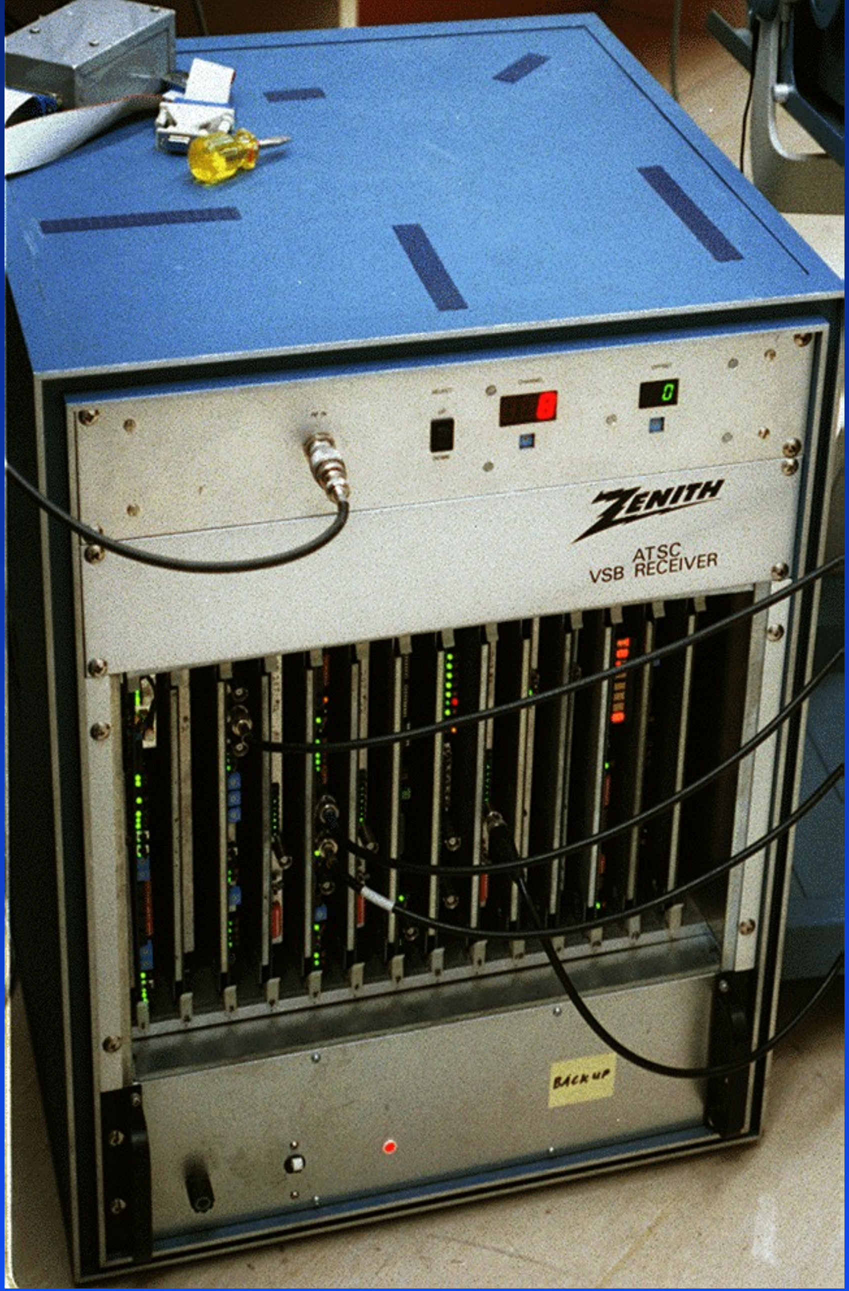

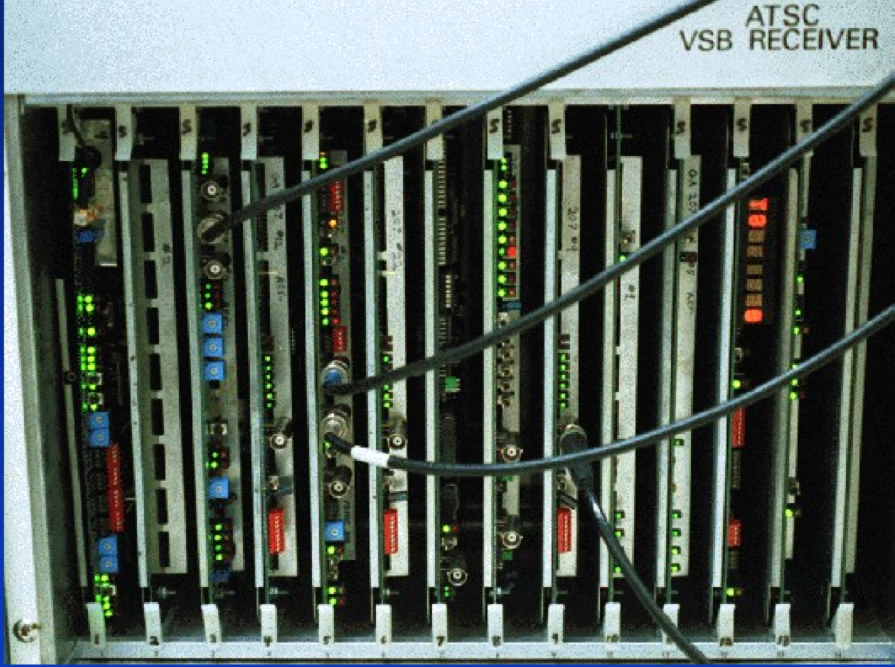

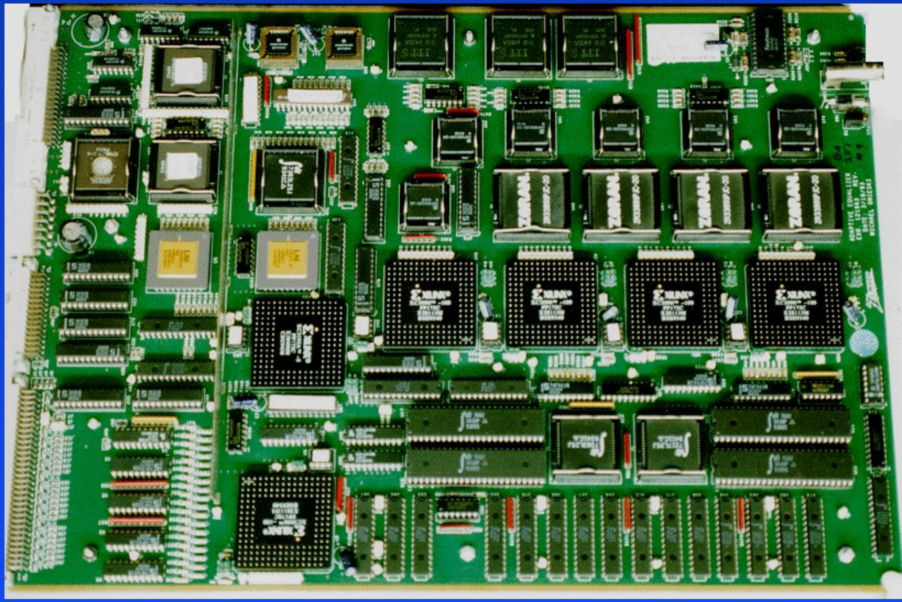

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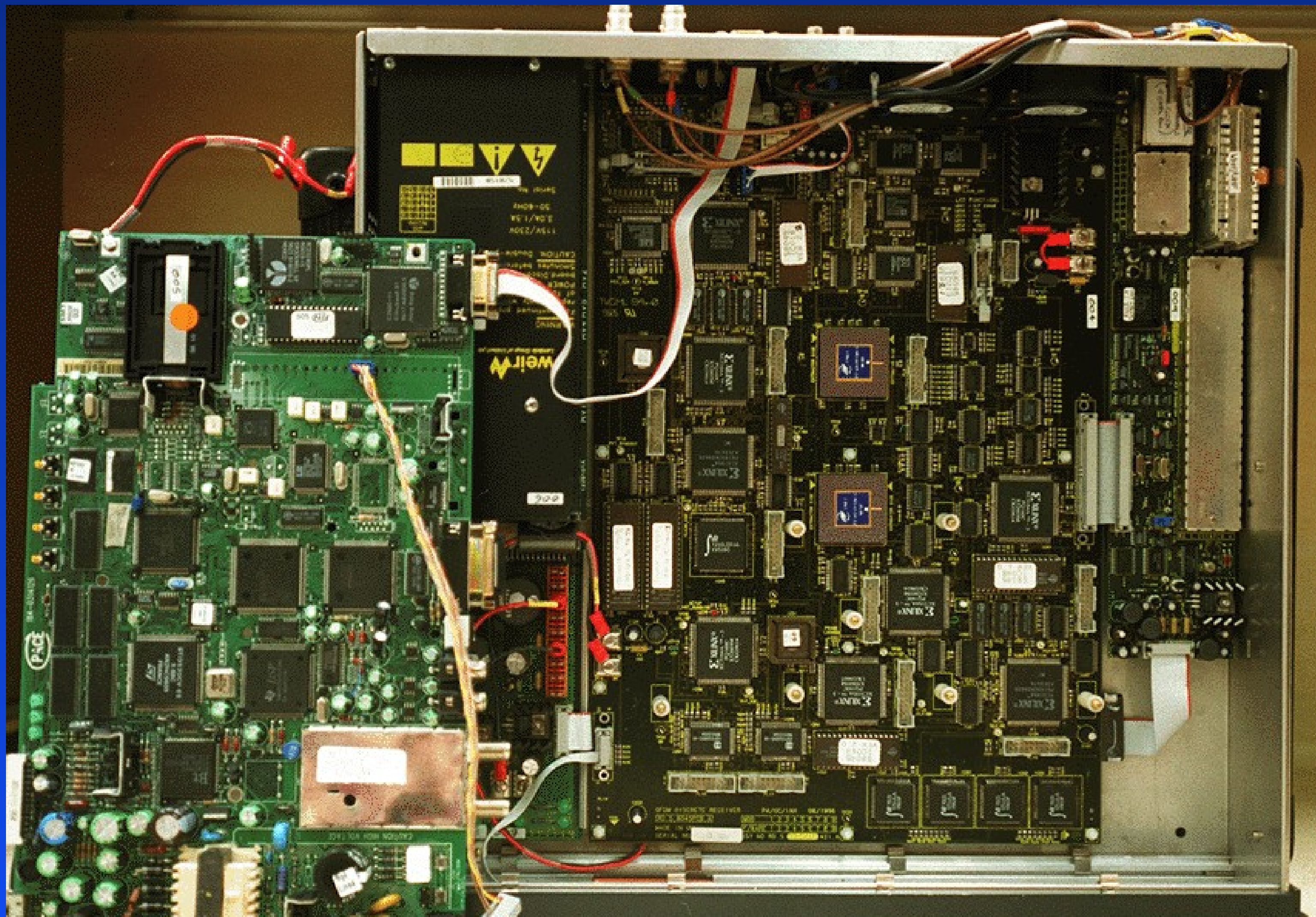
COFDM - Commercial Receiver

- News Data Systems - System 3000

COFDM - Current Hardware



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Australian DTTB System Evaluation

- Australia has a Unique Broadcasting Environment.
- Australian TV channels are 7 MHz wide on both VHF & UHF
- We use PAL-B with sound system G
- Any DTTB system will need to be configured to suit the existing television broadcasting environment during the transition period
- Digital has to Fit in with PAL-B

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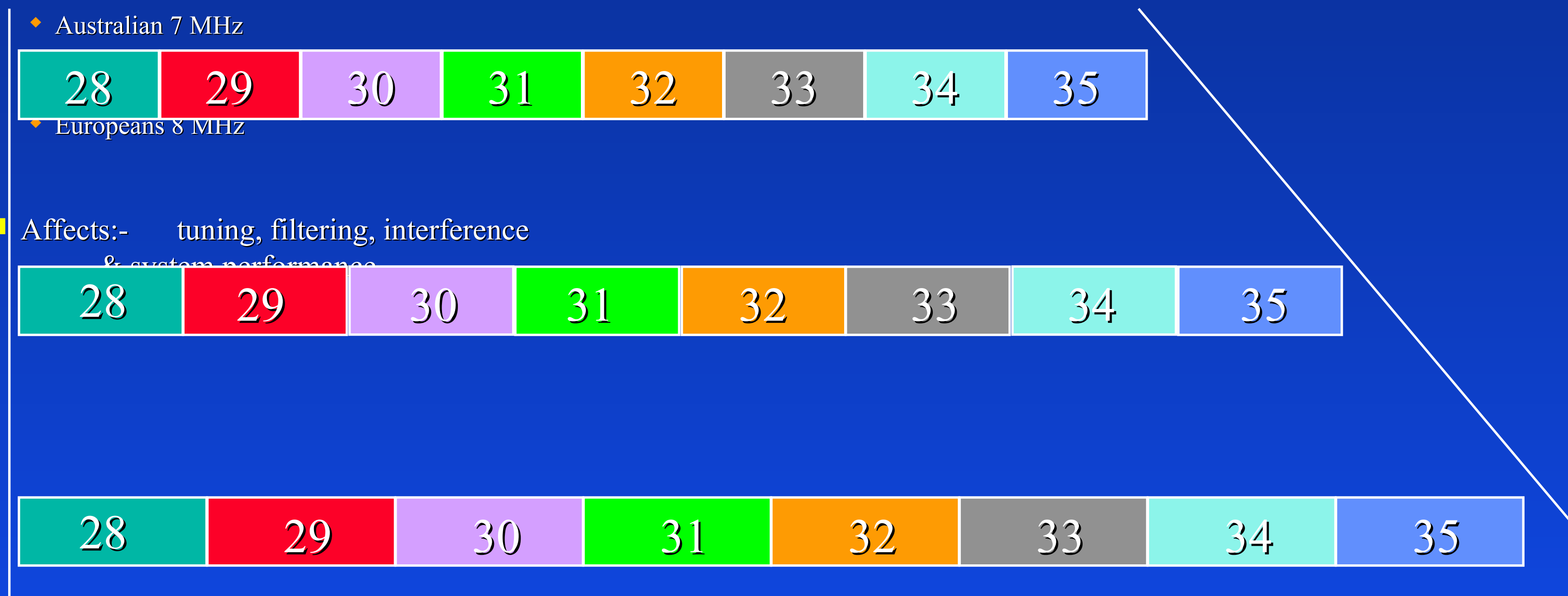
Digital Has to Fit In With PAL

- World TV channel bandwidths vary
  - USA / Japan 6 MHz
  - Australian 7 MHz
  - Europeans 8 MHz
- Affects:- tuning, filtering, interference & system performance

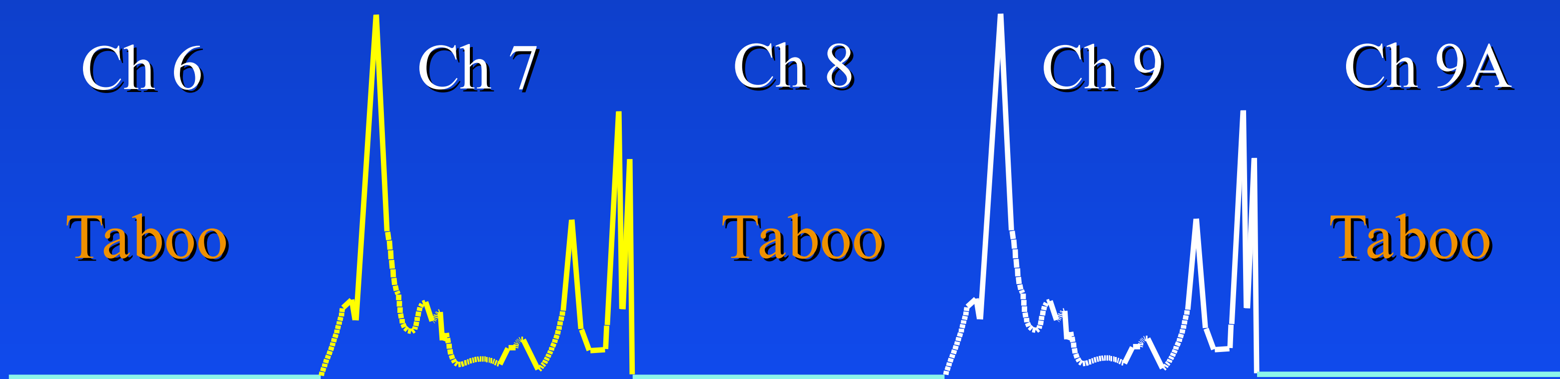


Digital Has to Fit In With PAL

- Digital television system development is focused in Europe & USA
  - The systems standards are designed to meet the needs of the developers
  - They focus on their countries needs first
  - Australian input is through standards organisations such as the ITU-R, DVB & ATSC
  - Australia is looking for a system to satisfy its OWN Future Broadcasting Needs

Channel Spacing

- Existing analog TV channels are spaced so they do not interfere with each other.
- Gap between PAL TV services
  - VHF 1 channel
  - UHF 2 channels
- Digital TV can make use of these gaps



VHF Television Spectrum

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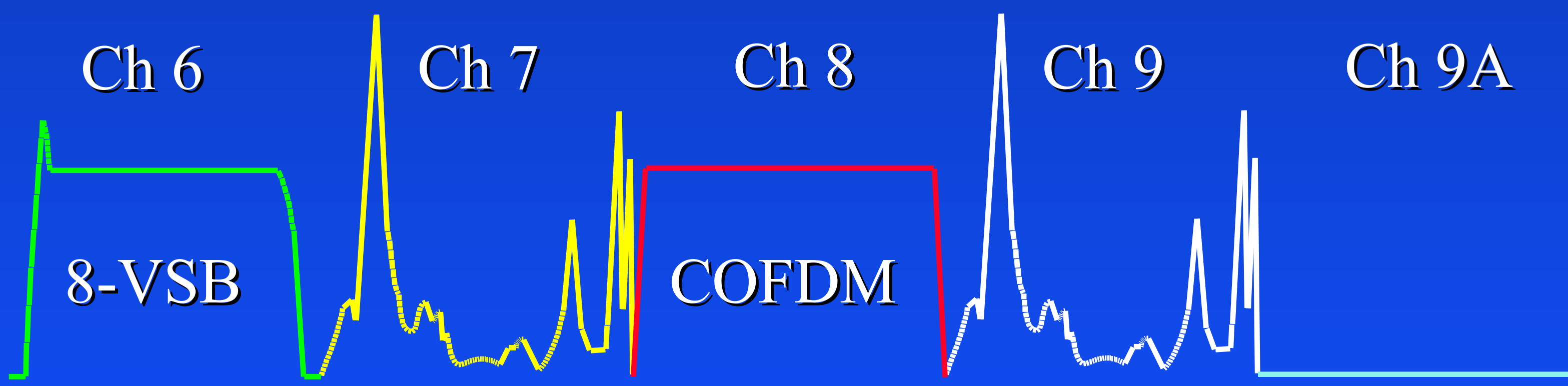
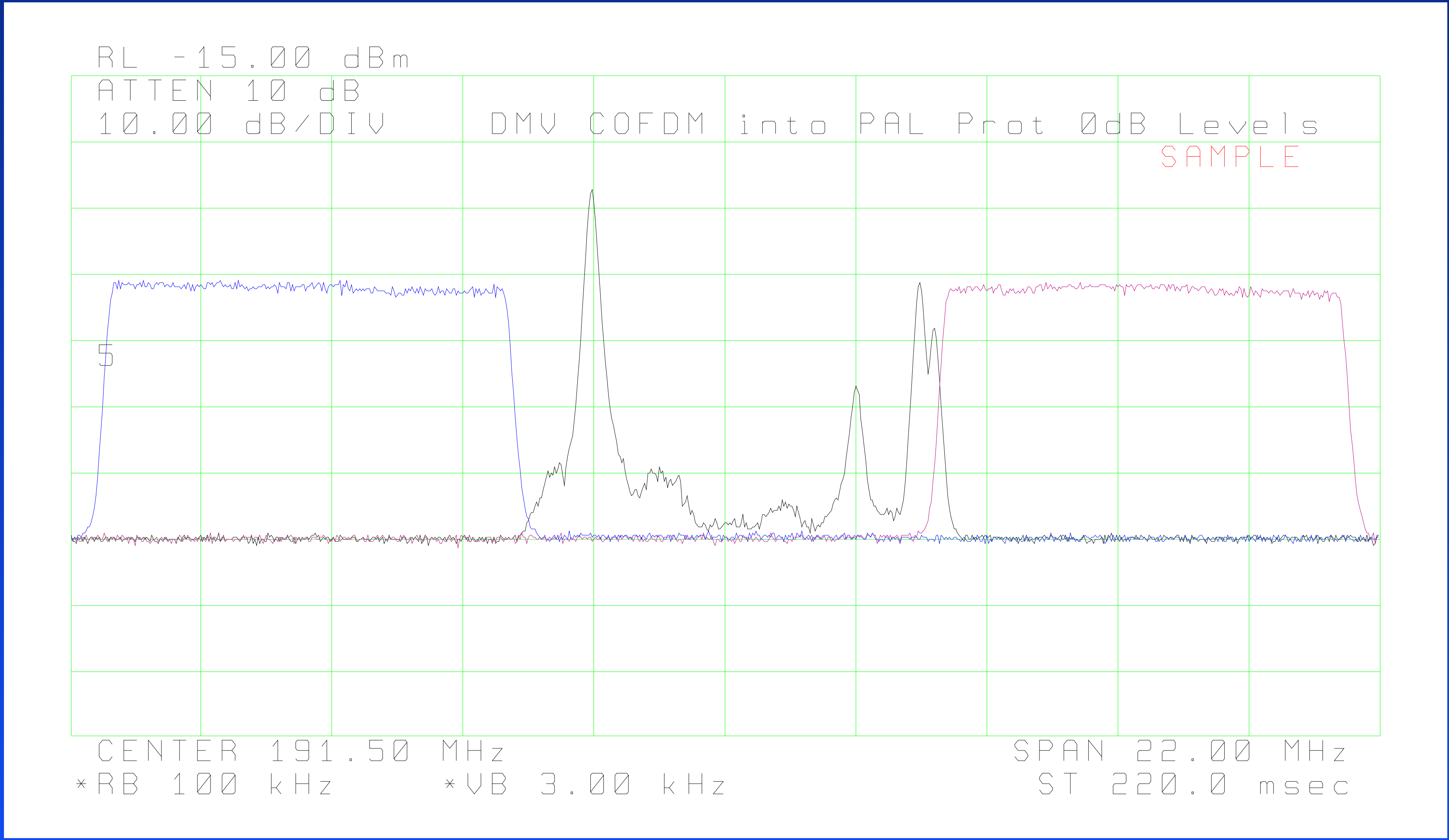
Digital Challenges

- Digital TV must co-exist with existing PAL services
  - DTV operates at lower power
  - DTV copes higher interference levels
  - Share transmission infra-structure
  - DTV needs different planning methods



VHF Television Spectrum

DTTB & PAL in Adjacent Channels



Digital Service Area Planning

- Analog TV has a slow gradual failure
  - Existing PAL service was planned for:
    50 % availability at
    50 % of locations
- Digital TV has a “cliff edge” failure
  - Digital TV needs planning for:
    90% availability at:
    70% of Rural locations
    85% of Suburban locations
    95% of Urban locations

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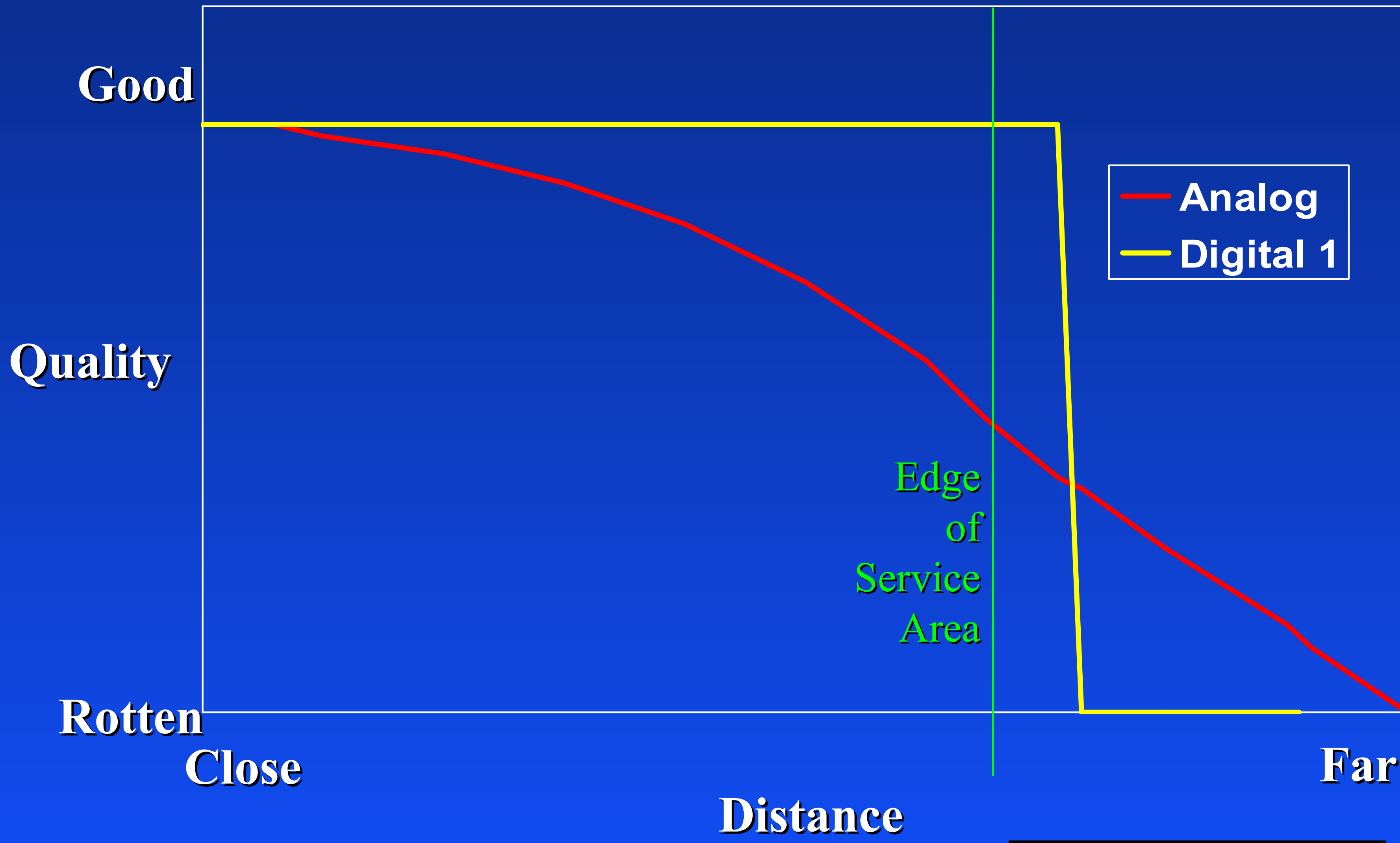
TV System Failure Characteristic



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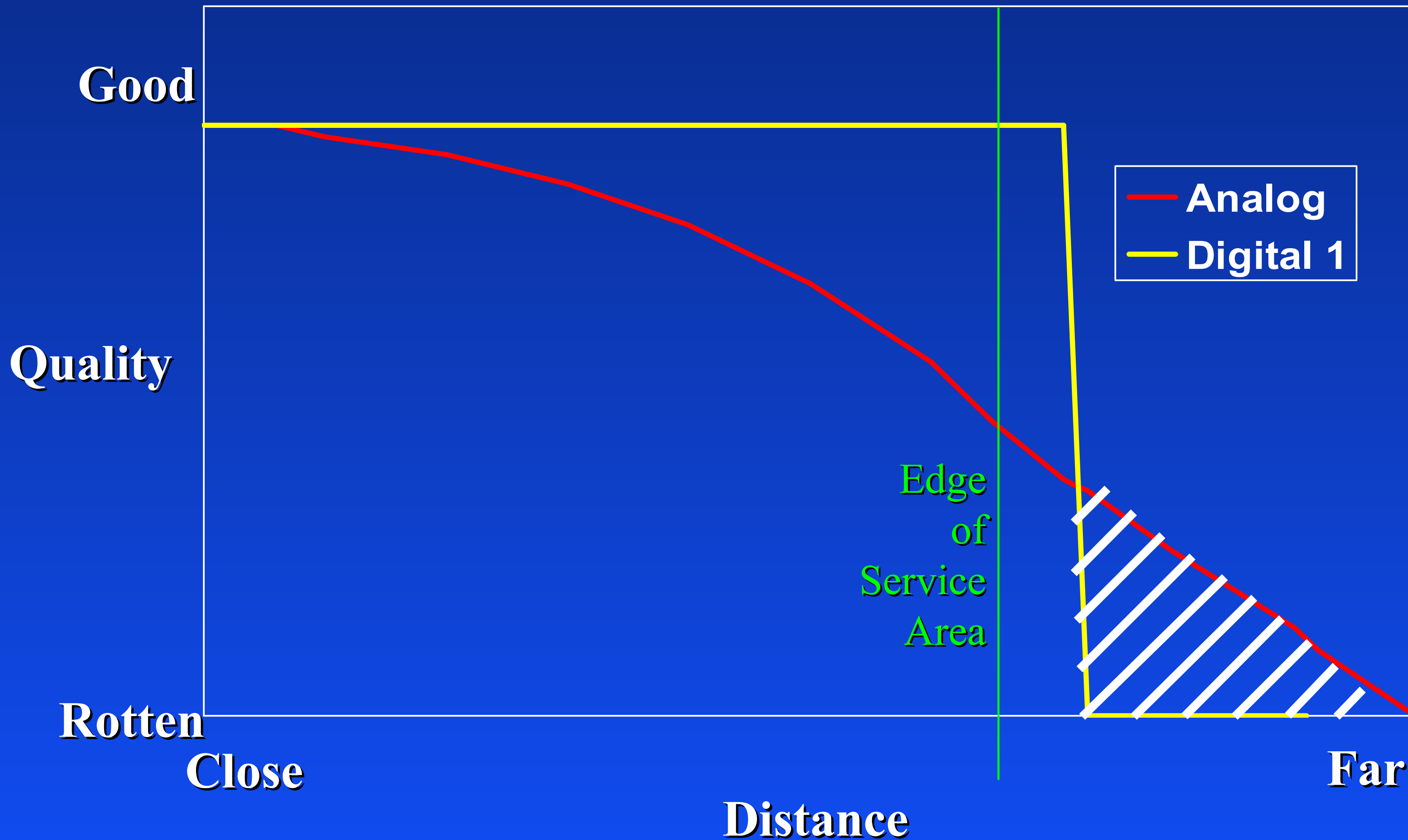
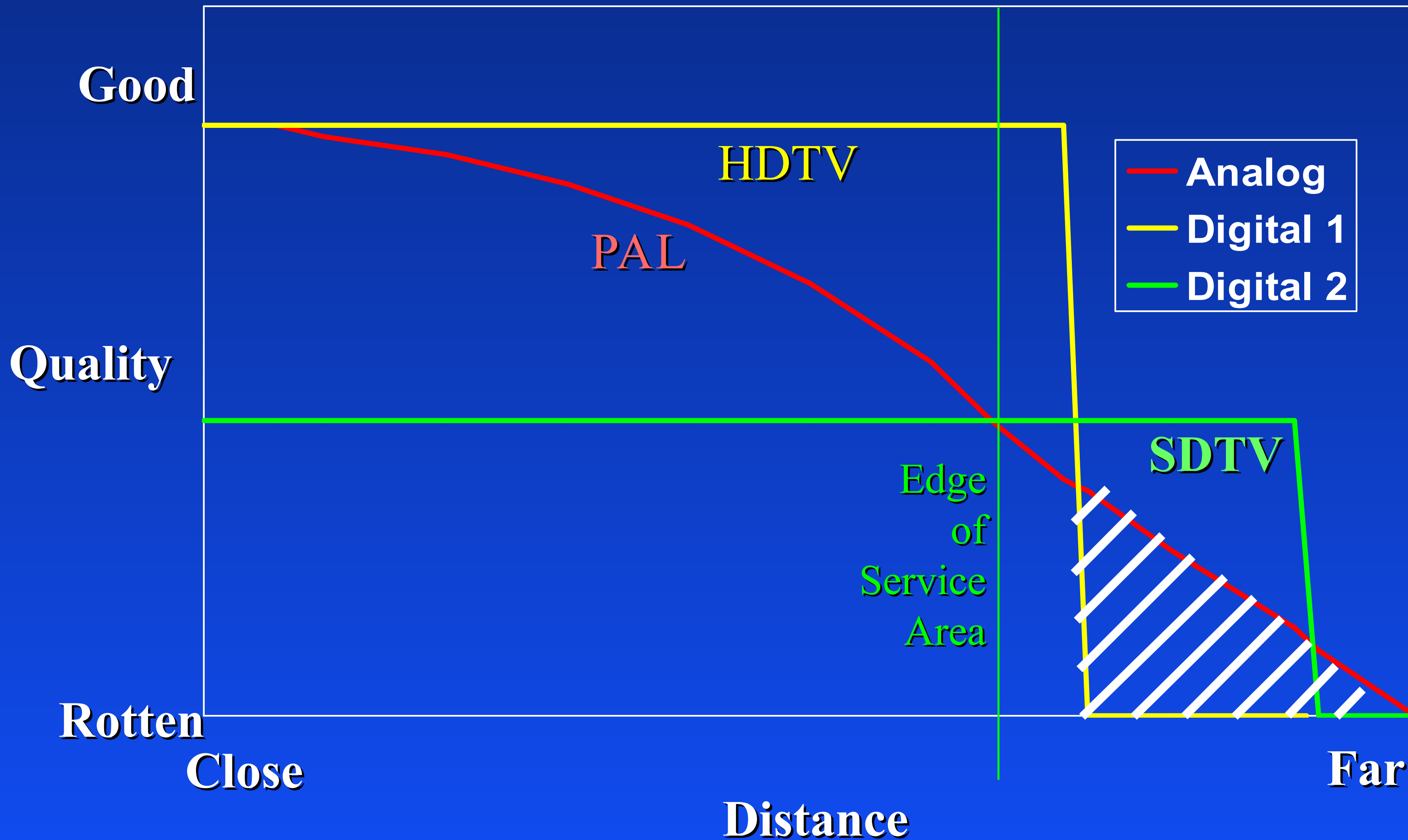
TV System Failure Characteristic



TV System Failure Characteristic



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Digital Provides New Concepts

- Single frequency networks (SFNs) can help solve difficult coverage situations
  - SFNs allow the reuse of a transmission frequency many times in the same area so long as exactly the same program is carried
  - Allows lower power operation
  - Better shaping of coverage
  - Improved service availability
  - Better spectrum efficiency

Australian Digital Testing

- Communications laboratory function is to advise the Australian government on new communications technology
- 1990 - L-band Eureka 147 DAB experiments including coverage, gap fillers & SFNs
- 1994 - CCI & ACI testing of PAL receivers using noise to simulate digital transmissions.
- 1996 HD-divine COFDM modem
  - BER & interference testing

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1996 DVB-T Demonstration

- NDS built a VHF 7 MHz receiver in 4 weeks
- Complete 2K DVB-T transmission system loaned to FACTS
- November 1996 - DVB-T demonstrated at ITU-R TG 11/3 final meeting in Sydney
- Minister switched on first Australian SDTV 16:9 digital program at FACTS dinner
- Transmission system remained in Australia for further testing.

Laboratory Testing of DVB-T

- Testing commenced March 1997
- Automated test system used to minimise error

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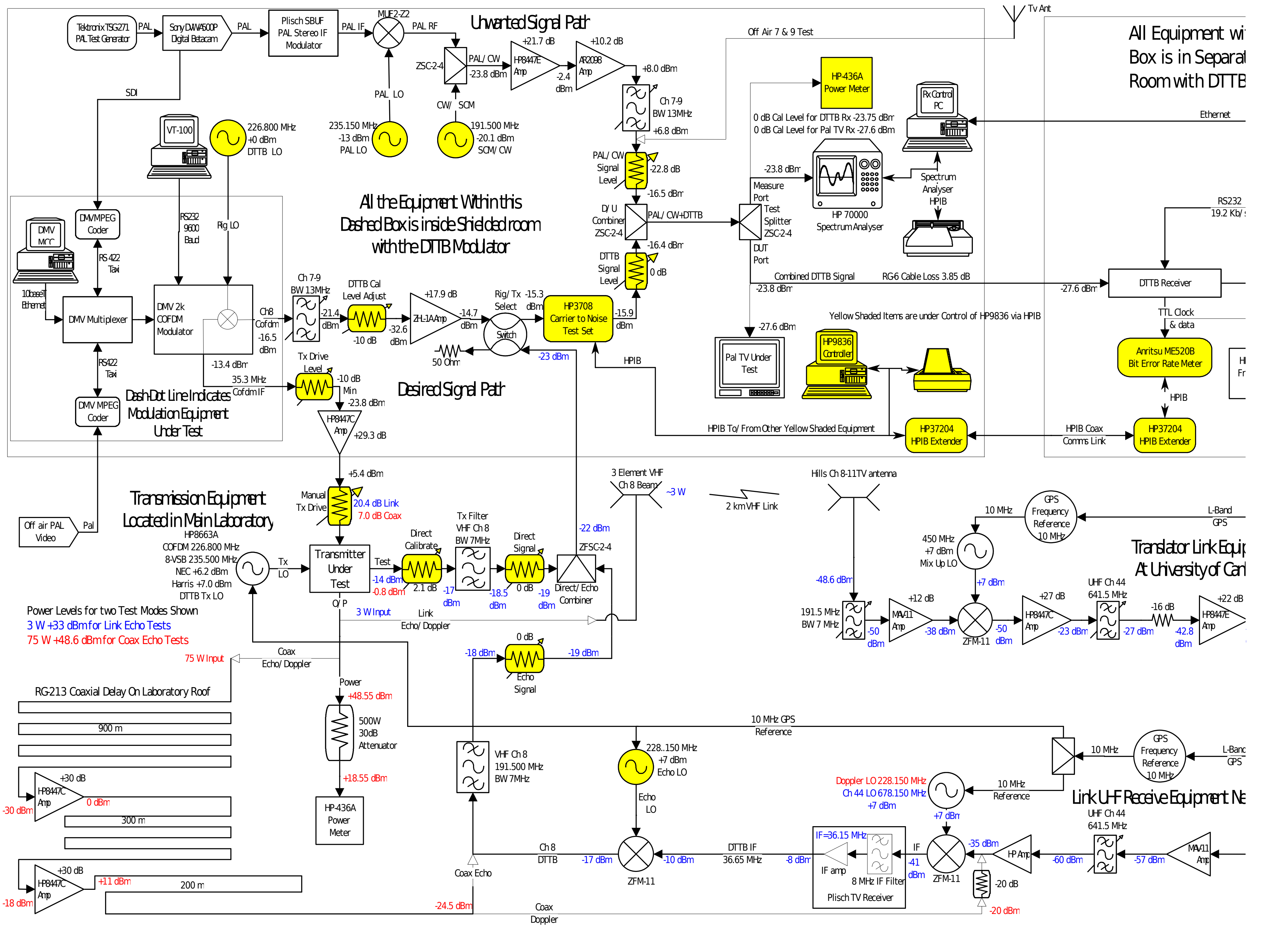
Laboratory Testing of DVB-T

- Digital failure primarily determined by bit error rate measurement
- Analog system interference assessed by subjective evaluation using Limit of Perceptibility (LOP) and Subjective Comparison Method (SCM) techniques.
- Tests designed to evaluate Australian conditions

ATSC Testing

- During DVB-T tests efforts were made to obtain & evaluate the ATSC system
- ATSC system was made available over 4 week period in July 1997
- The same measurements preformed on DVB-T were repeated for ATSC.
- Australian operational conditions were used throughout treating the 6 MHz ATSC system the same as a 7 MHz system.



Unwanted Signal Path
Tektronix TSG271 PAL Test Generator
PAL
Sony DVW-A500P Digital Betacam
PAL
Plisch SBUF PAL Stereo IF Modulator
PAL IF
MUF2-Z2
PAL RF
ZSC-2-4
PAL/ CW
-23.8 dBm
+21.7 dB
HP8447E Amp
-2.4 dBm
+10.2 dB
AR2098 Amp
+8.0 dBm
Ch 7-9 BW 13MHz
+6.8 dBm
Tv Ant
Off Air 7 & 9 Test
All Equipment wi
Box is in Separat
Room with DTTB
HP-436A Power Meter
Rx Control PC
Ethernet
0 dB Cal Level for DTTB Rx -23.75 dBm
0 dB Cal Level for Pal TV Rx -27.6 dBm
SDI
VT-100
226.800 MHz
+0 dBm
DTTB LO
235.150 MHz
-13 dBm
PAL LO
PAL LO
CW/ SCM
191.500 MHz
-20.1 dBm
SCM/ CW
PAL/ CW Signal Level
-22.8 dB
-16.5 dBm
-23.8 dBm
Measure Port
Test Splitter ZSC-2-4
DUT Port
HP 70000 Spectrum Analyser
Spectrum Analyser HPIB
D/ U Combiner ZSC-2-4
PAL/ CW+DTTB
-16.4 dBm
DTTB Signal Level
0 dB
All the Equipment Within this Dashed Box is inside Shielded room with the DTTB Modulator
DMV MCC
DMV MPEG Coder
RS232 9600 Baud
Rig LO
RS 422 Taxi
10baseT Ethernet
DMV Multiplexer
DMV 2k COFDM Modulator
Ch8 Cofdm
-16.5 dBm
Ch 7-9 BW 13MHz
-21.4 dBm
DTTB Cal Level Adjust
-10 dB
-32.6 dBm
+17.9 dB
ZHL-1A Amp
-14.7 dBm
Rig/ Tx Select
Switch
-15.3 dBm
HP3708 Carrier to Noise Test Set
-15.9 dBm
50 Ohm
-23 dBm
HPIB
Combined DTTB Signal
RG6 Cable Loss 3.85 dB
-23.8 dBm
-27.6 dBm
DTTB Receiver
RS232 19.2 Kb/ s
TTL Clock & data
Yellow Shaded Items are under Control of HP9836 via HPIB
-27.6 dBm
Pal TV Under Test
HP9836 Controller
Anritsu ME520B Bit Error Rate Meter
HPIB
RS422 Taxi
-13.4 dBm
35.3 MHz Cofdm IF
Tx Drive Level
-10 dB Min
-23.8 dBm
Dash-Dot Line Indicates Modulation Equipment Under Test
Desired Signal Path
DMV MPEG Coder
HP8447C Amp
+29.3 dB
HPIB To/ From Other Yellow Shaded Equipment
HP37204 HPIB Extender
HPIB Coax Comms Link
HP37204 HPIB Extender
+5.4 dBm
Manual Tx Drive
20.4 dB Link
7.0 dB Coax
Transmission Equipment Located in Main Laboratory
Off air PAL Video
Pal
HP8663A
COFDM 226.800 MHz
8-VSB 235.500 MHz
NEC +6.2 dBm
Harris +7.0 dBm
DTTB Tx LO
Tx LO
Transmitter Under Test
O/ P
Test
-14 dBm
-0.8 dBm
Direct Calibrate
2.1 dB
Tx Filter VHF Ch 8 BW 7MHz
-17 dBm
Direct Signal
-18.5 dBm
0 dB
-19 dBm
-22 dBm
ZFSC-2-4
Direct/ Echo Combiner
3 Element VHF Ch 8 Beam
~3 W
2 km VHF Link
Hills Ch 8-11 TV antenna
GPS Frequency Reference 10 MHz
10 MHz
L-Band GPS
450 MHz
+7 dBm
Mix Up LO
Translator Link Equip
At University of Can
-48.6 dBm
+7 dBm
191.5 MHz BW 7 MHz
-50 dBm
+12 dB
MAV11 Amp
-38 dBm
ZFM-11
-50 dBm
+27 dB
HP8447C Amp
-23 dBm
UHF Ch 44 641.5 MHz
-27 dBm
-16 dB
-42.8 dBm
+22 dB
HP8447E Amp
Power Levels for two Test Modes Shown
3 W +33 dBm for Link Echo Tests
75 W +48.6 dBm for Coax Echo Tests
3 W Input
Link Echo/ Doppler
75 W Input
Coax Echo/ Doppler
0 dB
-18 dBm
-19 dBm
Echo Signal
Power
+48.55 dBm
500W 30dB Attenuator
+18.55 dBm
HP-436A Power Meter
RG-213 Coaxial Delay On Laboratory Roof
900 m
+30 dB
HP8447C Amp
-30 dBm
0 dBm
300 m
+30 dB
HP8447C Amp
-18 dBm
+11 dBm
200 m
-24.5 dBm
Coax Echo
Coax Doppler
10 MHz GPS Reference
VHF Ch 8 191.500 MHz BW 7MHz
228..150 MHz
+7 dBm
Echo LO
Echo LO
Ch 8 DTTB
-17 dBm
ZFM-11
-10 dBm
DTTB IF 36.65 MHz
-8 dBm
IF=36.15 MHz
IF amp
8 MHz IF Filter
Plisch TV Receiver
IF
-41 dBm
ZFM-11
Doppler LO 228.150 MHz
Ch 44 LO 678.150 MHz
+7 dBm
+7 dBm
10 MHz Reference
10 MHz
GPS Frequency Reference 10 MHz
L-Band GPS
Link UHF Receive Equipment Ne
UHF Ch 44 641.5 MHz
-35 dBm
HP Amp
-60 dBm
-57 dBm
MAV11 Amp
-20 dB
-20 dBm

Laboratory Tests - Test Rig

C/N Set & Attenuators   EUT   PAL & CW

Control Computer   Domestic Television Receiver   Modulator Control Computers   Spectrum Analysers   Plot & Printing

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Test Rig - Modulation Equipment

Power Meter

RF LO

COFDM
Modulator

MPEG Mux

MPEG Mux

MPEG Encoder

MPEG Encoder

PAL & CW
Interference
Generators

8-VSB
Modulator

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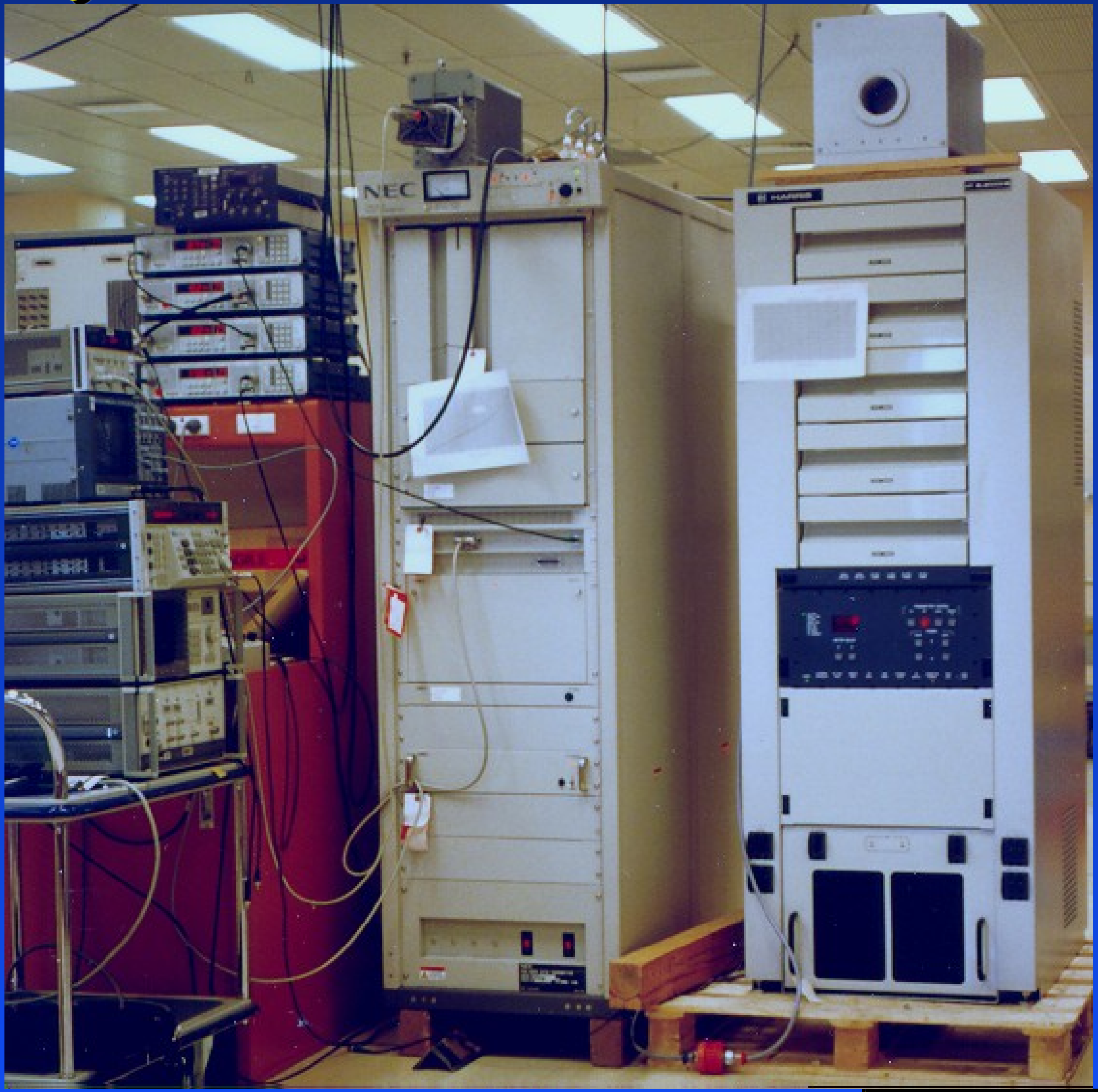
Laboratory Tests - Transmitters



Echo Combiner

Power Meter

Digital CRO

Tx LO

Spectrum Analyser

Loads

Harris 1 kW Tx

Harris Exciter

NEC 200 W Tx

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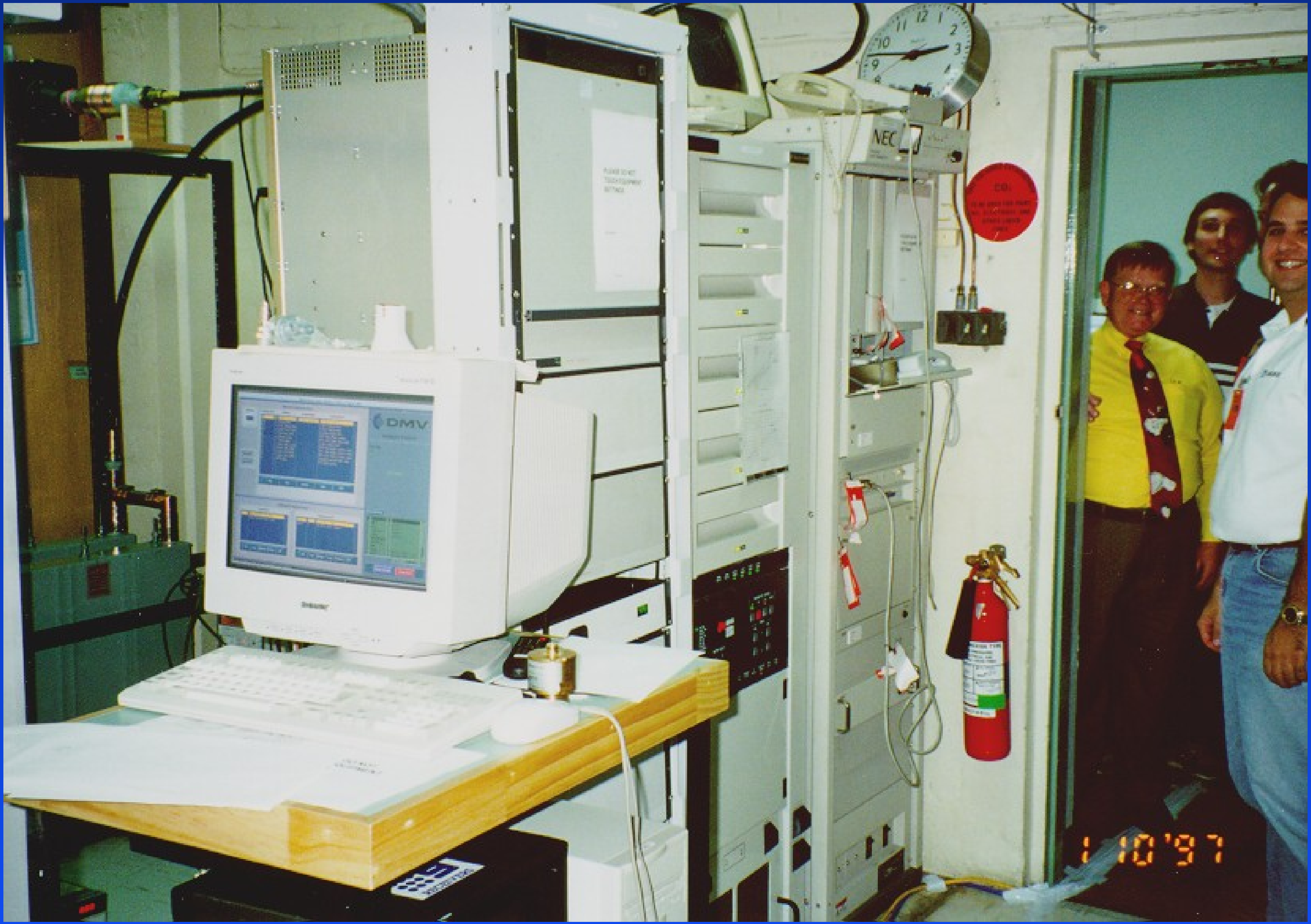
Digital Transmitters TCN-9 Sydney



Field Trial & Demonstration

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Lab Tests - VHF/UHF Transposer

Power Supply

VHF Input Filter

RF Amp

RF LO

10 Watt UHF Amplifier

Level Adjust

UHF Amps

UHF BPF Filter

Mixer

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Order of Measurements

- FACTS Advanced TV Specialists Group directed the priority of Testing
- Laboratory Tests First
  1. DTTB into PAL protection
  2. DTTB System Parameters
  3. PAL into DTTB protection
  4. Other Interferers & Degradations
- Field Tests Later

Main Results - Lab Tests

- C/N ATSC 4 dB better than DVB-T.
  This Advantage offset by Poor Noise Figure
- DVB-T is better than ATSC for Multipath
- ATSC is better than DVB-T for Impulse Noise
- ATSC cannot handle Flutter or Doppler Echoes
- ATSC is very sensitive to Transmission system impairments and IF translation
- DVB-T is better at handling Co-channel PAL
- DVB-T is better rejecting on channel interference (CW)

General Parameters - Aust Tests

Parameter	DVB-T	ATSC
Data Payload	19.35 Mb/s	19.39 Mb/s
Carriers	1705	1
Symbol Time	256 us	93 ns
Time Interleaving	1 Symbol	4 ms
Reed Solomon code rate	188/204	187/207
IF Bandwidth (3 dB)	6.67 MHz	5.38 MHz

Payload Bitrate Mb/s

COFDM MOD TYPE	FEC Code Rate	Sys C/N (dB)	Min Sig Level (dBuV)	Calc Rx NF (dB)	Guard 1/4 (Mb/s)	Guard 1/8 (Mb/s)	Guard 1/16 (Mb/s)	Guard 1/32 (Mb/s)
QPSK	1/2	5.4	11.7	4.8	4.35	4.84	5.12	5.28
QPSK	2/3	6.6	13.2	5.1	5.81	6.45	6.83	7.04
QPSK	3/4	7.6	14.8	5.7	6.53	7.26	7.68	7.92
QPSK	5/6	8.7	16.8	6.6	7.26	8.06	8.54	8.80
QPSK	7/8	9.5	19.2	8.2	7.62	8.47	8.96	9.24
16-QAM	1/2	11.2	17.7	5.0	8.71	9.68	10.25	10.56
16-QAM	2/3	13.0	19.6	5.1	11.61	12.90	13.66	14.07
16-QAM	3/4	14.1	20.9	5.3	13.06	14.51	15.37	15.83
16-QAM	5/6	15.5	22.9	5.9	14.51	16.13	17.08	17.59
16-QAM	7/8	16.3	24.9	7.1	15.24	16.93	17.93	18.47
64-QAM	1/2	16.8	23.3	5.0	13.06	14.51	15.37	15.83
64-QAM	2/3	19.1	25.2	4.6	17.42	19.35	20.49	21.11
64-QAM	3/4	20.6	27.5	5.4	19.59	21.77	23.05	23.75
64-QAM	5/6	22.2	30.0	6.3	21.77	24.19	25.61	26.39
64-QAM	7/8	23.7	32.4	7.2	22.86	25.40	26.89	27.71
8-VSB	2/3	15.1	27.2	11.2	-	-	-	19.39

Blue Payload Figures are 188/204 scaled from actual measurement

Red Figures are calculated from the 1/32 Guard interval data

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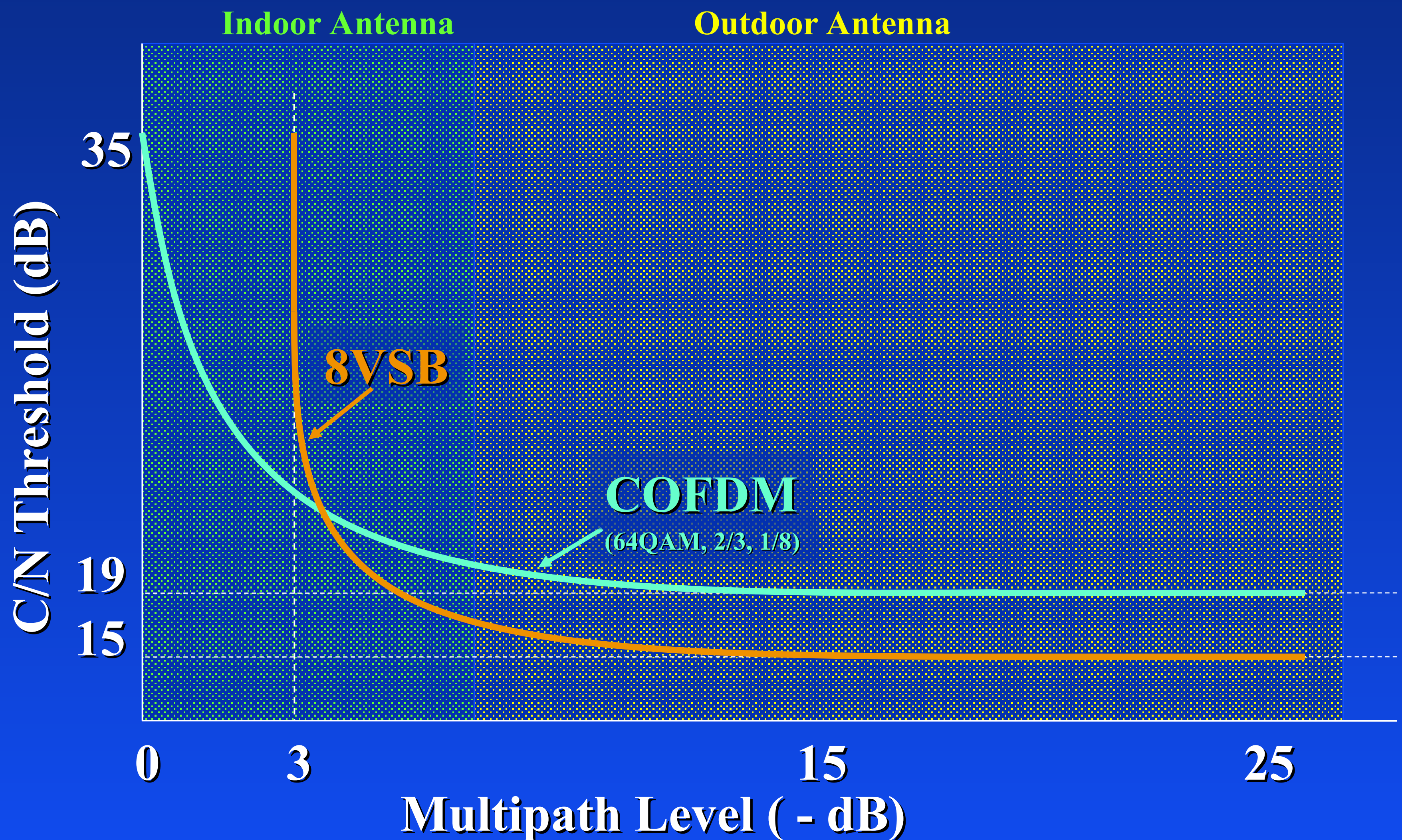
AWGN Receiver Performance

Parameter	DVB-T	ATSC
Carrier to Noise Threshold (in native system BW)	19.1 dB	15.1 dB
Simulated Theoretical C/N for optimum system	16.5 dB	14.9 dB
Minimum Signal Level	25.2 dBuV	27.2 dBuV
Receiver noise figure	4.6 dB	11.2 dB
Rx Level for 1 dB C/N Loss	34 dBuV	35 dBuV

DTTB System Multipath Character



(Conditions: Static multipath, Equal Rx NF, No Co-channel or impulse interference)

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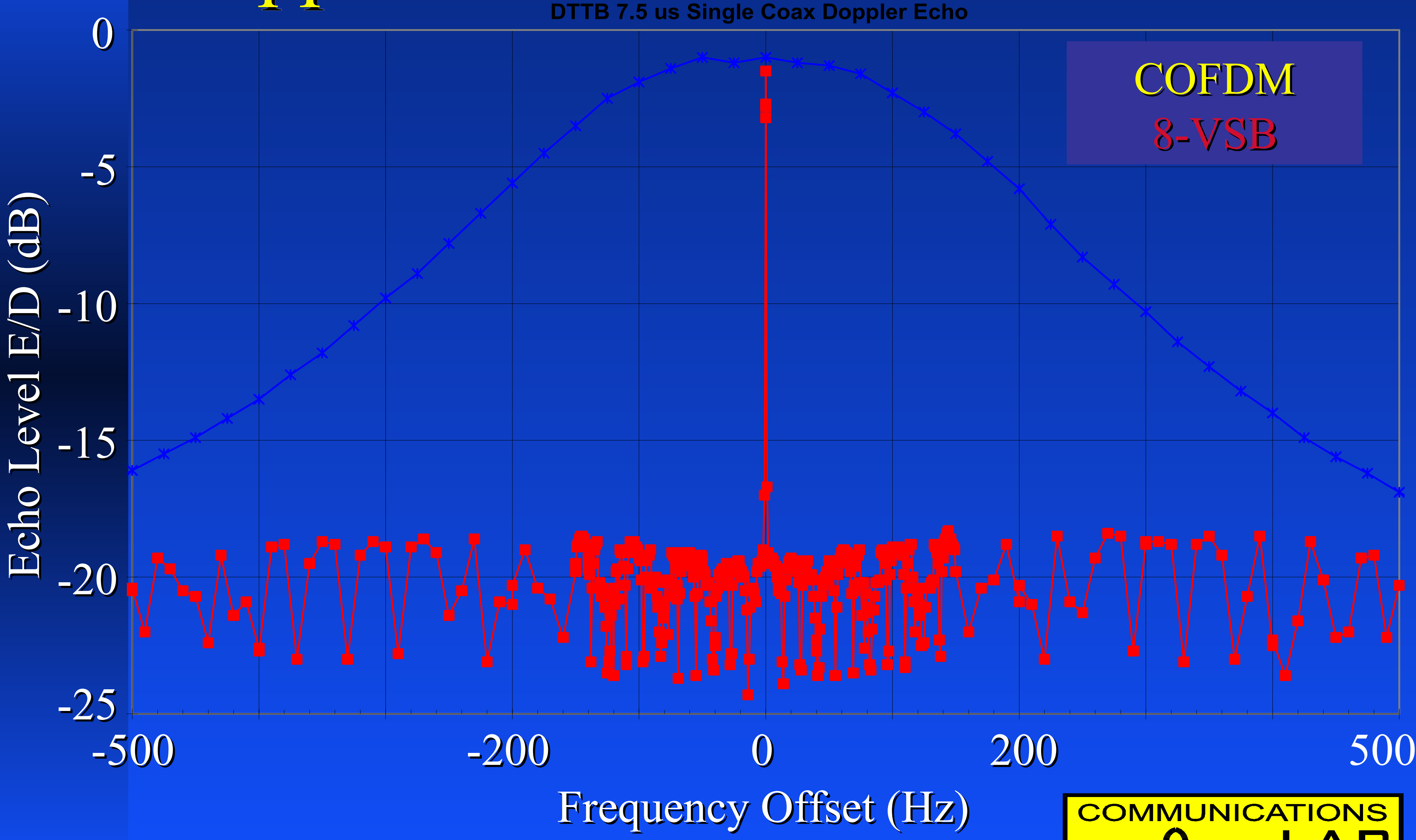
AWGN Performance

- C/N 4 dB more power required for DVB-T to achieve the same coverage as ATSC.
- Better C/N performance ATSC offset by poor receiver noise figure
- ATSC C/N is very close to the theoretical DVB-T implementation is still over 2.5 dB higher than the simulated margin.
- Other DVB-T modes have different C/N Thresholds and Data Rates

Multipath & Flutter Measurements

Parameter	DVB-T	ATSC
7.2 us Coax pre ghost	0 dB	-13.5 dB
7.2 us Coax post ghost	0 dB	-2.2 dB
Echo correction range	32 us	+3 to -20 us
Doppler single echo performance (-3 dB echoes)	140 Hz	1 Hz

Doppler Echo - 7.5 us Coax Cable



Transmitter Performance Sensitivity

Parameter	DVB-T	ATSC
Transmitter/Translator Linearity & Inter-mod Sensitivity	Low	High
Group Delay / Combiner / Filter Sensitivity	Low	< 50 ns

Impulse Noise - Results

- Impulse Sensitivity (Differential to PAL grade 4)
  - **DVB-T** 9 -14 dB
  - **ATSC** 17-25 dB
- Difficult to measure & characterise.
- Mainly affects the lower VHF frequencies
- ATSC is 8 to 11 dB better at handling impulsive noise than DVB-T

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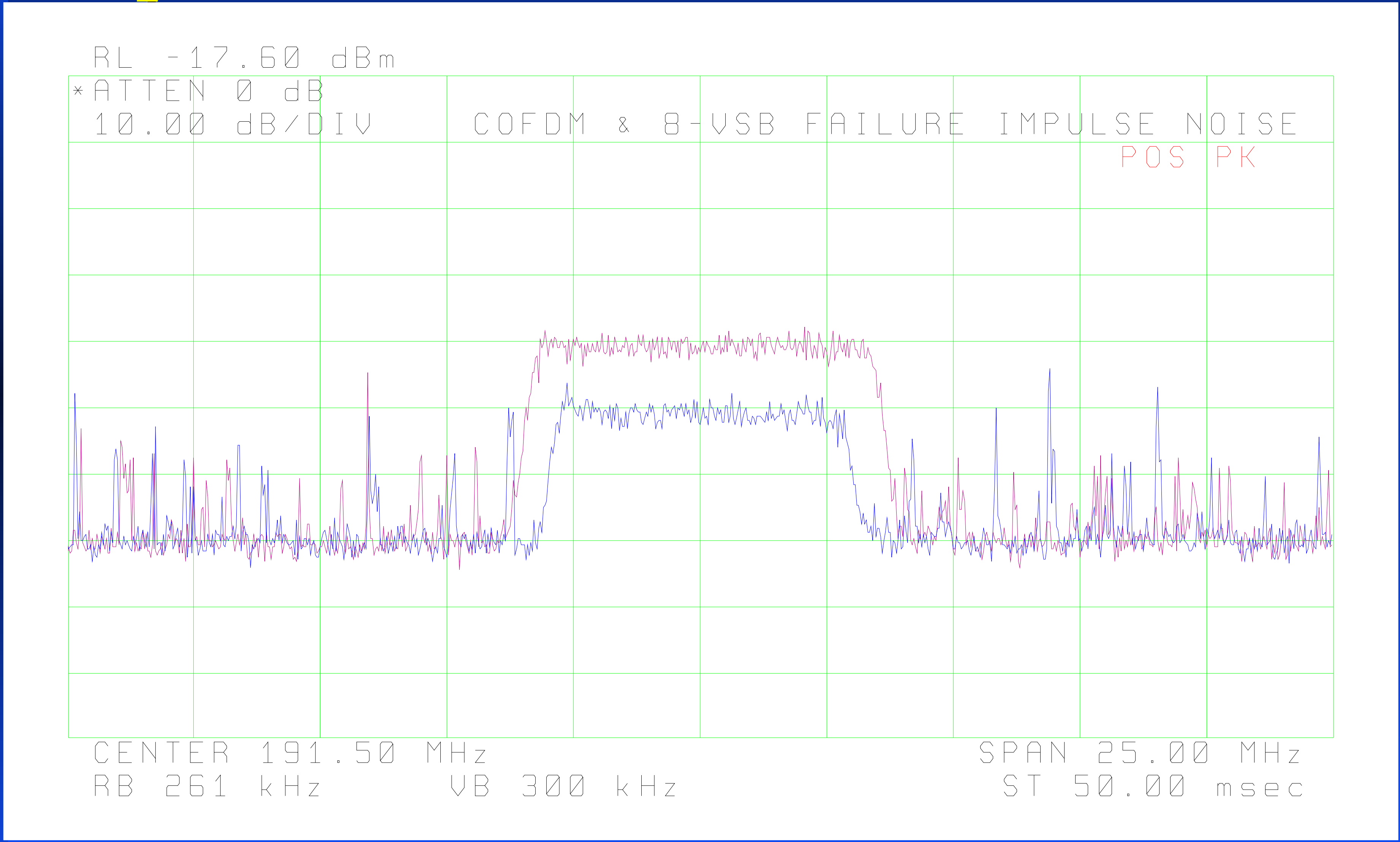
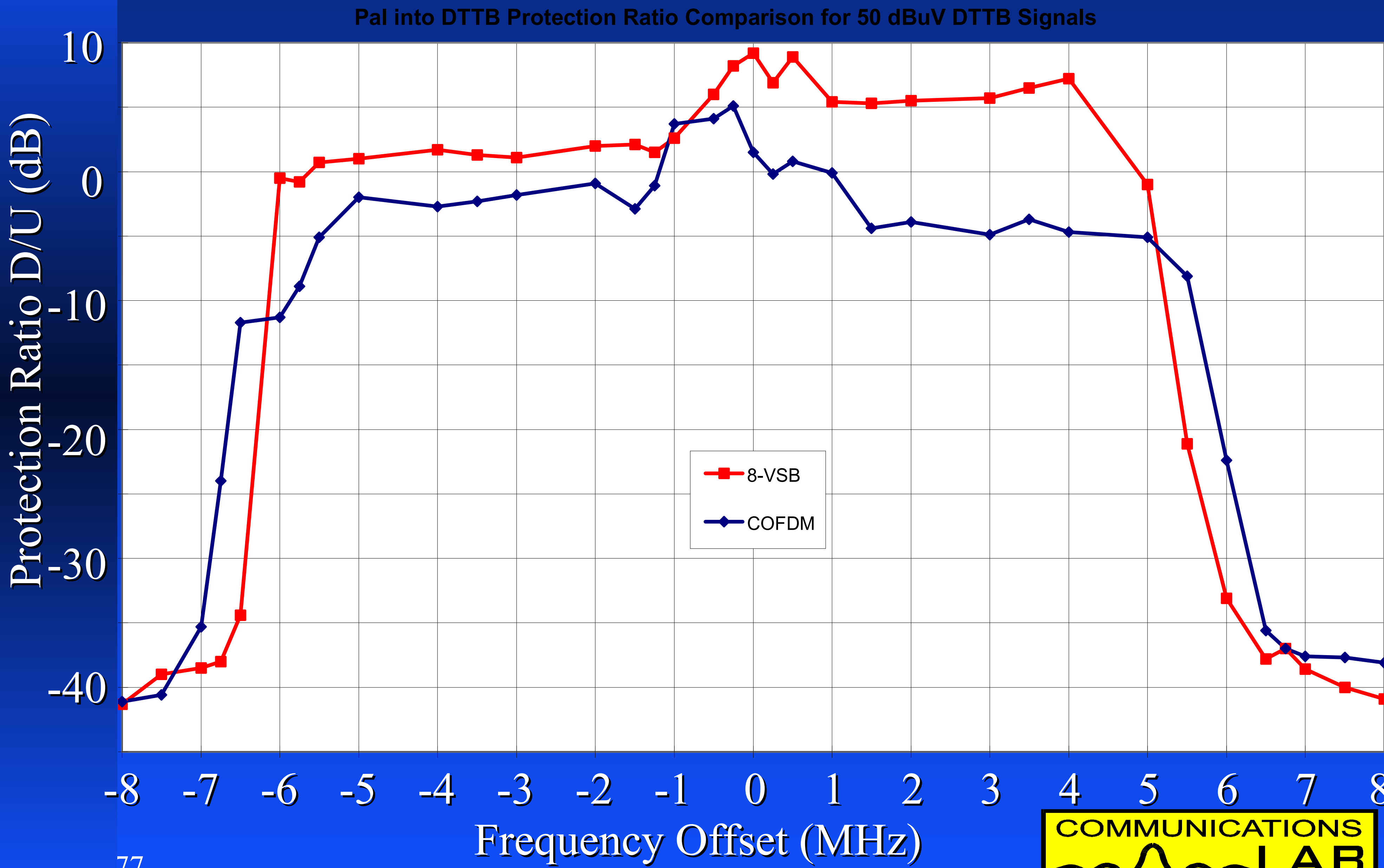
Impulse Noise - Plot



DTTB into PAL - Subjective

DTTB into PAL B Protection D/U (dB)							
System Test Description		Mean	StdDev	Num	Min	Median	Max
DVB-T 7 MHz Tropospheric Interference	Ch 7 lower adj. ch.	-9.5	3.3	12	-14.0	-10.0	-4.0
	Ch 8 Co-Channel	35.8	1.4	12	33.5	36.0	38.5
	Ch 9 upper adj. ch.	-10.6	4.9	12	-20.0	-10.0	-3.0
DVB-T 7 MHz Continuous Interference	Ch 7 lower adj. ch.	-5.3	3.8	12	-9.5	-6.5	2.5
	Ch 8 Co-Channel	41.1	2.0	12	38.5	40.8	45.0
	Ch 9 upper adj. ch.	-6.4	4.3	12	-14.0	-6.8	1.0
DVB-T 7 MHz Limit of Perceptibility	Ch 7 lower adj. ch.	3.5	3.8	12	-2.5	2.8	10.0
	Ch 8 Co-Channel	50.4	0.9	14	48.5	50.3	52.0
	Ch 9 upper adj. ch.	5.1	5.8	16	-1.0	3.8	20.0
ATSC 6 MHz Tropospheric Interference	Ch 7 lower adj. ch.	-7.0	3.4	15	-12.5	-7.0	-2.0
	Ch 8 Co-Channel	38.7	2.6	41	34.5	38.5	44.0
	Ch 9 upper adj. ch.	-7.1	3.5	17	-14.0	-6.0	-3.5
ATSC 6 MHz Continuous Interference	Ch 7 lower adj. ch.	-0.9	4.3	15	-5.5	-2.0	8.0
	Ch 8 Co-Channel	45.5	2.2	41	41.0	45.0	50.5
	Ch 9 upper adj. ch.	-0.3	2.9	17	-5.5	0.0	3.0
ATSC 6 MHz Limit of Perceptibility	Ch 7 lower adj. ch.	5.0	4.4	15	0.0	4.0	13.0
	Ch 8 Co-Channel	51.4	2.5	41	47.0	51.5	56.5
	Ch 9 upper adj. ch.	5.4	3.1	17	0.0	4.5	10.5

PAL into DTTB - Protection Plot



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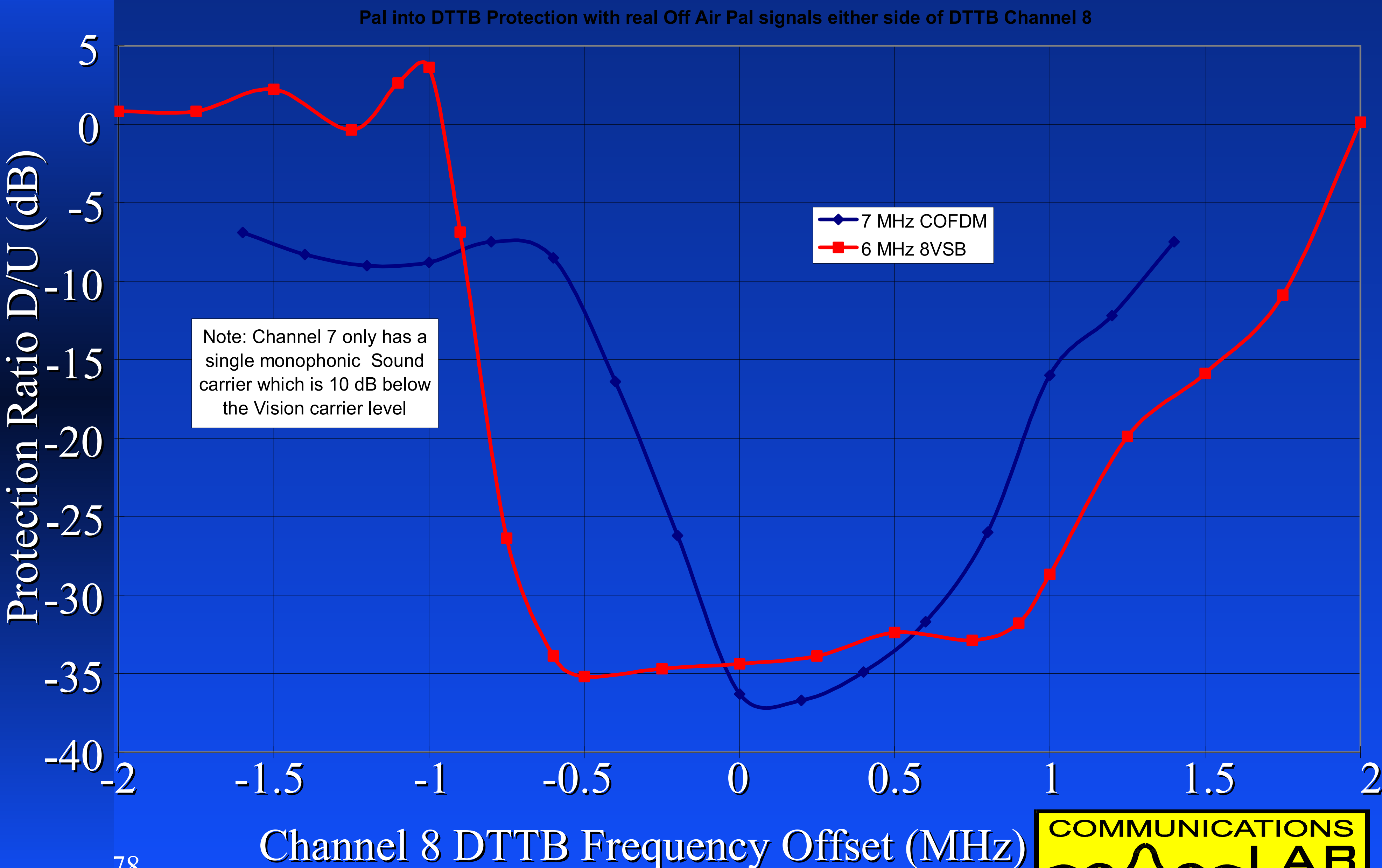
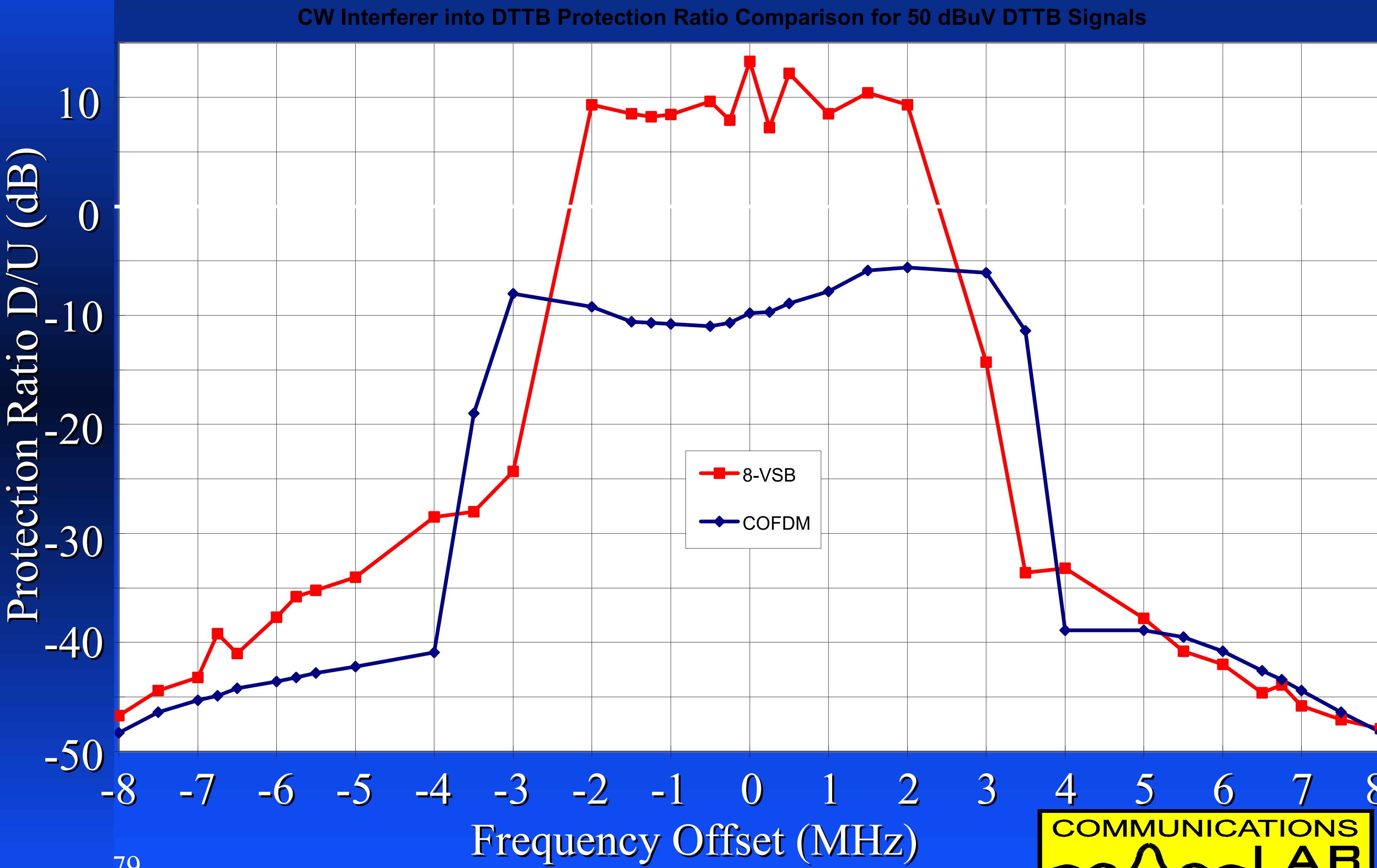
Off Air PAL into DTTB - Plot



CW into DTTB - Protection Plot



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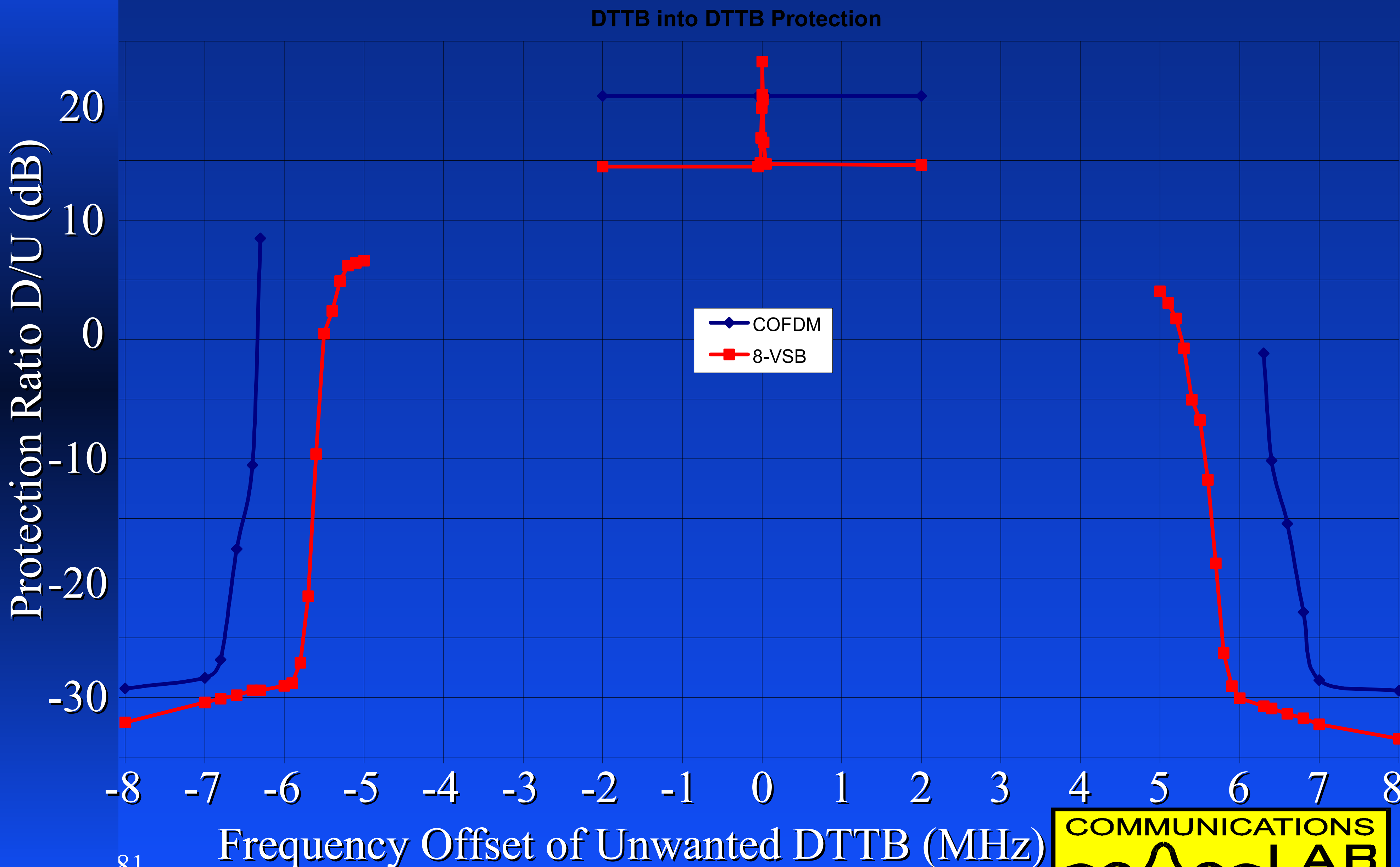
DTTB into DTTB - Overview

DTTB TYPE	Ch 7 Lower Adj Ch (dB)	Co Channel (dB)	Ch 9 Upper Adj Ch (dB)
DVB-T-7	-28.3	20	-28.5
ATSC-6	-30.4	14.6	-32.2

- Adjacent channel performance of ATSC is better than DVB-T
- The Co-channel protection of both digital systems approximates to the system carrier to noise threshold.

DTTB into DTTB - Protection Plot



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Field Testing - Van

- A field test vehicle was built in a small van.

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Field Testing

- Field tests were conducted in Sydney over a 1 month period on VHF channel 8.

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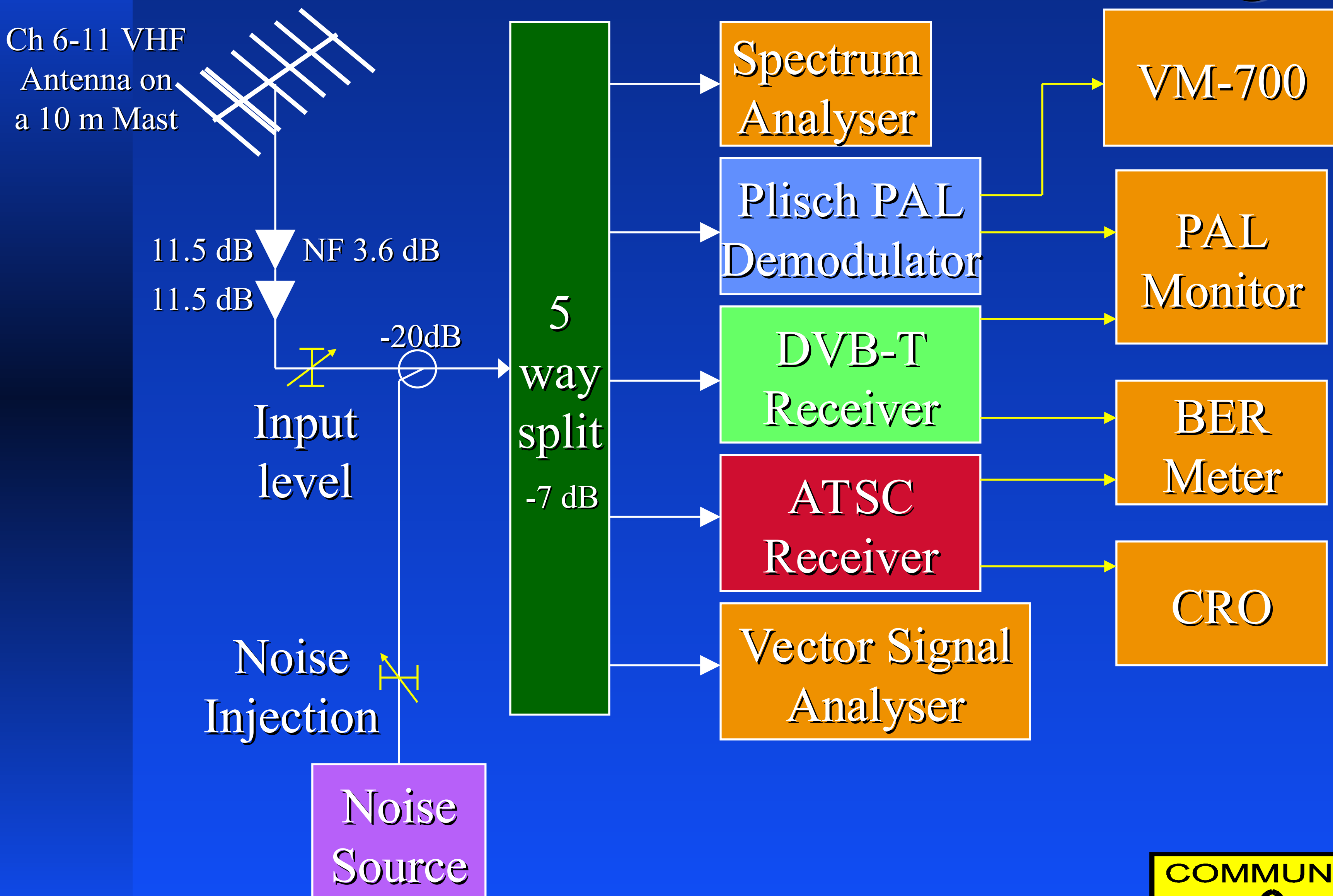
Field Testing

- Over 115 sites were measured
- Power level for the field test was 14 dB below adjacent analog television channels 7 & 9
- Analog and digital television performance for both systems were evaluated at each site.

Field Test Vehicle Block Diagram



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Field Testing - Method

- Field tests were conducted in Sydney over a 1 month period on VHF channel 8.
- Some simultaneous tests were conducted on VHF channel 6
- Power level for the field test was 14 dB below adjacent analog television channels 7 & 9
- Analog and digital television performance for both systems were evaluated at each site.
- Conducted by Independent Consultant & Mr Wayne Dickson of TEN

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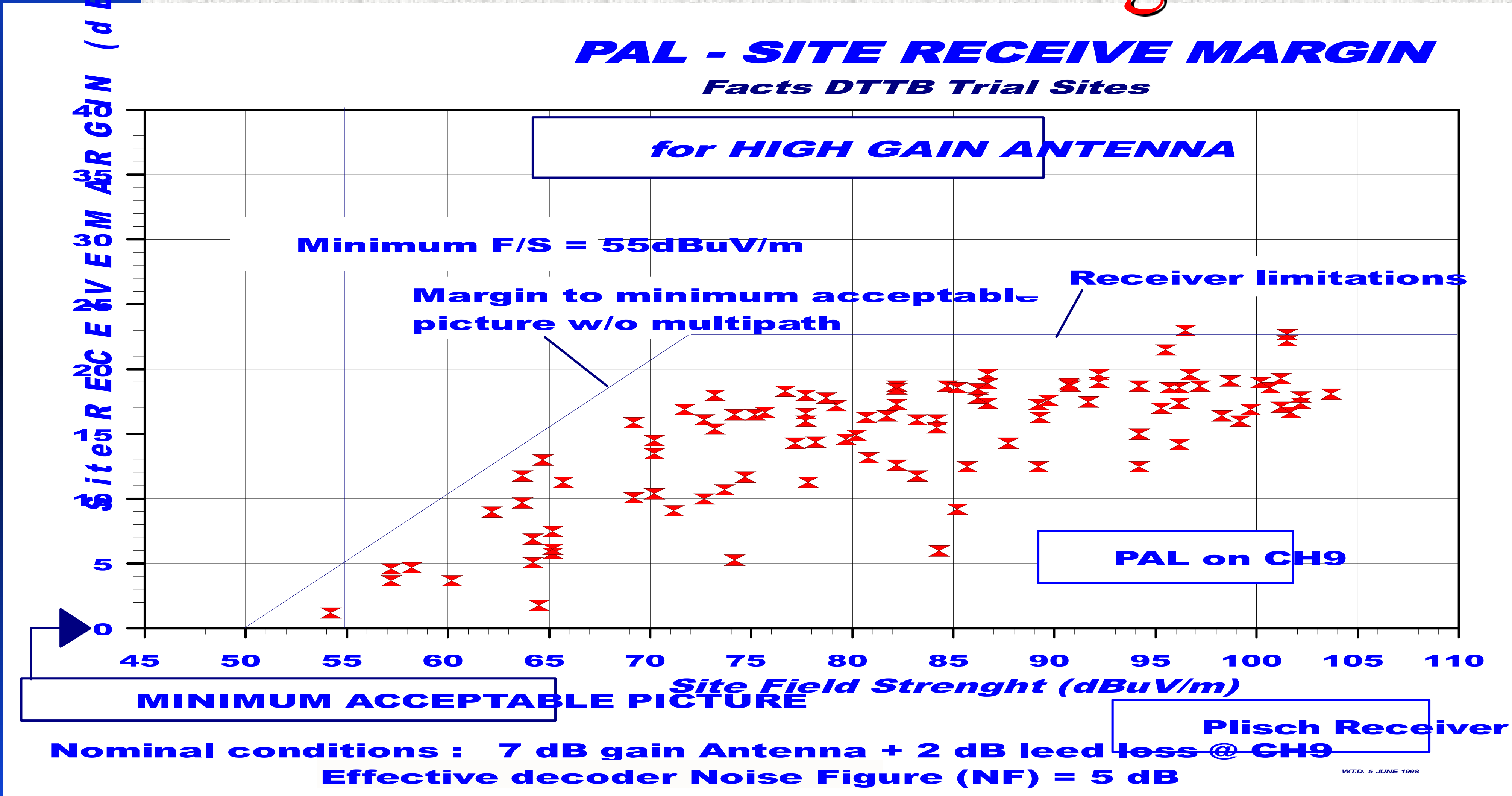
Field Test - Data Collected each Site

- Common Masthead Amp used (NF ~ 3.6 dB)
- Analog PAL transmission character (7,9 & 10)
- Measure level, multipath, quality & Video S/N
- Measure DVB & ATSC reception (Ch 8)
- Record DTTB & Analog Spectrum
- Measure Noise Margin (C/N Margin)
- Measure Level Threshold (Signal Margin)
- Measure antenna off pointing sensitivity

Australian DTTB Field Trial
PAL Receive Margin



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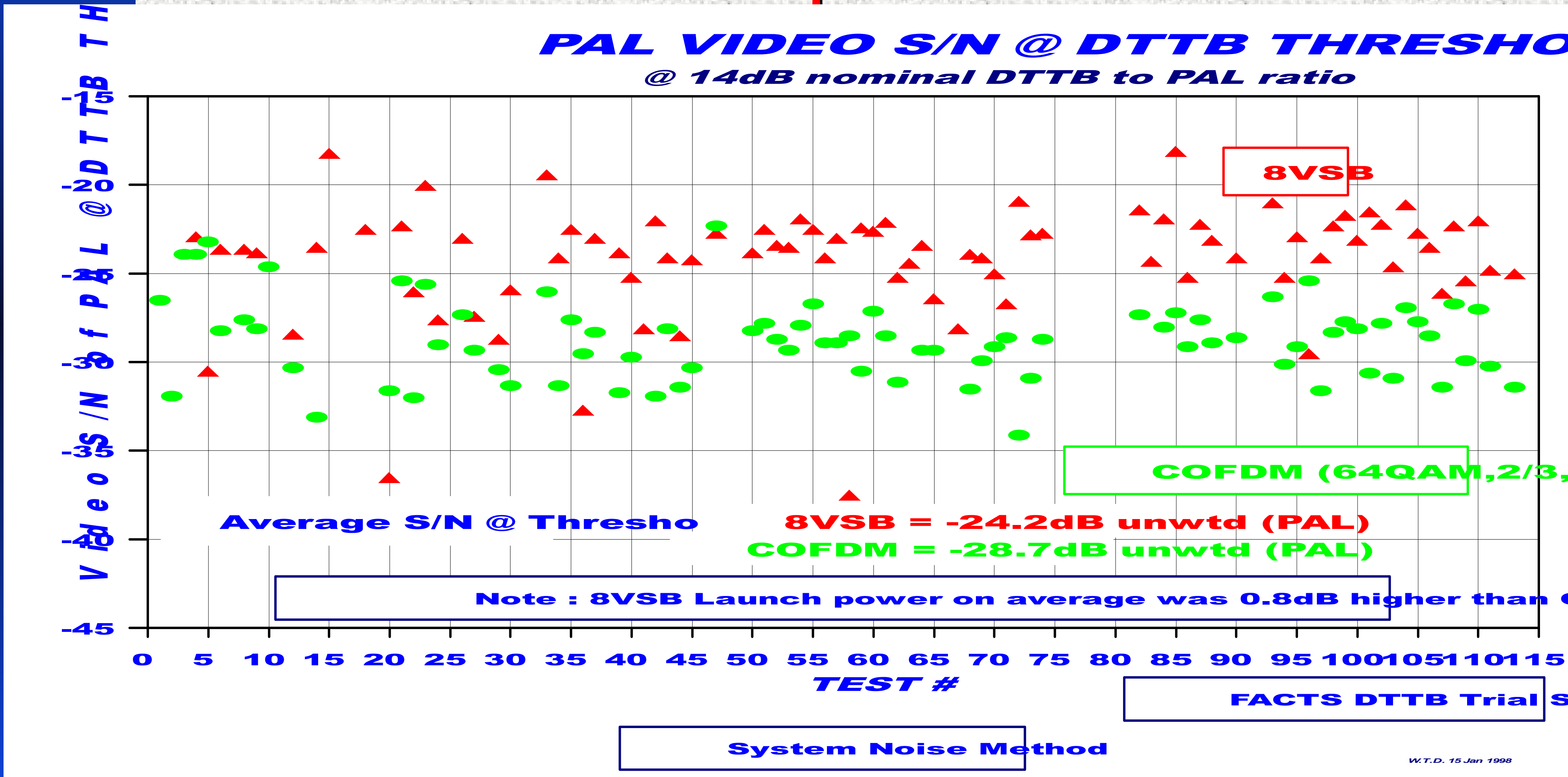
Australian DTTB Field Trial

DTTB compared to PAL



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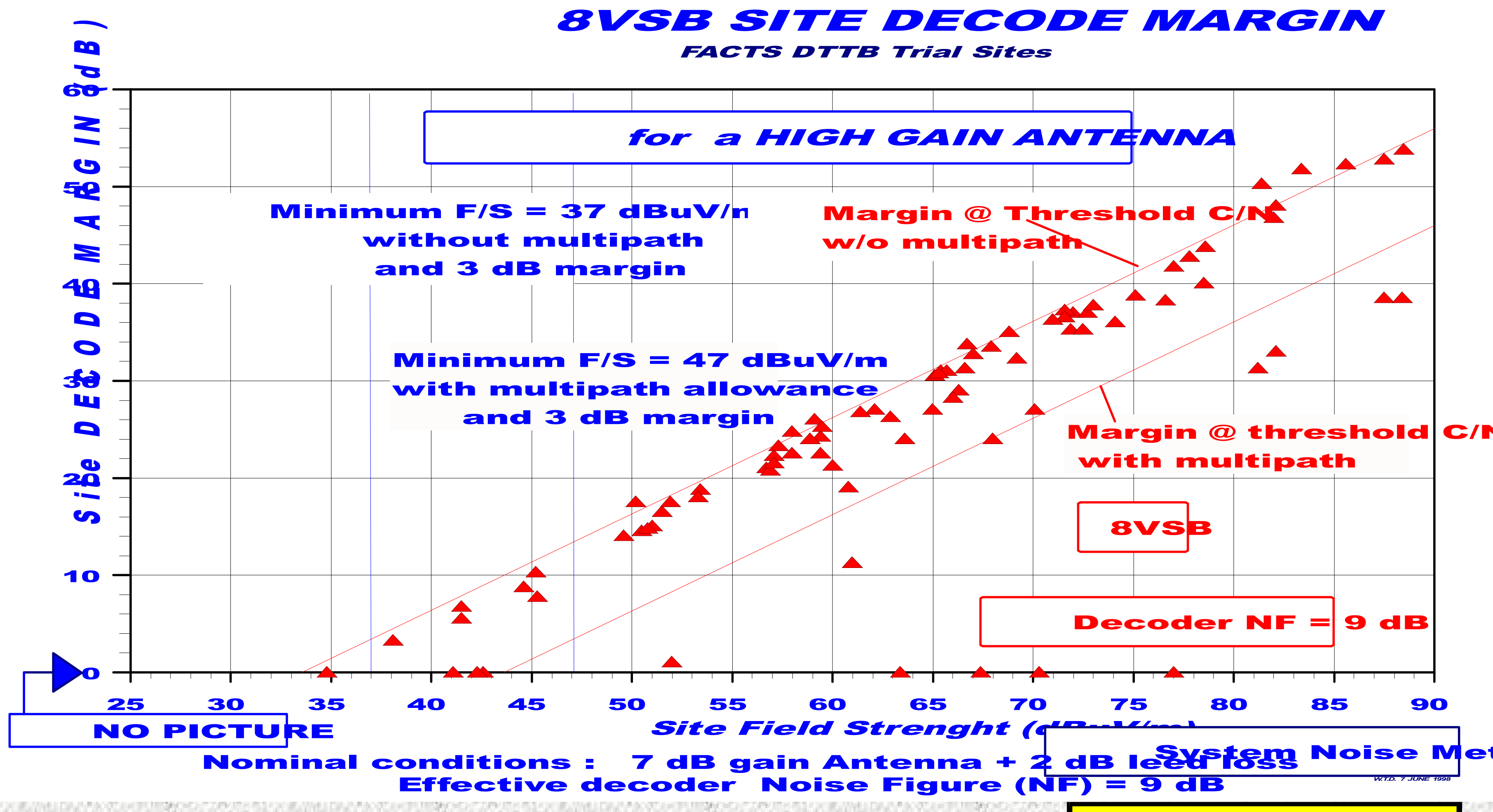
Australian DTTB Field Trial

8VSB Decoder Margin



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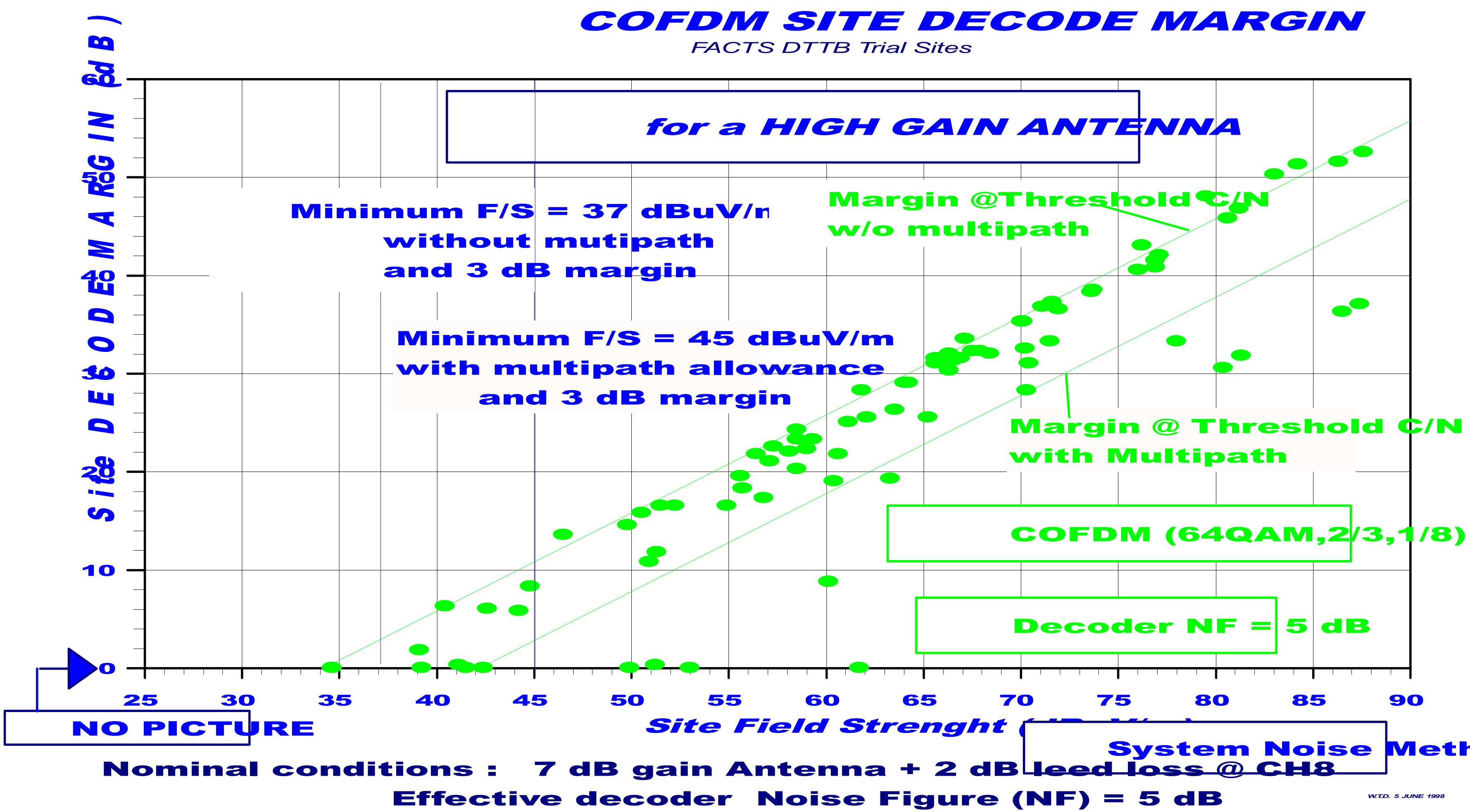
Australian DTTB Field Trial

COFDM Decoder Margin



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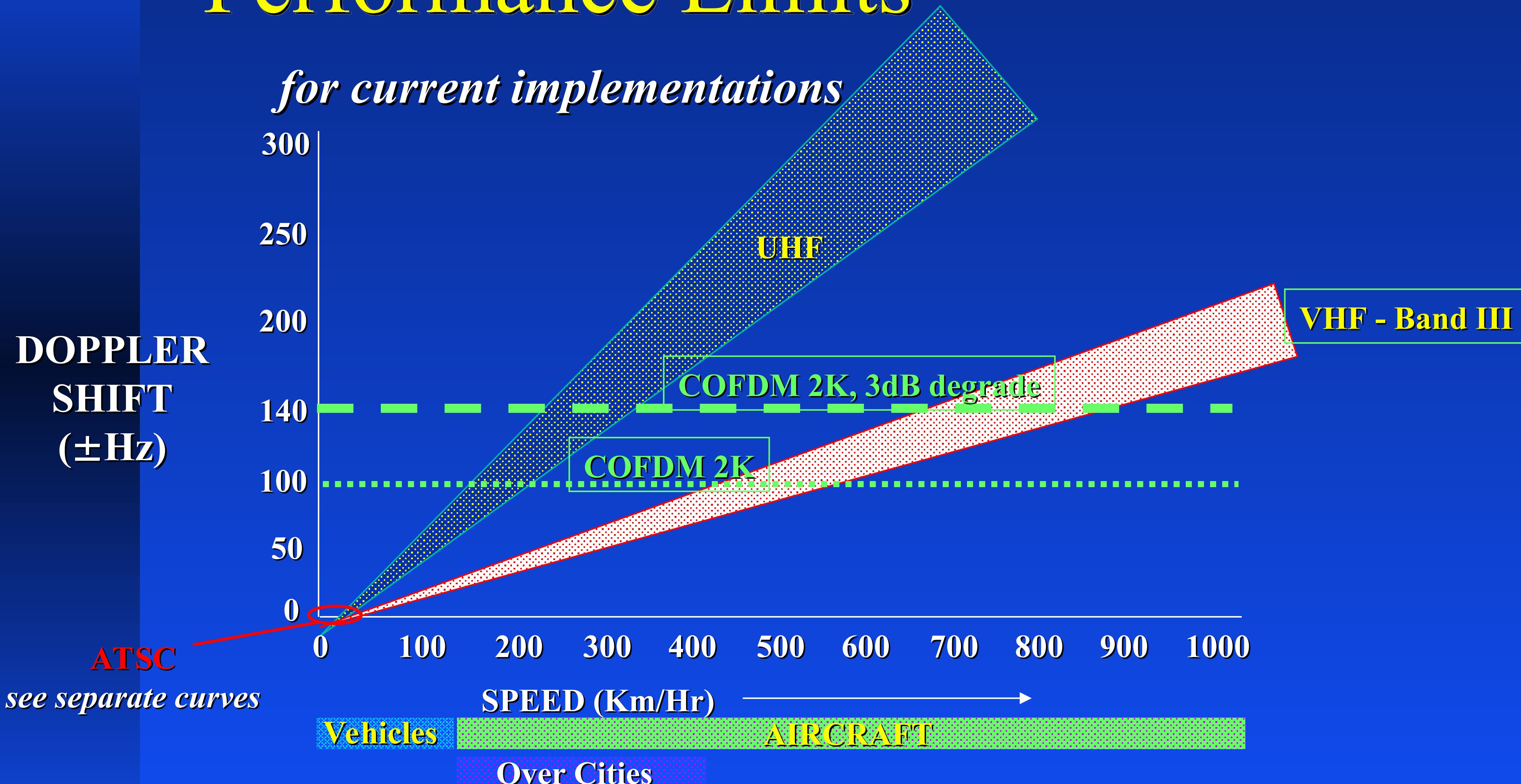
DTTB Systems Doppler Performance Limits

for current implementations



COFDM implementations will inherently handle post and pre-ghosts equally within the selected guard interval.

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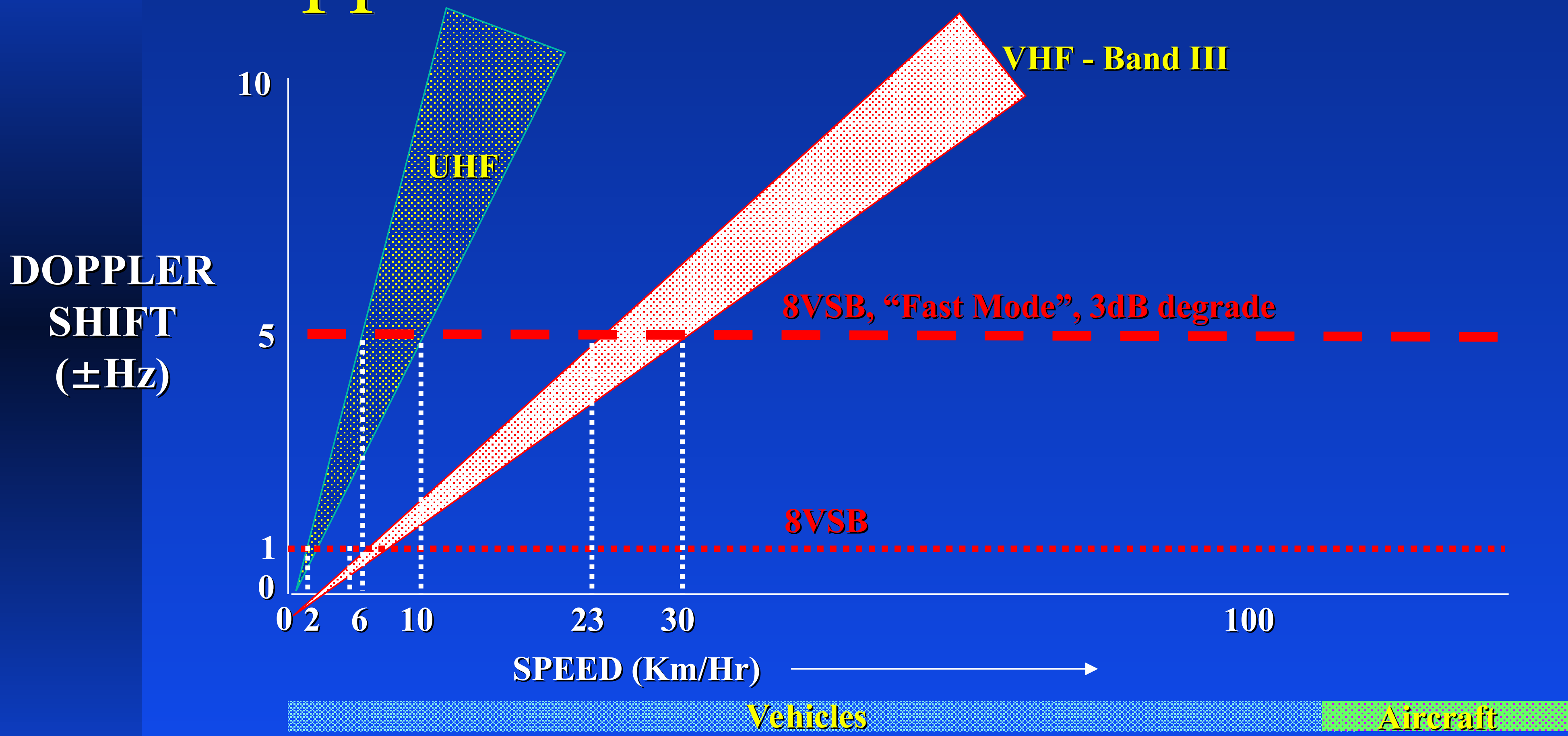
ATSC 8-VSB
Doppler Performance Limits



8VSB implementations of equalisers are likely to cater for post ghosts up to 30 uSec and pre-ghosts up to 3 uSec only.

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Field Test - Observations

- At -14 dB DTTB power when there was a reasonable PAL picture both 8-VSB & COFDM worked at the vast majority of Sites
- When PAL had:
  - Grain (noise) and some echoes (multipath), both 8-VSB & COFDM failed
  - Flutter, caused by aircraft or vehicles, 8-VSB failed
  - Impulsive noise & some grain, COFDM failed

The Tests - Some World Firsts

- First independent direct comparative tests between the two digital modulation systems
- First extensive tests of both systems in a 7 MHz PAL-B channel environment
- First tests of VHF adjacent channel operation
- First test of ATSC in a PAL environment
- First test of DVB-T in the VHF band

HDTV - Demonstrations

- In October and November 1997 the ATSC and DVB-T system proponents both demonstrated their systems by transmitting HDTV programs to audiences in Sydney.

- These demonstrations showed that both systems were HDTV capable.

Test Reports

- Lab and field data was compiled and factually presented in detailed reports.
- Aim to present data in an unbiased way without drawing conclusions based on single parameters
- Summary reports for both the laboratory and field trials were also produced, concentrating on the interesting data.
- These reports provided a solid technical basis to assess the two DTTB modulation systems.

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The Selection Committee

- A selection committee was formed from FACTS ATV specialists group Representing:
  - National broadcasters (ABC and SBS)
  - The commercial networks (7,9 & 10)
  - The regional commercial broadcasters
  - The Department of Communications and the Arts
  - The Australian Broadcasting Authority

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Selection Panel - Responsibility

- Analysing the comparative tests and other available factual information
- Establishing the relevance of the performance differences to Australian broadcasting
- Recommending the system to be used

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Selection Result - June 1998

- The selection committee unanimously selected the 7 MHz DVB-T modulation system for use in Australia

- The criteria that were set aside would, however, not have changed the selection decision

More Selections

- Sub-committees formed to investigate:
  - Service information data standard
  - Multichannel audio system
  - HDTV video production format
- July 1998 3 further recommendations
  - SI data standard be based on DVB-SI
  - AC3 multichannel audio is the preferred audio encoding format
  - 1920/1080/50 Hz interlaced 1125 lines is the preferred video production format

Multichannel Sound - MPEG 1/2

- Two sound coding systems exist
- MPEG Audio Layer II was developed in conjunction with the European DVB technology
  - Uses Musicam Compression with 32 sub bands
  - MPEG 1 is basic Stereo 2 channel mode
  - MPEG 2 adds enhancement information to allow 5.1 or 7.1 channels with full backwards compatibility with the simple MPEG 1 decoders
  - MPEG 1 Is compatible with Pro-Logic processing.
  - Bitrate 224 kb/s MPEG 1
  - Bitrate 480 kb/s MPEG 2 5.1

Multichannel Sound - Dolby AC-3

- Dolby AC-3 was developed as a 5.1 channel surround sound system from the beginning.
  - Compression Filter bank is 8 x greater than MPEG 2 (256)
  - Must always send full 5.1 channel mix One bitstream serves everyone
  - Decoder provides downmix for Mono, Stereo or Pro-Logic
  - Listener controls the dynamic range, Audio is sent clean
  - Bitrate 384 kb/s or 448 kb/s

Studio Multichannel Sound

- Present AES3 PCM Audio
  does not cater for 5.1 channel surround.
- Dolby has produced a system called Dolby E
  - Handles 6-8 audio inputs
  - Uses low compression 3-4:1
  - Can be transported/stored on 2ch PCM audio equipment
  - Incorporates time stamps and is segmented at the video frame rate allowing editing on video frame boundaries

Display Technology

- For HDTV displays need to be large
- Captures viewers perceptual vision
- Viewing distance will be closer (3H)
- Largest CRT Tubes limited by size
- Projectors are expensive and Bulky
- Flat Panel Display Technology seen as the HDTV display technology of the future
  - Producing large flat panels is difficult

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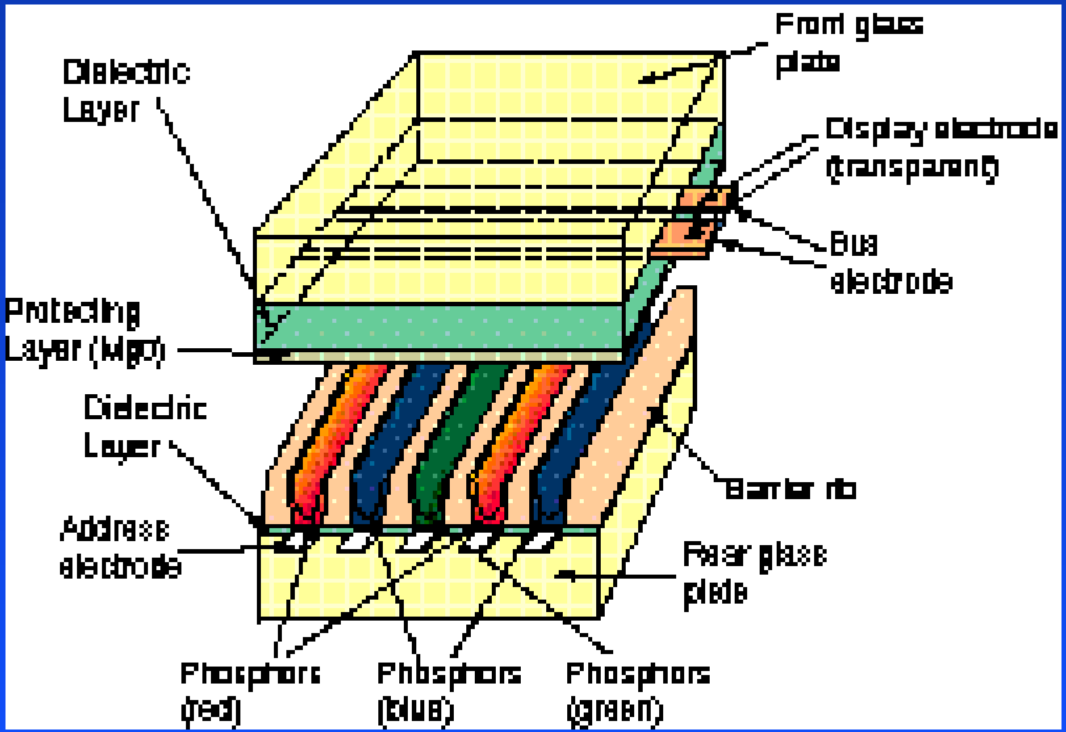
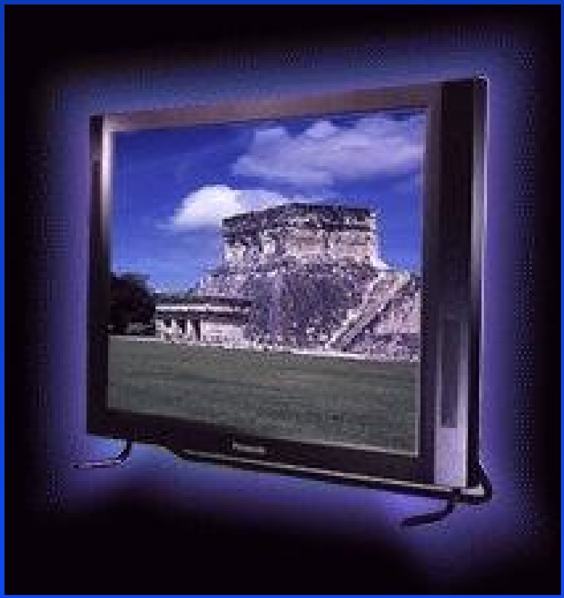
Plasma Panel Displays

- PDPs from Fujitsu & Mitsubishi look like providing HDTV Display solution.
- Latest innovations such as ALiS have doubled the vertical resolution to over 1000 lines.





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Staging & Sets

- HDTV resolution & Aspect ratio will mean changes to production:
  - Greater attention to detail
  - Set construction
  - Set painting more accurate
  - Makeup
  - Lighting (more light)
  - Framing of Shots (4:3, 14:9, 16:9, 2.21:1)
  - Use of Zoom & Pan

Studio/Field Storage

- Digital Video Tape probably 270 Mb/s.
- D5 & D1 have been used up to now.
  - 3-4 times compression applied to the HDTV material for storage => Need HD encoder between camera & Storage device
- Disk Video Servers
- Compressed transport stream storage (20-50 Mb/s) on SX, D-Bcam, DVC-PRO etc.
- New formats will be developed, not here yet.

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Government Legislation

- While the selection process was underway the Australian government considered legislation to define the implementation of digital television services in Australia.
  Two Acts have been passed.
  - Television broadcasting services (digital conversion) Act 1998
  - Datacasting charge (imposition) Act 1998

The Digital Conversion Act - 1

- Mandates HDTV content level requirement
- 5 FTA broadcasters get a free loan of adjacent channel spectrum to start DTV
- Simulcasting of digital and analog services is required for at least 8 years after digital startup
- Jan 1 2001 commencement in metro markets
- Commencement by 2004 in regional markets
- Multi-channel and subscription services not allowed for commercial broadcasters

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The Digital Conversion Act - 2

- Multi-view programs may be allowed subject to review
- Review before 2000 if National broadcasters should be allowed some multi-channelling to address community needs
- No new commercial broadcasting services until 2007
- Closed captioning is required on some services
- Minister can determine digital system standard

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The Datacasting Imposition Act - 1

- Datacasting defined as services "other than a broadcasting service" delivered using broadcasting spectrum
- Unused spectrum after planning of digital TV services - available to datacasters - via auction
- FTA broadcasters unable to bid for datacasting spectrum allocations
- Community television access is to be provided by datacaster free of charge

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The Datacasting Imposition Act - 2

- Review before 2000 to determine the types of services to be allowed as datacasting
- Datacasters not allowed to provide de-facto broadcast or Pay TV type services
- FTA Broadcasters may use spare transmission capacity for datacasting
- FTA broadcasters will be charged if they provide datacast services

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What Are the Next Steps?

- Standards Australia - CT/2 committees
  - In Process at present
  - Develop transmission standards
  - Develop reception equipment standards
  - Draft standards ready by early 1999

On Air Testing

- NTA VHF & UHF trials
  - 2K & 8K operation
  - Planning
  - SFNs
  - Gap fillers
- Ch 12 VHF @ 2.5 kW
- CH 29 UHF @ 1.25 kW

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Channel 9A

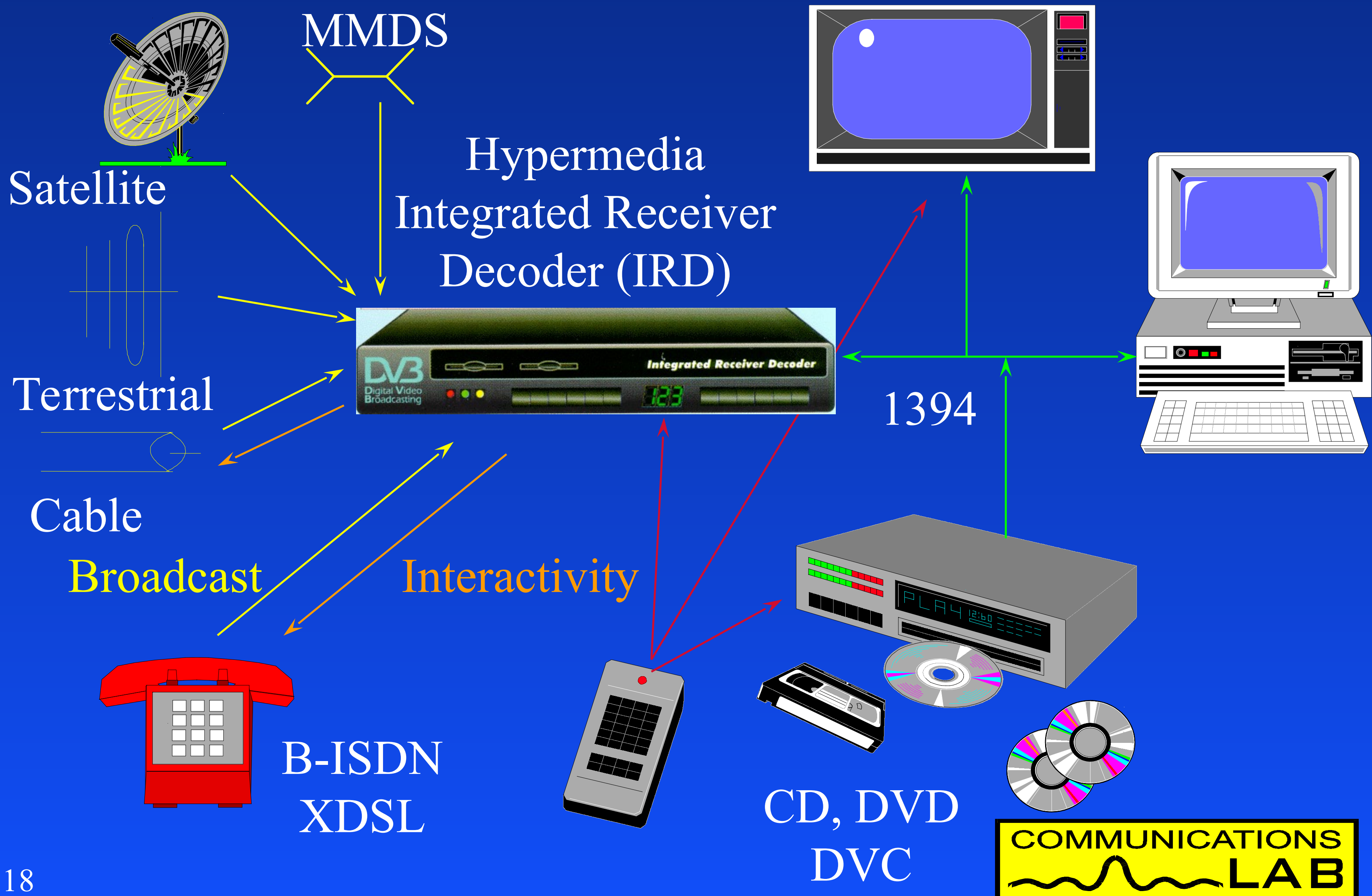
- SBS want to use band III 6 MHz channel 9A in metro areas options:
  - Truncation of 7 MHz COFDM
  - Transmission of 6 MHz COFDM
  - Offsetting digital/analog transmissions

Propagation Investigations

- Indoor reception tests
  - Multipath propagation
  - Building attenuation
  - Impulse sensitivity

- Adjacent area co-channel simulcast operation

A Future Digital System Concept



The End

Thankyou for your attention

Any questions?