GATESAIR

ISDBT Workshop

March 12, 2015

Manila, Philippines

Featuring
GatesAir's

Martyn Horspool
Product Manager,
TV Transmission

ISDBT Workshop

Manila, Philippines, March 12, 2015

Martyn Horspool
Product Manager, TV Transmission
GatesAir

Manila, Philippines

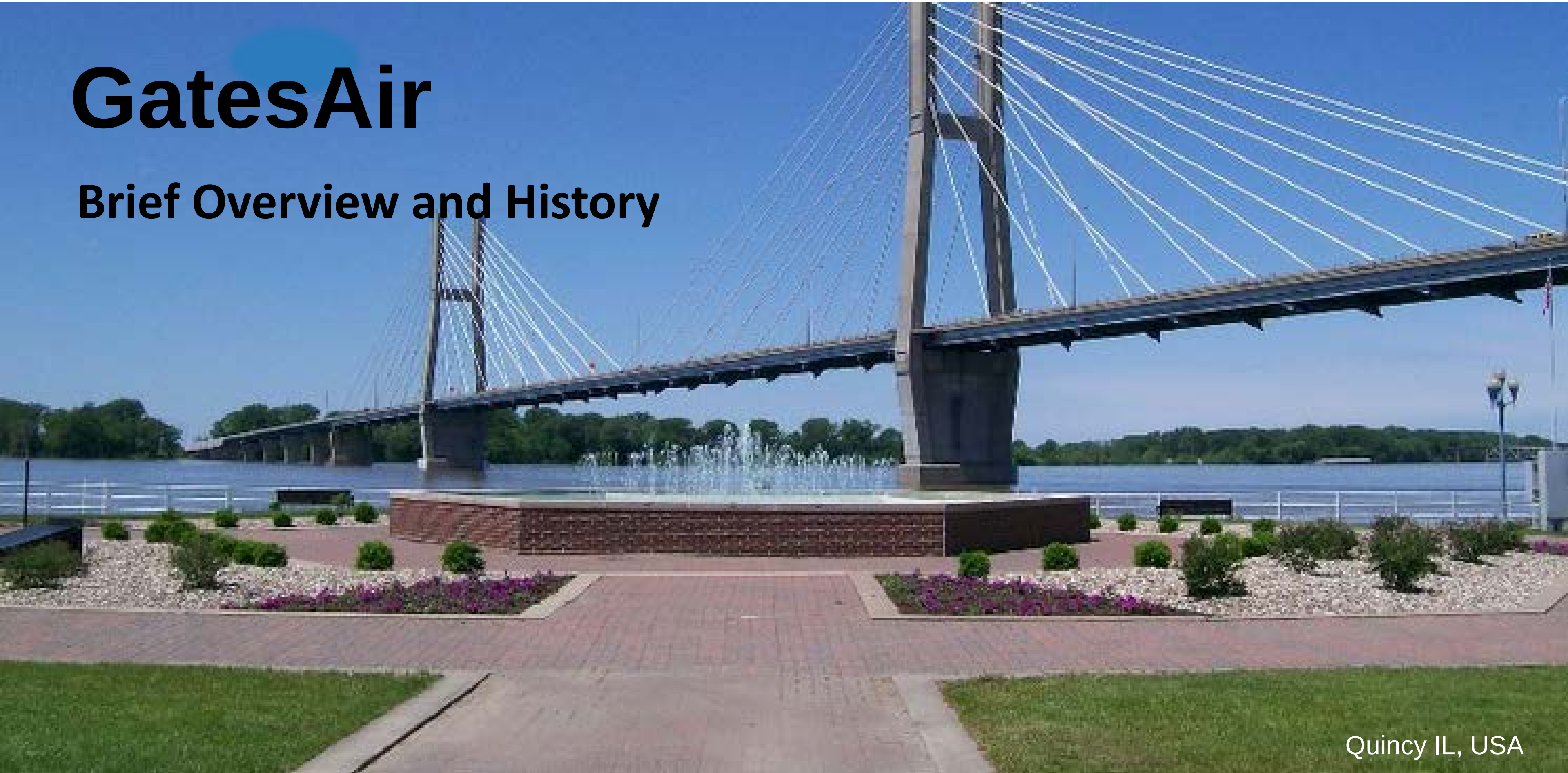
Today's Agenda

- Welcome/Introductions
- GatesAir… Brief Introduction and History
- Review of COFDM Modulation Characteristics (on thumb drive only)
- ISDB-T Overview/Training
- ISDB-T Single Frequency Network (SFN) and GatesAir Solution
- ISDB-T Coverage and Planning
- New High-Efficiency Transmitter Products for ISDB-T:
  - High Power Liquid-Cooled Solid State (ULXT)
  - Low and Medium Power Air-Cooled Solid State (UAXT & UAXT Ultra Compact)
- GA experience and Site References for ISDB-T Deployments
- Challenges and Lessons Learned
- Q&A and lucky draw for prizes

Connecting What's Next

GatesAir

Brief Overview and History



Quincy IL, USA

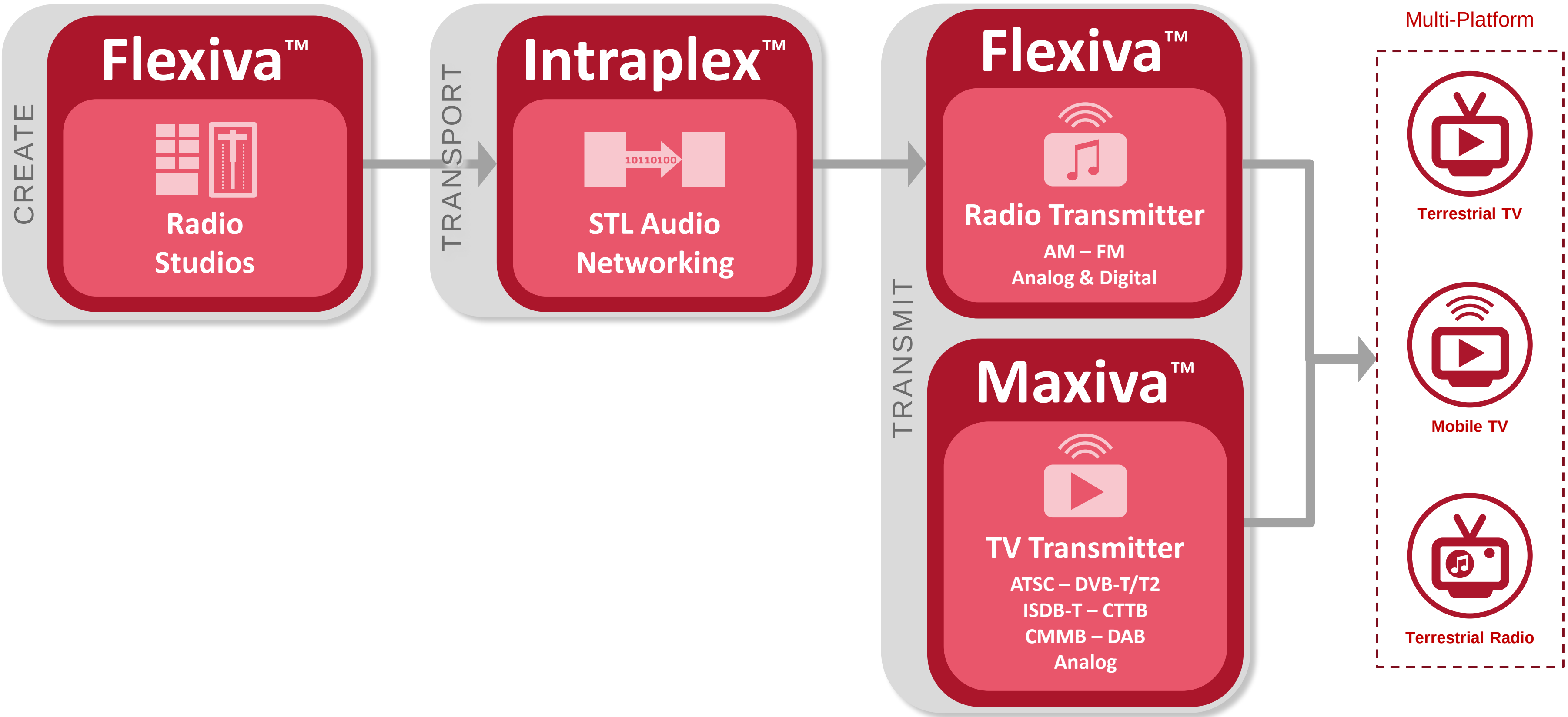
Introduction & History of GatesAir

- **1922** – Gates Radio starts business. Parker Gates was only 15 years old
- **1950** - Gates Radio had become a major Radio equipment supplier in USA
- **1957** – Harris Corporation acquires Gates Radio
- **2013** – Gores Group acquires Harris Broadcast Division
- **2014** – Harris Broadcast splits into two companies – Imagine Communications and GatesAir




GATESAIR
TM
1922
GATES
First Commercial Radio Station
1929
First TV Broadcast
1957
HARRIS INTERTYPE CORPORATION
GATES
A DIVISION OF HARRIS-INTERTYPE
Harris Acquires Gates Radio
1996
HD
First Digital TV Broadcast
2008
Mobile TV
What's Next
UltraHD, LTE Broadcast

End-to-End Terrestrial Transmission Solutions



GatesAir Products Support All Standards

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CREATE

Flexiva™ – Studio

- Analog Audio
- AES/EBU
- TCP/IP
- Ethernet / CAT5
- USB

TRANSPORT

Intraplex™ – STL

10110100

- T1/E1
- AES67 / IP
- TDM / RJ-48C
- BNC
- RF

TRANSMIT

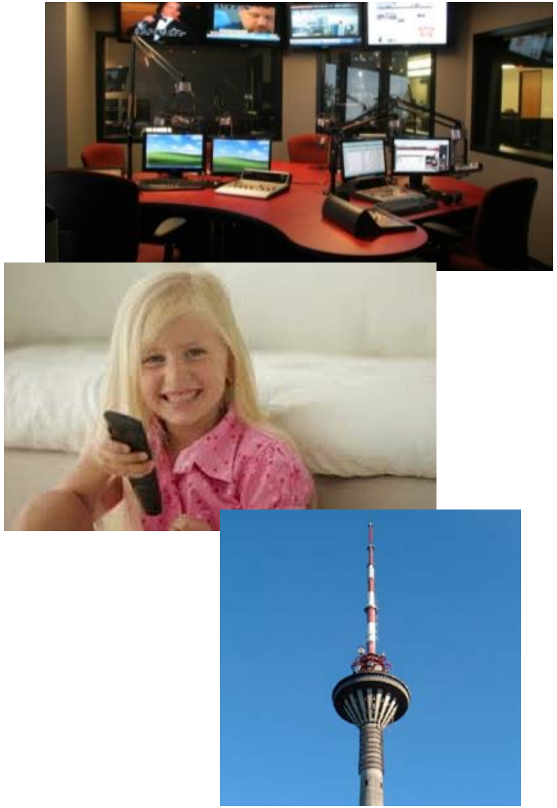
Flexiva™ – Radio

- AM / FM
- HD Radio
- DRM
- DAB

Maxiva™ – TV

- UHF / VHF
- ATSC – DVB-T/T2
- ISDB-T – CTTB
- CMMB – DAB

Best-In-Class Transmission Solutions



- Market leader in transmission solutions for core broadcasters, network operators and government-sponsored broadcast networks
- Lowest transmission total cost of ownership (TCO) for broadcasters worldwide
- Innovative, world class products that solve evolving customer needs
- Exceptional pre- and post-sales services
- Unique capability to deliver transmission solutions that enable new revenue

Customers Around The World…

- Customers include top media companies around the world
- Systems are mission-critical to customer’s business
- Long-term customers in over 100 countries with relationships ranging up to 70+ years

Committed to Providing the Best Service

- We do what it takes to help our customers succeed
- 24/7 service with training centers, repair centers, and parts depots around the world
- Our support teams consist of innovative technical experts who can offer project planning and management, on-site service, and commissioning
- Support situations involving product performance, integration, and operational processing
- Superior, industry-competitive warranties
- Service package options are available

Product Portfolio

Create

Networked
Digital Radio
Studios

Transport

Contribution &
Distribution:
IP - TDM - RF

Transmit Radio

AM - FM - DAB
Analog & Digital

Transmit TV

VHF - UHF
Analog & Digital

TRANSMIT: Television Broadcast Solutions

The industry’s most efficient, high-performance transmitters with the lowest TCO

GatesAir’s legacy of innovation in over-the-air UHF and VHF is unsurpassed

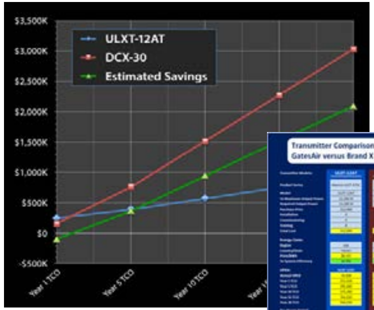
Ongoing support for standard changes that will occur over the life of a transmitter

UHF and VHF Transmitters

- Low-to-high power, high quality signal in all formats/standards
- Deliver rich, multi-format content for all coverage needs
- Facilitate multiple, updatable modulation schemes
- Deploy TV or DAB digital radio content transmission via VHF
- Remotely monitor and analyze signal via web interface

TV Accessories

- Operate multiple transmitters on the same frequency
- Improve coverage, boost redundancy, increase up-time



Television: Maxiva Product Family

GATESAIR

	Low Power Air Cooled	High Power Liquid Cooled	Super High Power LC
	5W → 2kW	→ 10kW	→ 40kW+
UHF Band IV/V	 Maxiva™ UAXT	 Maxiva™ ULXT	 Maxiva™ ULXT (Multi-rack)
VHF Band III	 Maxiva™ VAX-3D	 Maxiva™ VLX	Supports All Standards, Including: DVB T2, ISDB-T, DVB

Advanced Technology

- 40% less weight
- 50% less volume
- 44% lower cost
- 55% more efficient

- VHF and UHF Broadband High Efficiency technology for digital TV and radio delivers lowest total cost of ownership
- Software defined modulation capability addresses today's needs and tomorrow's opportunities

Maxiva ULXT

What is PowerSmart® ?

PowerSmart® is the on-going GatesAir design initiative to create the most efficient transmitter designs and products. GatesAir leverages the most sophisticated tools to develop cost, energy, and space efficient solutions.

Television

The Maxiva™ family of UHF transmitters led this initiative with the first 50V LDMOS device-driven transmitter in the industry setting a new benchmark for power density and efficiency.

Radio

The Flexiva™ family of FM transmitters set new benchmarks with operating efficiencies of up to 72%, the first FM design to use 50V LDMOS devices, and the smallest footprint at 10kW and higher power levels.

Actively Defining the Future of Broadcasting

GatesAir is an active member, partnered with, or sponsors:

- **ATSC**
- **DVB** Project Office
- **World DMB**
- **DRM** Consortium
- **Ibiquity (HD Radio)**
- **Mackenzie University**, São Paulo, Brazil
- **ABU**, Asia-Pacific Broadcast Union

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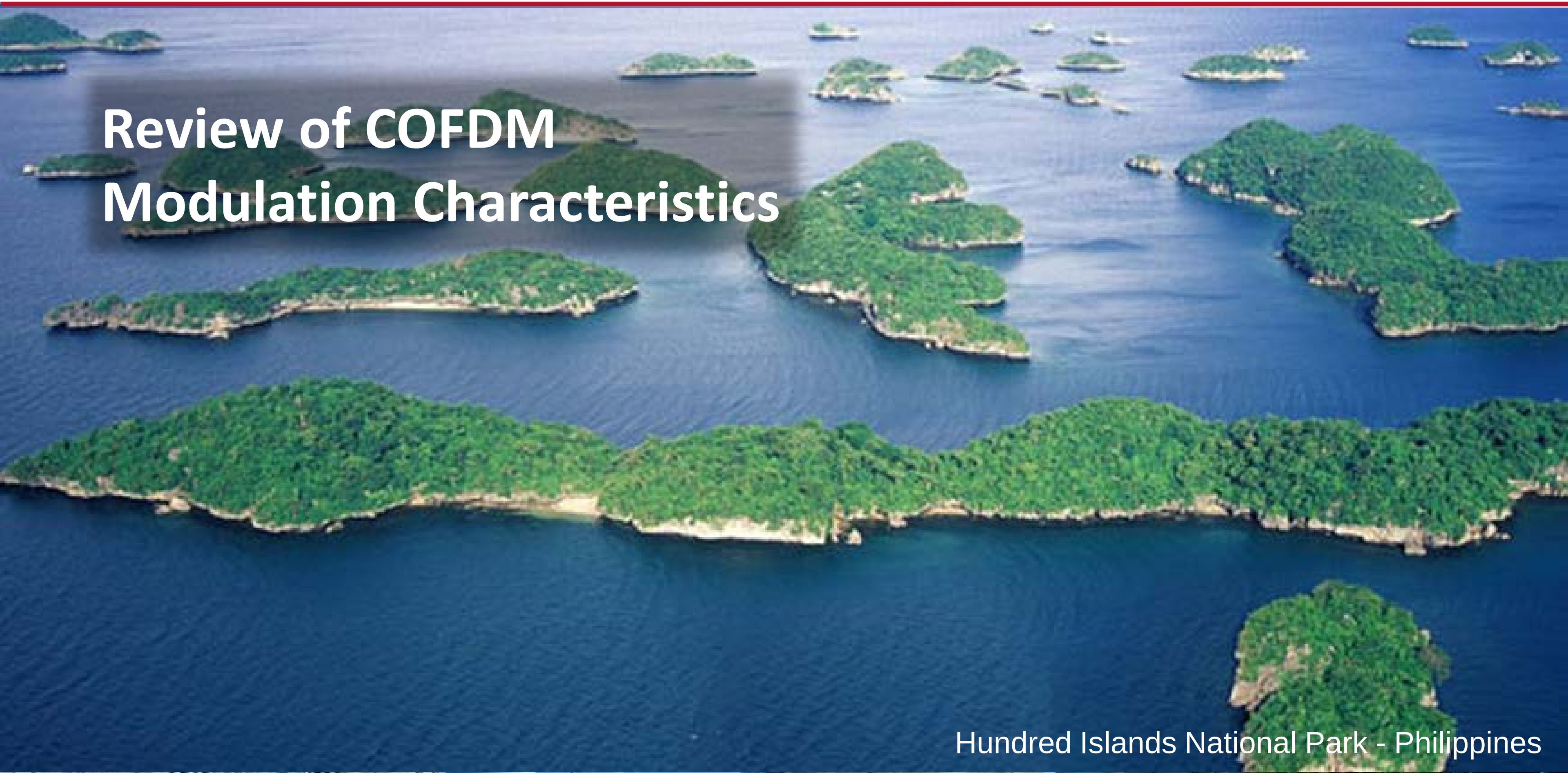
Connecting What’s Next

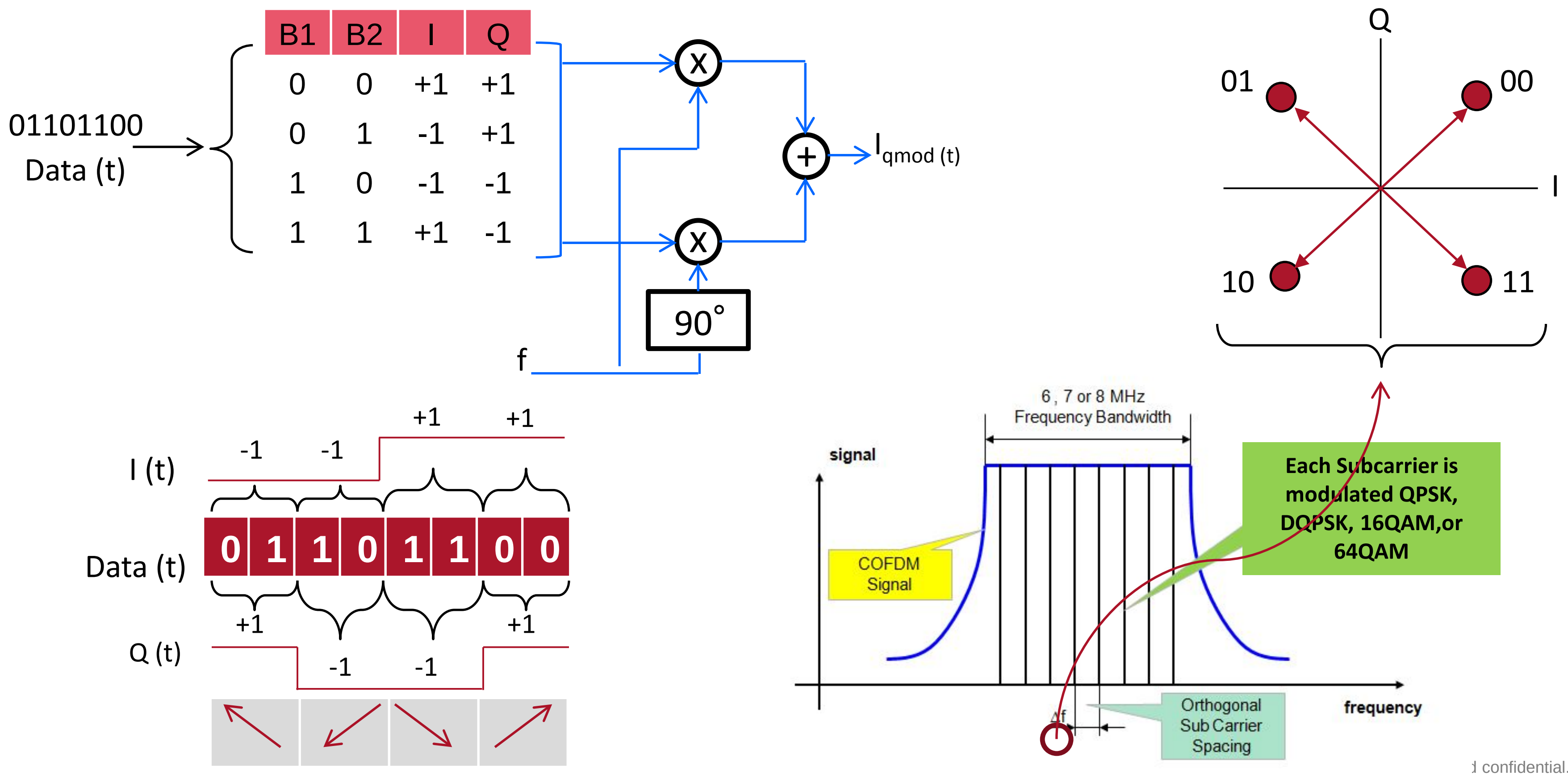
Review of COFDM Modulation Characteristics



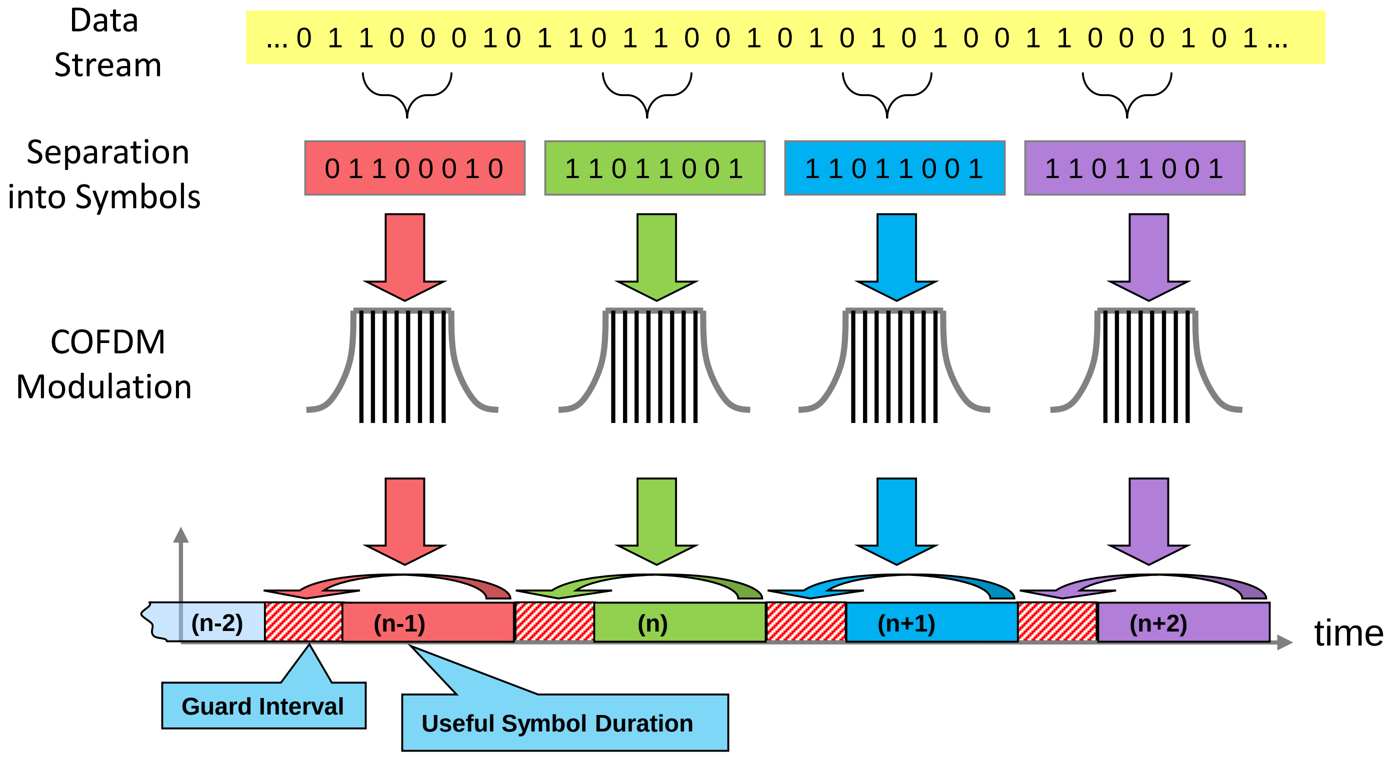
Hundred Islands National Park - Philippines

COFDM Modulation (Modulation Mapper)

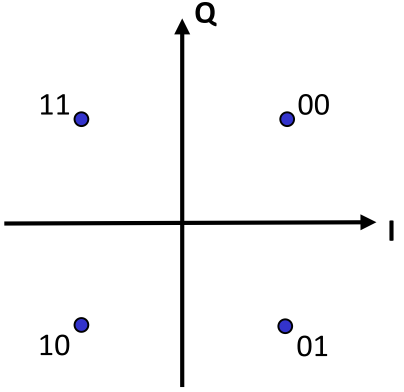
B1	B2	I	Q
0	0	+1	+1
0	1	-1	+1
1	0	-1	-1
1	1	+1	-1



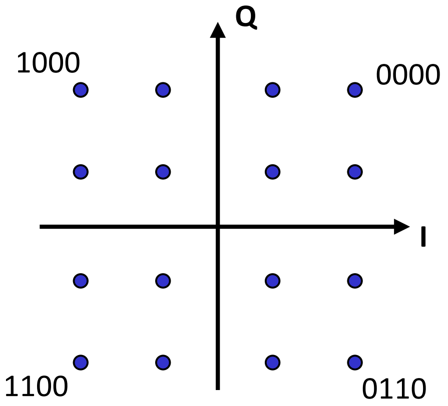
Modulation (Visualization of COFDM Modulation)



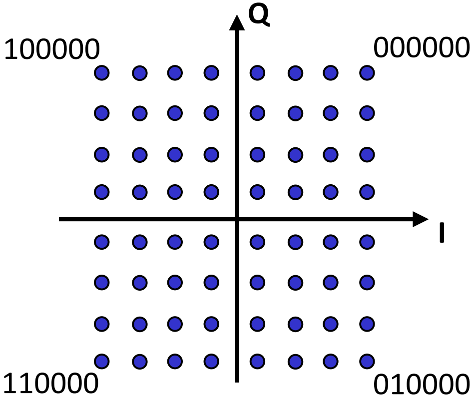
Subcarrier Modulation



QPSK



16-QAM



64-QAM

QPSK:
4 carrier positions

A QPSK carrier can transport 2 bits

16-QAM:
16 carrier positions

A 16-QAM carrier can transport 4 bits

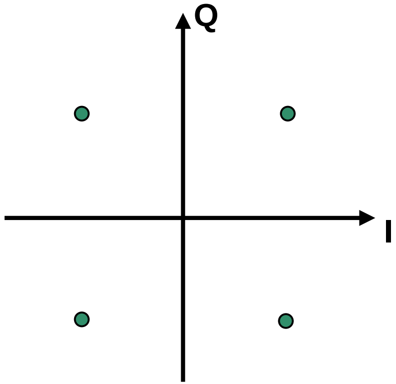
64-QAM:
64 carrier positions

A 64-QAM carrier can transport 6 bits

QPSK = Quadrature Phase Shift Key

QAM = Quadrature Amplitude Modulation

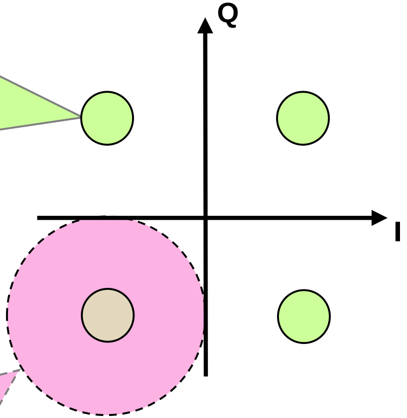
QPSK Modulation



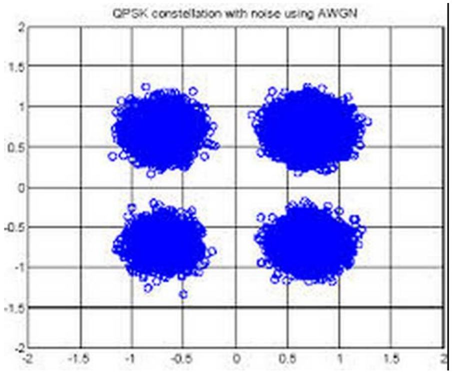
Constellation Diagram
of a QPSK signal
as generated
in the transmitter

Inaccuracy caused by noise added in the transmission channel

Maximum allowed inaccuracy for error free reception

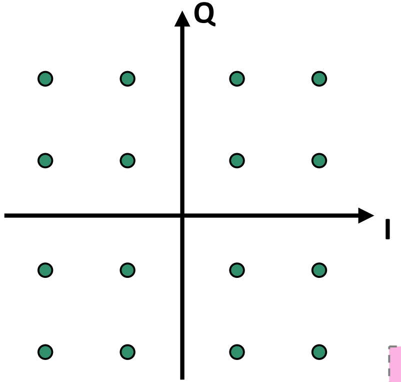


Constellation Diagram of a
QPSK Signal
as received by a receiver

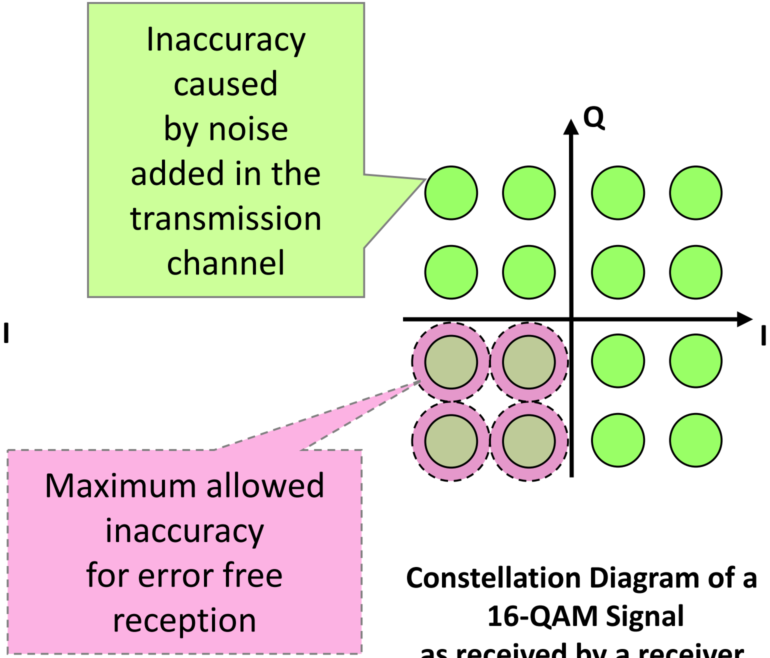


AWGN (Noise) on a QPSK
signal at receiver

16 QAM Sub Carrier Modulation

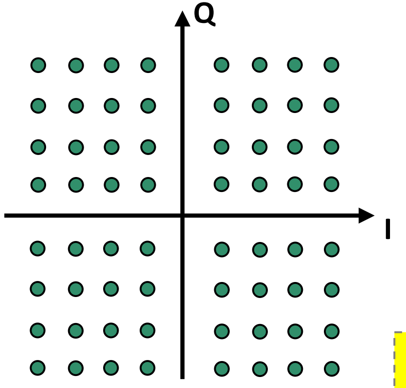


Constellation Diagram of a 16-QAM signal as generated in the transmitter



Constellation Diagram of a 16-QAM Signal as received by a receiver

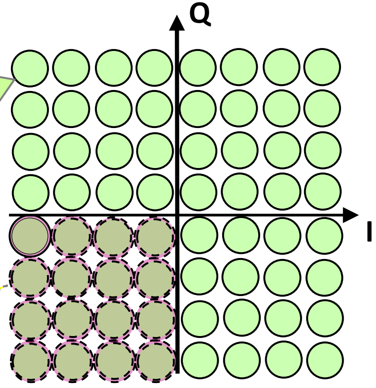
64 QAM Sub Carrier Modulation



Constellation diagram of a 64-QAM signal as generated in the transmitter

Inaccuracy caused by noise added in the transmission channel

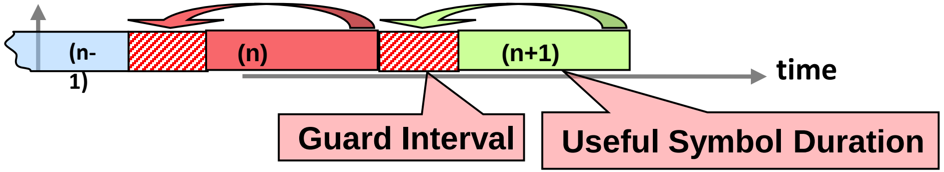
Maximum allowed inaccuracy for error free reception



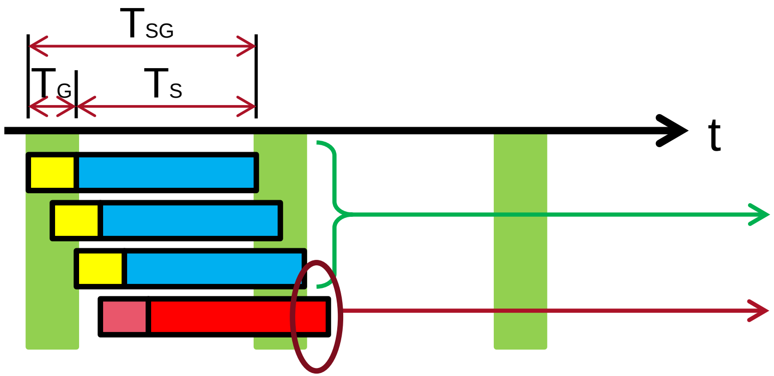
Constellation Diagram of a 64-QAM Signal as received by a receiver

Guard Interval

- The guard interval is used to ensure that distinct transmissions do not interfere with one another.



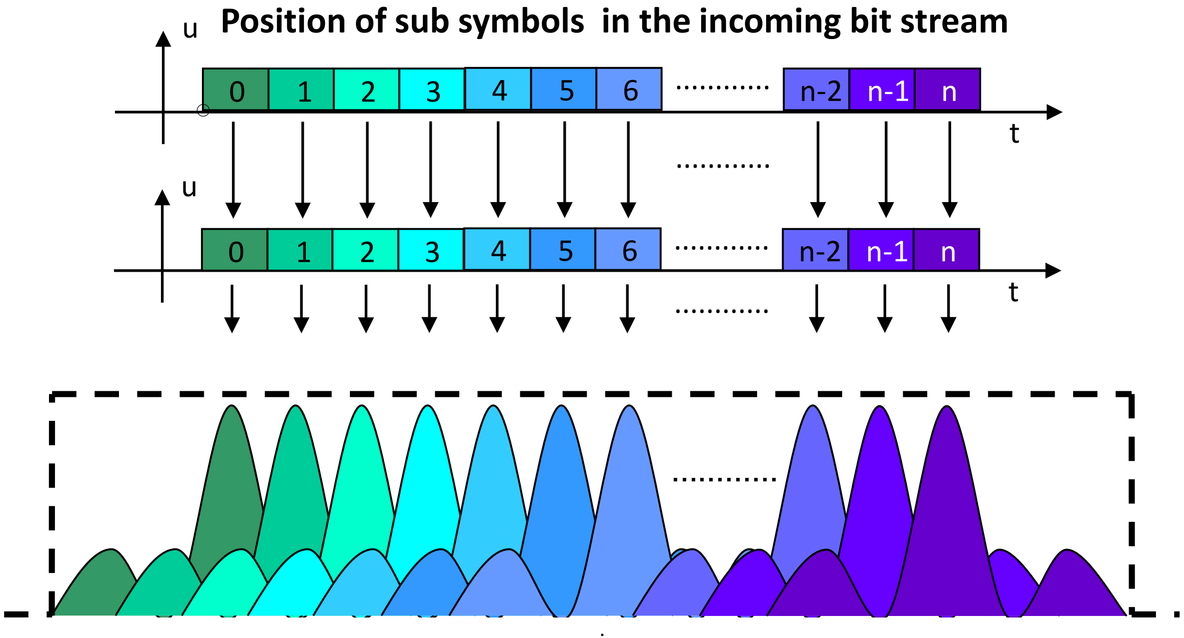
- The guard interval is not empty, the guard interval includes a copy of part of the data that was previously transmitted.



Multi path signals received within the guard interval help the receiver by adding additional signal strength

Multi path signals received outside the guard interval are destructive interference.

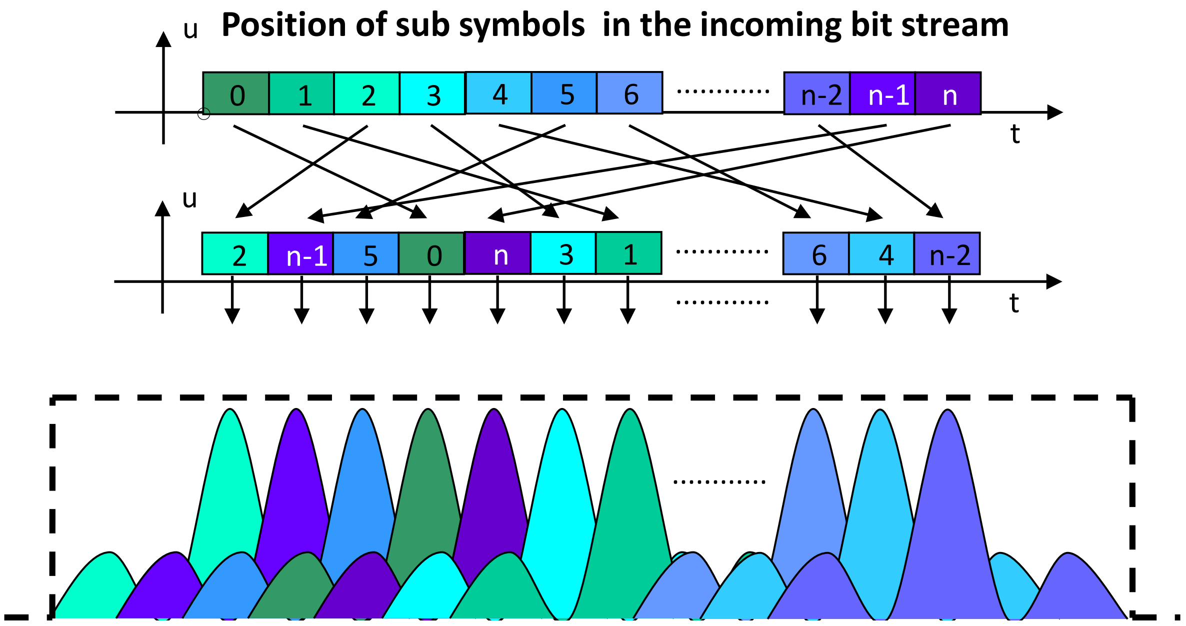
COFDM Modulation (No Interleaving)



Position of sub symbols assigned to the sub carriers in the OFDM signal is the same as their position in the incoming data stream

If several adjacent sub carriers are attenuated, as could happen with multipath or other types of interference, the adjacent data will be corrupted. This type of error is difficult for the forward error correction circuits to correct.

COFDM Modulation (With Interleaving)



Position of sub symbols assigned to the sub carriers in the COFDM signal is not the same as their position in the incoming data stream

If several adjacent sub carriers are attenuated, because of multipath or other types of interference, the corrupted data will be interleaved throughout the data stream when the incoming data stream order is re-established in the receiver. This type of error is easier for the forward error correction circuits to correct.

ISDB-T Overview / Training

Philippines

DTV Selection Made! - June 11, 2012

GATESAIR

Manila Standard TODAY

FRIDAY June 11, 2010 | A9

BUSINESS

NTC picks Japan's digital TV technology

By Jeremiah F. de Guzman

THE National Telecommunications Commission has selected Japan's integrated services digital broadcasting technology in the Philippines' bid to shift from analog to digital television.

"In order to facilitate the entry of digital broadcast services in the country and for the protection of the consuming public, there is a need to adopt a specific standard for the delivery of digital terrestrial television services," the NTC said in a draft circular.

"The [ISDB-T] standard shall be the sole standard in the delivery of [DTT] in the country," the commission said.

ISDB-T, introduced in 2003, is adopted in Japan, Brazil and Peru.

European's digital video broadcast system, which was introduced in 1998 and being used in 121 countries, including France, India and Taiwan, was Japan's closest rival in the selection process.

DVB-T offered set top boxes costing between $13 and $14, while ISDB-T quoted a factory price of $12 from its offer of around $40 to $50 last year.

The NTC said it made the decision after convening two technical working groups and on the recommendation of the majority shareholders in the television industry, which include the Kapisanan ng mga Brodkaster ng Pilipinas.

The digital terrestrial TV refers to the implementation of the digital technology in the TV service that provides a greater number of channels and better quality of picture and sound through a conventional aerial antenna instead of a satellite or cable connection.

The NTC said Japan's ISDB-T was a "flexible digital TV transmission system" that could provide audio, video and data services to fixed, mobile and hand-held devices without the need for an additional facility.

The commission has set a public hearing on the issue today. It asked interested parties to submit their respective position papers on the preferred digital TV platform.

Broadcasting companies ABS-CBN Broadcasting Corp., GMA Network Inc. and TV5 earlier said they were leaning toward the Japanese standard after its proponents lowered the price of set top boxes.

The Japanese government earlier offered to manufacture set top boxes for the country's transition.

NTC Deputy Commissioner Douglas Michael Mallillin said the proponents of integrated services digital broadcasting technology were intensely lobbying the government to outbid European's digital video broadcast technology.

Mallillin added that "the Japanese have made a commitment that if the Japanese standard is to be awarded, they will set up a factory here in the Philippines."

Dis-appointments

Victor C. Agustin
COCKTALES

WHAT is wrong with the staff work in Malacañang?

Staunch administration supporter Jose Leviste III is the latest person to deny that

Connecting What's Next

ISDB-Tb – What is it?

- **ISDB-Tb** is derived from the Japanese ISDB-T digital terrestrial television standard. Also called **ISDBT International**
- **I**ntegrated **S**ervices **D**igital **B**roadcasting - **T**errestrial **b**razil
- Defined by standard ABNT NBR 15601
- It is very similar to the Japanese version
- Main differences are the use of a more efficient H.264/MPEG-4 HE AAC video/audio Codec and new Middleware (Ginga)
- It is suitable for MFN and SFN applications
- It can transmit up to three hierarchical layers

ISDB-T Basic Transmission Parameters

Transmission Parameter	Mode 1	Mode 2	Mode 3
No. of OFDM segments	13		
Bandwidth	5.575 MHz	5.573 MHz	5.572 MHz
Carrier interval	3.968 kHz	1.984 kHz	0.992 kHz
No. of carriers	1405	2809	5617
Modulation system	QPSK, 16QAM, 64QAM, DQPSK		
Effective symbol length	252 μs	504 μs	1.008 ms
Guard-interval length	1/4, 1/8, 1/16, 1/32 of effective symbol length		
No. of symbols per frame	204		
Time interleave	4 maximum values: 0, about 0.13, 0.25, 0.5 sec		
Frequency interleave	Intra-segment or inter-segment interleaving		
Inner code	Convolutional coding (1/2, 2/3, 3/4, 5/6, 7/8)		
Outer code	RS (204, 188)		
Information bit rate	3.65 Mbps - 23.23 Mbps		
Hierarchical transmission	Maximum 3 levels		

ISDB-Tb – Brazil Timeline

- 1999 – Initiation of the technical evaluation to choose the standard
- 2003 – Foundation of Committee of SBTVD.
- 2006 – Selected the standard based on the Japanese system
- 2007 – Defined the transmission schedule
- Dec 2007 – First ISDB-Tb digital transmission in Sao Paulo – Brazil
- 2010 – DTV coverage extended to 20 state capitals and 10 inner cities – Much of Brazil can watch the South African World cup in HDTV!
- 2012 – 72% of Brazil's 433 major cities now have DTV coverage
- 2016 – Analog shut down in 6 major cities, starting in April
- 2018 – Analog shut down for Brazil complete by end of the year

ISDB-T Compared to ISDB-Tb/International

ISDB-T

Japan

Full Seg
Video: MPEG2
Audio: MPEG2 Layer 3

One Seg
Video: H264 a 15fps
Audio: HE-AAC v1

Middleware
BML

ISDB-Tb / International

Brazil, Argentina, Philippines, Peru
Chile, Botswana, Others

Full Seg
Video: **H264 – MPEG4 Part 10**.
Audio: **HE-AAC (AAC+) 2.0 or 5.1**

One Seg
Video: H264 a **30fps**
Audio: **HE-AAC v2** (Parametric stereo)

Middleware
Ginga

ISDB-T and ISDB-Tb/International

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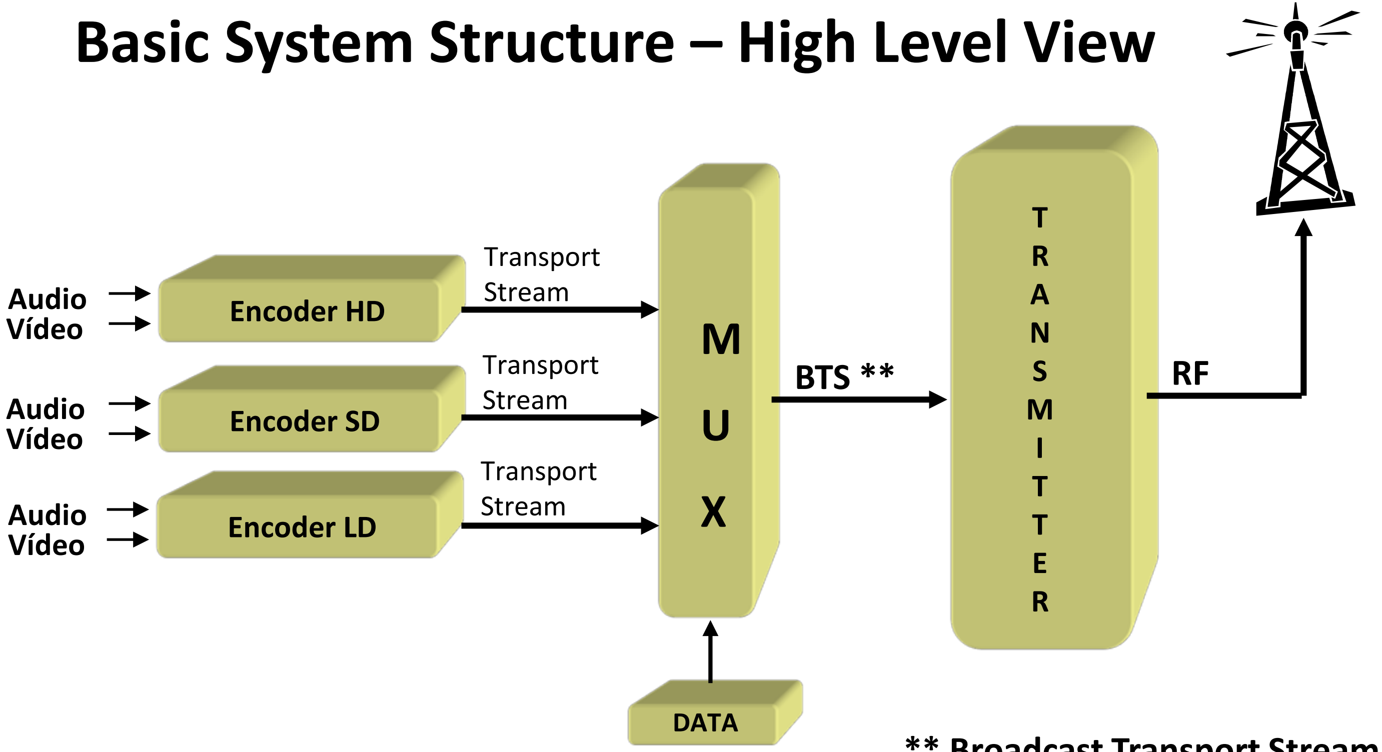
Standards have been Harmonized between Brazil and Japan:

Subject	ISDB-T (Japan)	ISDB-Tb/International
Terrestrial Transmission	ARIB SDT B31	ABNT 15601
Audio & Video Encoding	ARIB SDT B32	ABNT 15602
Multiplexer	ARIB SDT B10	ABNT 15603
Receiver	ARIB SDT B21	ABNT 15604
Security	ARIB SDT B25	ABNT 15605
Middleware	ARIB SDT B24	ABNT 15606
Interactive (return) Channel	ARIB SDT B14	ABNT 15607
Operational Guide	-	ABNT 15608
Accessibility	-	ABNT 15610

More information available at:
http://www.forumsbtvd.org.br/materias.asp?id=243

ISDB-Tb - Structure

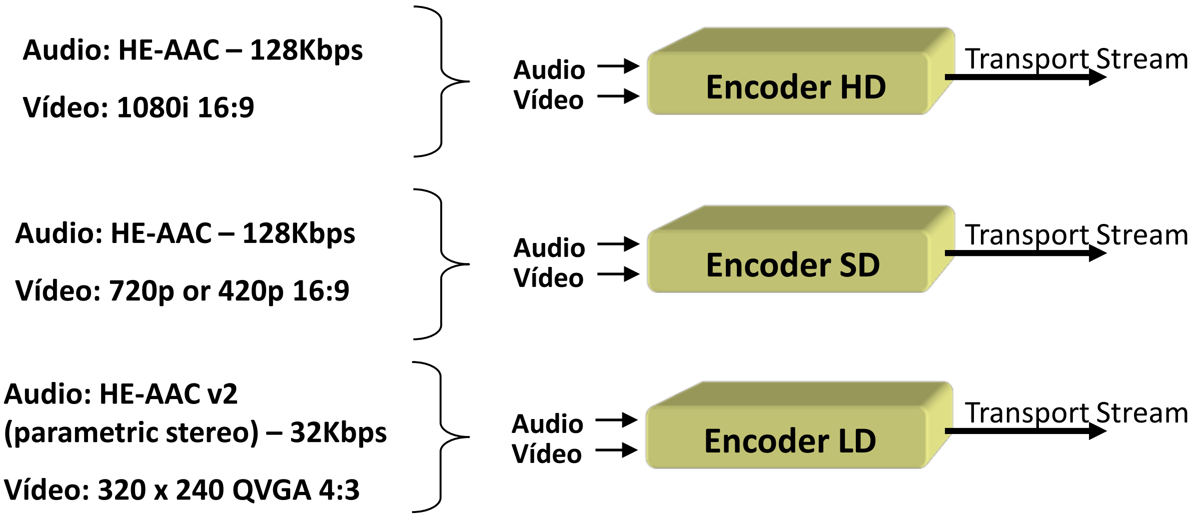
Basic System Structure – High Level View



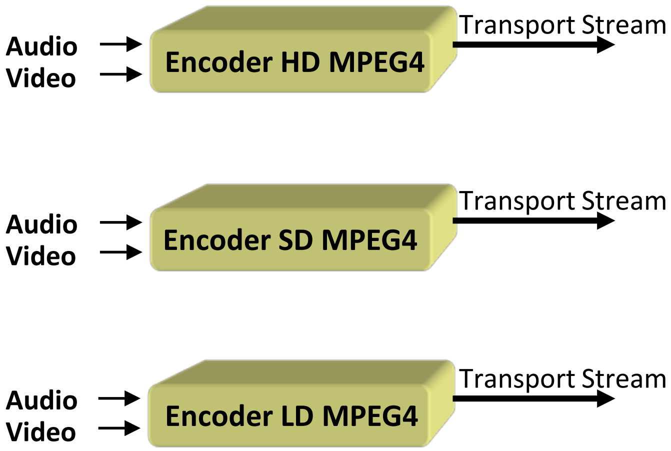
** Broadcast Transport Stream

ISDB-Tb - Structure

Basic System Structure - Video and Audio Paths



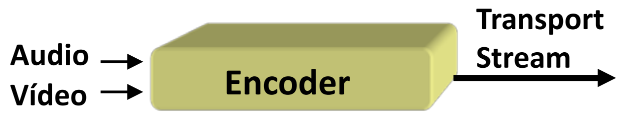
Basic System Structure – TS – Transport Stream



- Each TS packet flow is compressed data derived from the transport layer of MPEG (Moving Picture Expert Group).
- Each Packet Contains 188 Bytes.
- Each packet of 188 bytes in the TS is identified with a PID (Packet IDentifier)
- To identify the contents of each packet to the transport layer utilizes a set of MPEG tables:
  - PAT (Program Association Table)
  - PMT (Program Map Table)
  - In addition the PCR (Program Clock Reference) is added

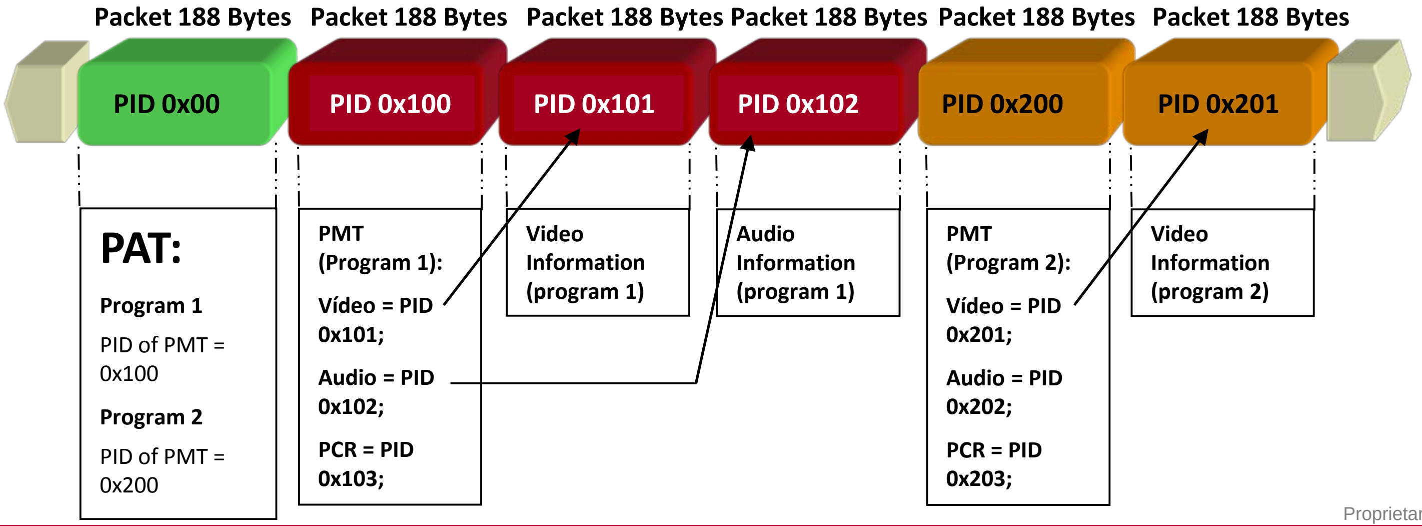
ISDB-Tb - Structure

Basic System Structure – TS – Transport Stream



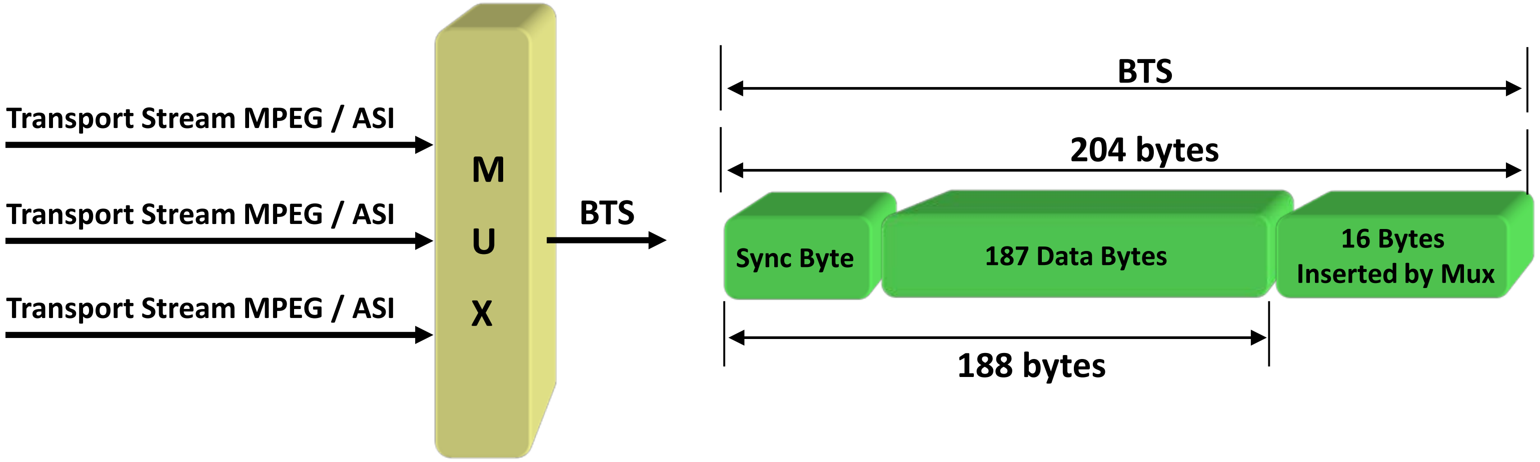
TS can include Audio + Vídeo + Data

Packet flow 188 bytes which form a TS



ISDB-Tb - Structure

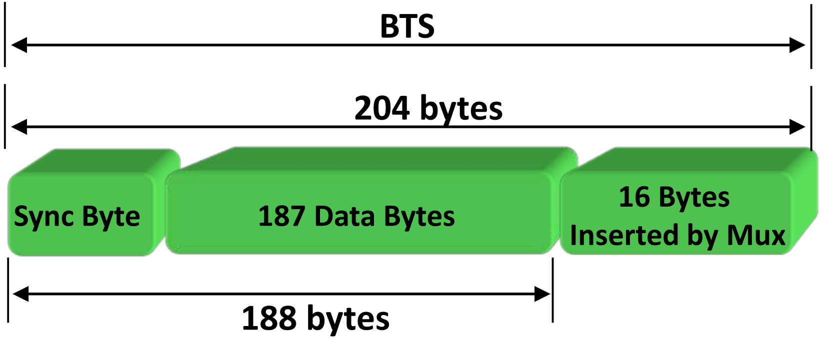
Basic Structure of BTS - Broadcast Transport Stream



BTS bit rate is 32.5079365 Mbps (Always this rate)

ISDB-Tb - Structure

Basic Structure of BTS - Broadcast Transport Stream

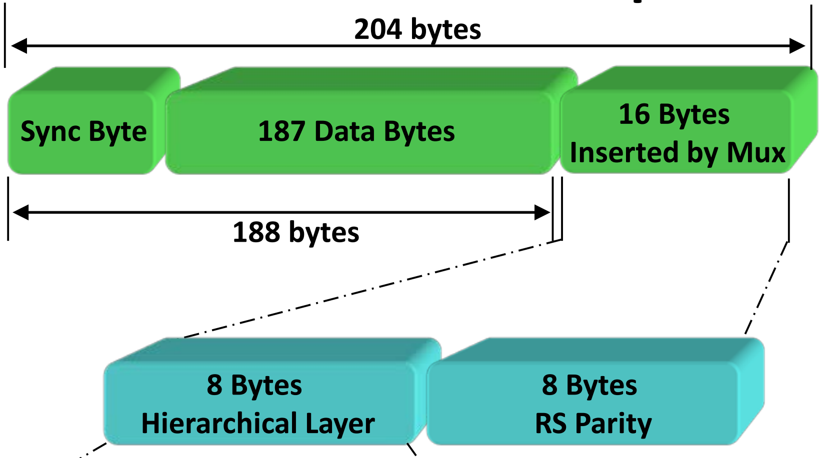


Tables added by the MUX:

- **NIT (Network Information Table)** - Carries Network Information and Programs
- **TOT (Time Offset Table)** - Carries information from the current day and time to update the Set-top box
- **EIT (Event Information Table)** - Carries data for program schedule

ISDB-Tb - Structure

Basic Structure of BTS – Broadcast Transport Stream – 16 Bytes



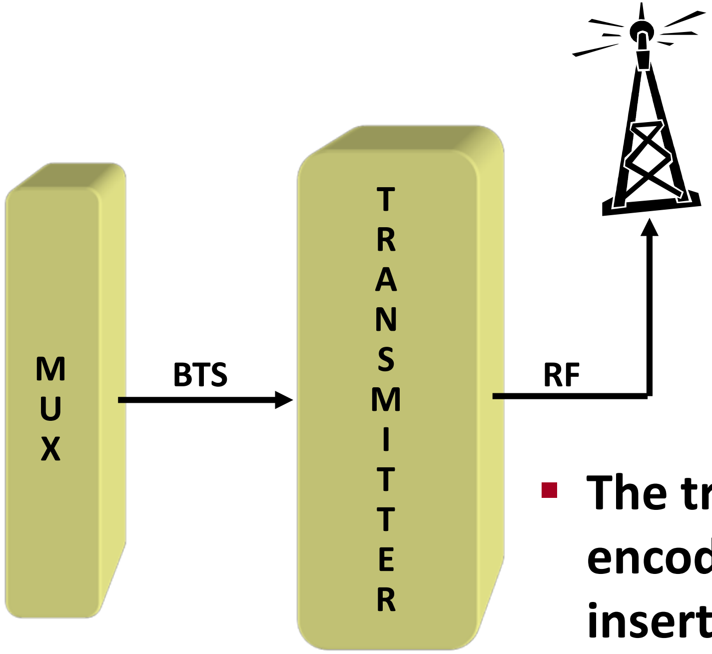
IIP (ISDB-T Information Packet). Data includes:

- No. of segments
- Code rate
- Modulation
- Time interleaver

Used by the transmitter / modulator system configuration. Carriers are transmitted in the TMCC (Transmission and Multiplexing Configuration Control)

ISDB-Tb - Structure

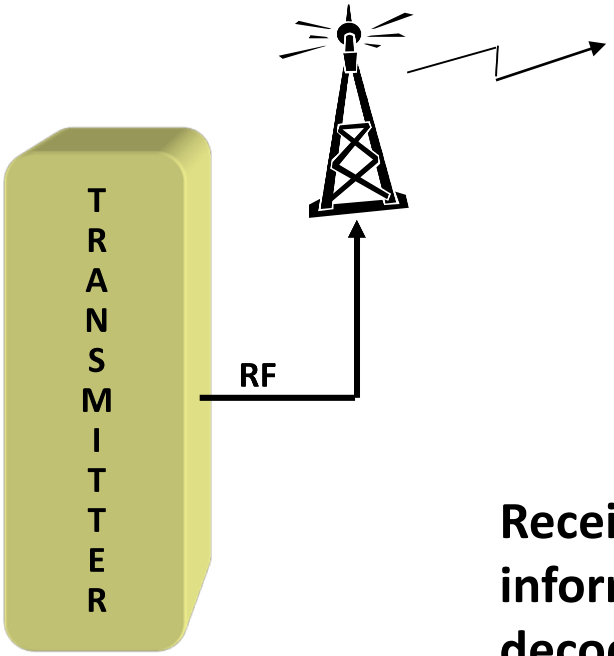
BTS to Transmitter



- The transmitter / modulator receives the encoded BTS, with all of the information inserted

ISDB-Tb - Structure

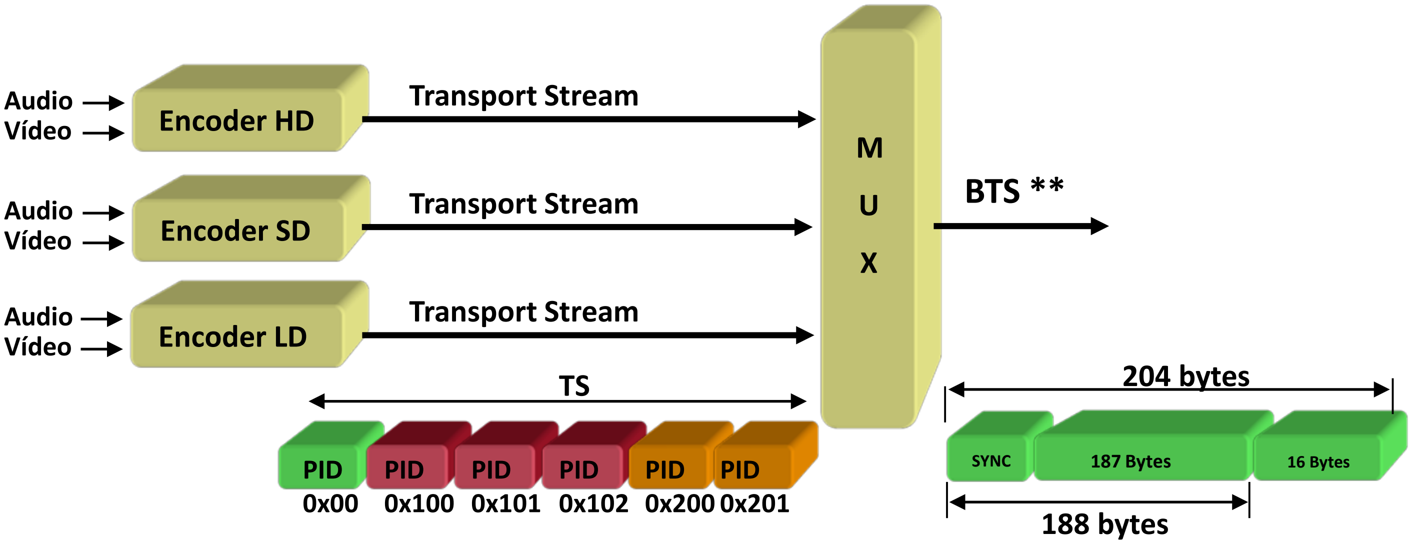
BTS to Transmitter



Receive devices receive and decode the IIP information using the TMCC carriers for correct decoding of information and programs

ISDB-Tb - Structure

Tables: PSI / SI (Program Specific Information / Service Information)

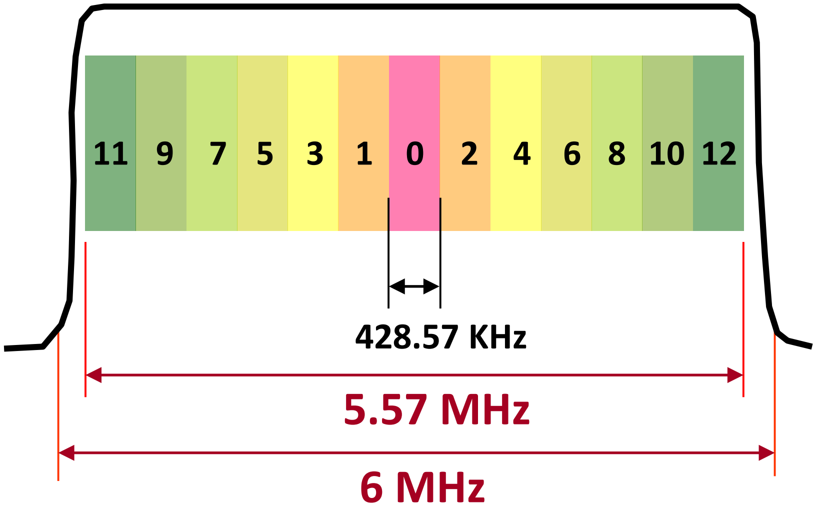


- PAT (Program Association Table)
- PMT (Program Map Table)

- NIT (Network Information Table)
- TOT (Time Offset Table)
- EIT (Event Information Table)
- CAT (Conditional Access Table)
- SDT (Service Description Table)

ISDB-Tb – RF Channel

6MHz Channel Bandwidth



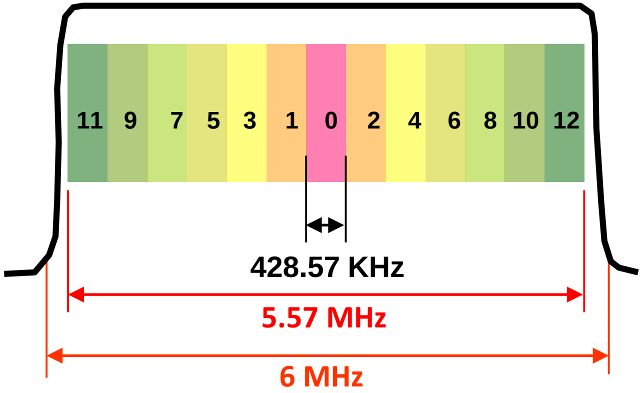
The 6MHz channel is divided into 13 equal OFDM* segments, each occupying 428.57 kHz (6/14 MHz)

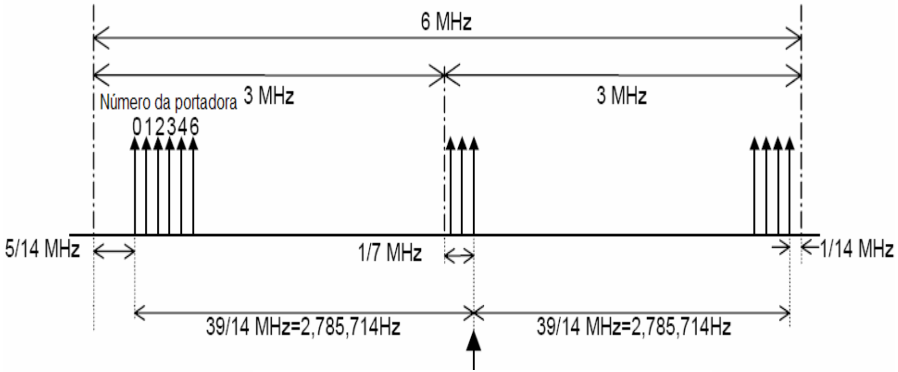
***OFDM – Orthogonal Frequency Division Multiplexing.**

ISDB-Tb – RF Channel

6MHz Channel – Offset Frequency

In Brazil, all ISDB-Tb channels use an offset of 1/7 MHz with respect to the center frequency





Center Frequency for ISDB-Tb

1/7 MHz = 0.142857MHz

Example: Channel 20 = 506 ~ 512MHz

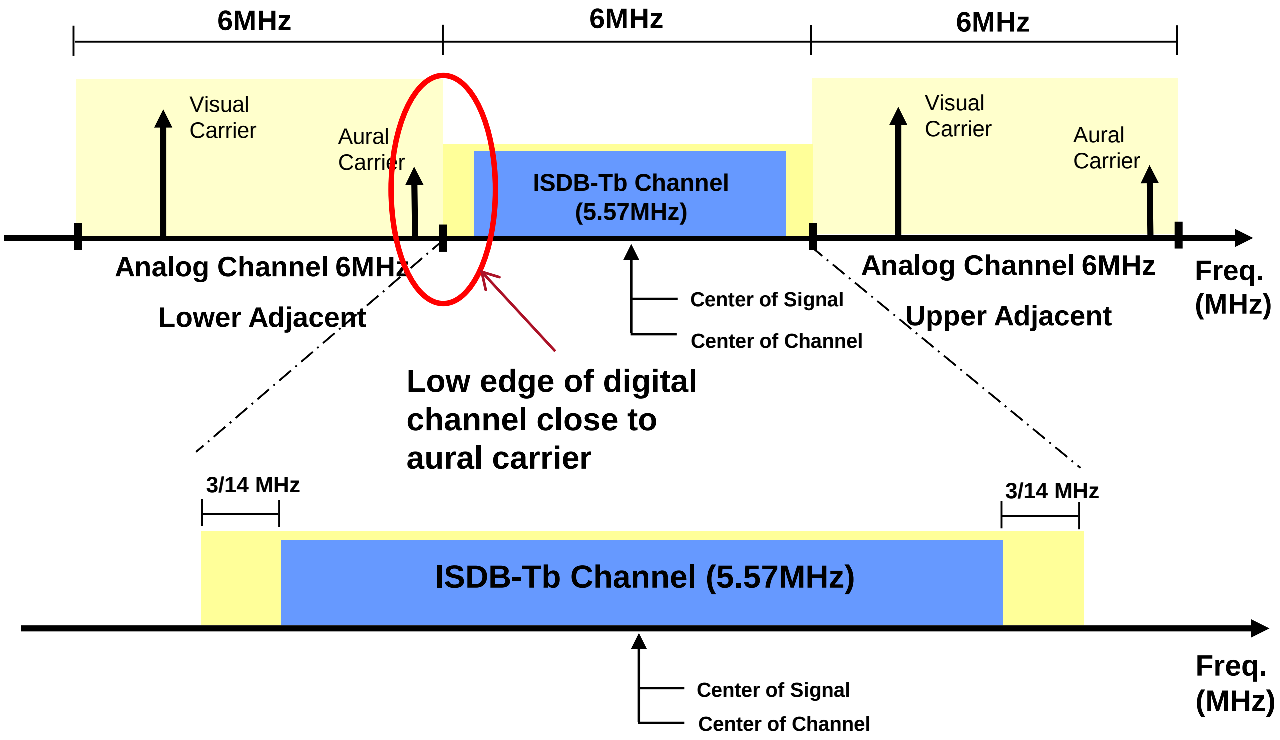
Center of channel is 509 + 0.142857

= 509.142857 MHz

6 MHz – 5.57 MHz = 0.43 MHz = 6/14 MHz

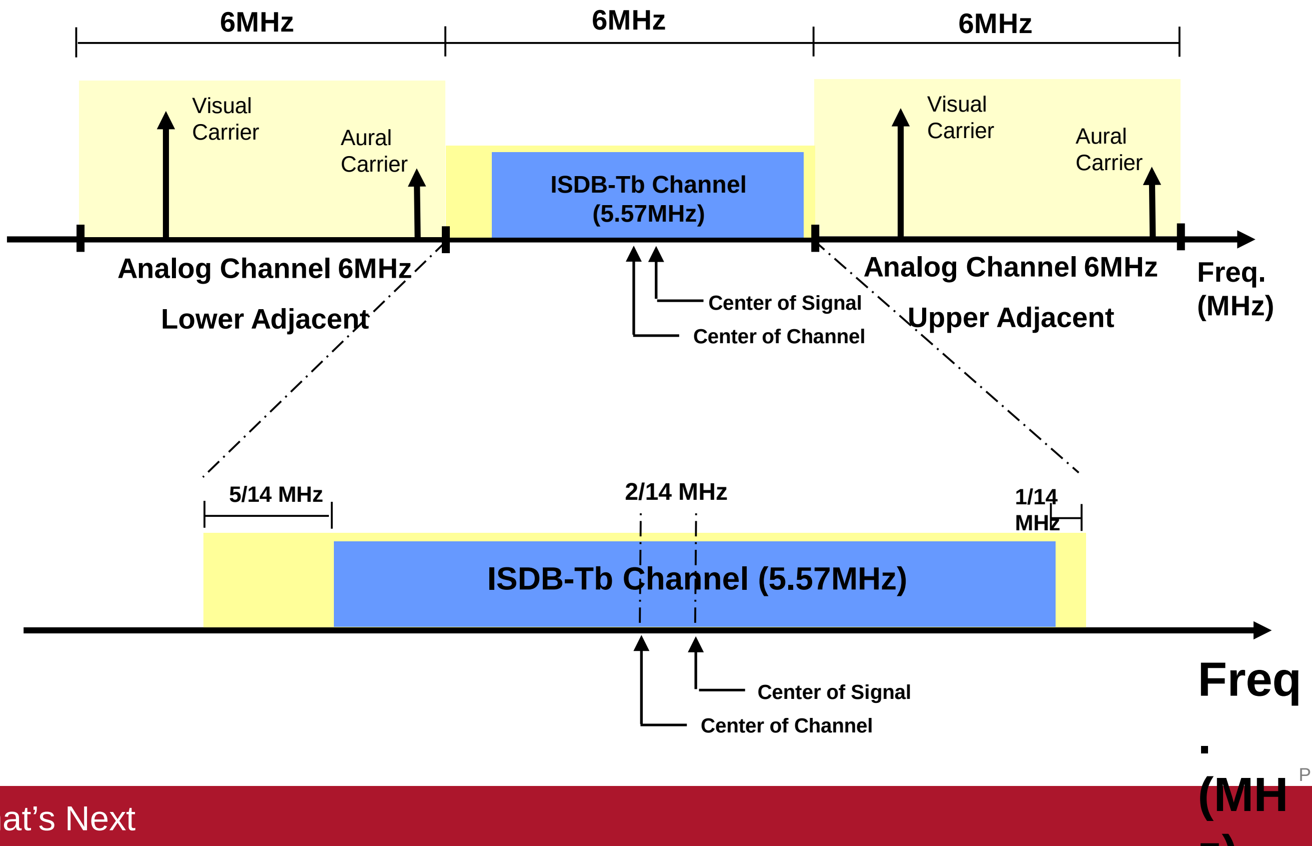
ISDB-Tb – RF Channel

6MHz Channel – No offset



ISDB-Tb – RF Channel

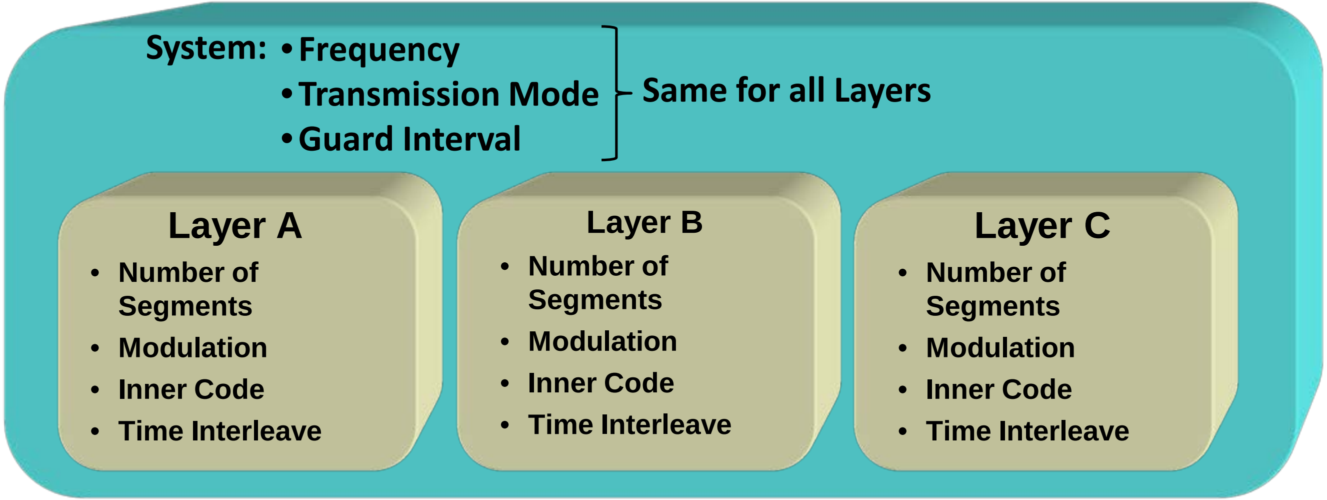
6MHz Channel – With 1/7 MHz Offset (to minimize interference to aural signal)



ISDB-Tb - Structure

Hierarchical Modulation

- The system can be set to 1, 2, or 3 layers
- The modulation of each layer can be set independently
- The configuration parameters of the system and of each layer are:



ISDB-Tb - Structure

Hierarchical Modulation - System parameters (always same for each layer):

1. Frequency

2. Mode of Transmission - Number of carriers per segment.

- **Mode 1**: 108 Carriers *(1,404 carriers over 13 segments)*
- **Mode 2**: 216 Carriers *(2,808 carriers over 13 segments)*
- **Mode 3**: 432 Carriers *(5,616 carriers over 13 segments)*

3. Guard Interval - Time interval between each OFDM Frame

Can be set to 1/4, 1/8, 1/16 or 1/32.

ISDB-Tb - Structure

Hierarchical Modulation - Configuration Parameters that can be set differently for each layer:

1. Number of segments in layer: 1 to 13

2. Modulation: DQPSK, QPSK, 16QAM and 64QAM

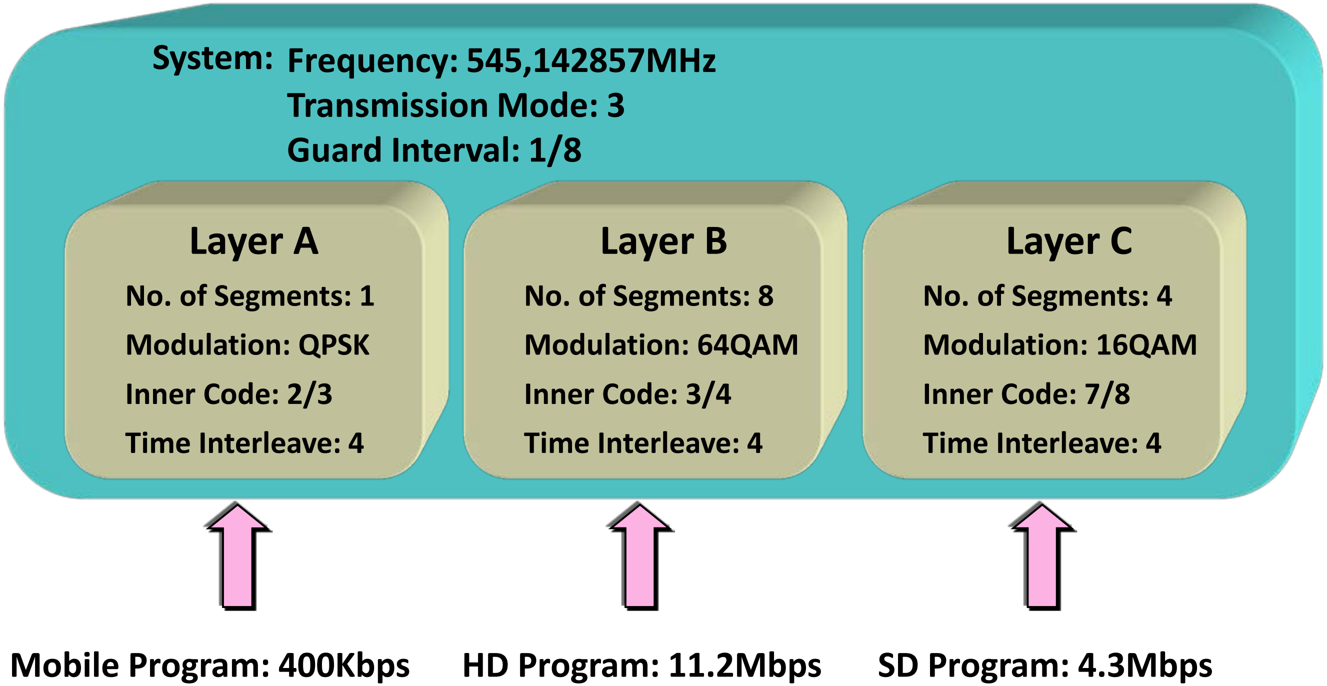
3. Inner code (FEC - Forward Error Correction): 1/2, 2/3, 3/4, 5/6, and 7/8.

4. Time Interleave:

- Transmission mode 1: 4, 8 or 16
- Transmission mode 2: 2, 4 or 8
- Transmission mode 3: 1, 2 or 4

ISDB-Tb - Structure

Example # 1 – Hierarchical Modulation – 3 Layers



ISDB-Tb - Structure

Example # 1 – Maximum Data Rate per Segment

Modulation	Code Rate	Number of TSP transmitted per segment (Mode 1/2/3)	Data Rate kbps			
			GI 1/4	GI 1/8	GI 1/16	GI 1/32
DQPSK QPSK	1/2	12/24/48	280,85	312,06	330,42	340,43
	2/3	16/32/64	374,47	416,08	440,56	453,91
	3/4	18/36/72	421,28	468,09	495,63	510,65
	5/6	20/40/80	468,09	520,10	550,70	567,39
	7/8	21/42/84	491,50	546,11	578,23	595,76
16QAM	1/2	24/48/96	561,71	624,13	660,84	680,87
	2/3	32/64/128	748,95	832,17	881,12	907,82
	3/4	36/72/144	842,57	936,19	991,26	1021,30
	5/6	40/80/160	936,19	1040,21	1101,40	1134,78
	7/8	42/84/168	983,00	1092,22	1156,47	1191,52
64QAM	1/2	36/72/144	842,57	936,19	991,26	1021,30
	2/3	48/96/192	1123,43	1248,26	1321,68	1361,74
	3/4	54/108/216	1263,86	1404,29	1486,90	1531,95
	5/6	60/120/240	1404,29	1560,32	1652,11	1702,17
	7/8	63/126/252	1474,50	1638,34	1734,71	1787,28

[a] Essa taxa de dados representa a taxa de dados (bits) por segmento para parâmetros de transmissão: taxa de dados (bits) = TSP transmitidos x 188 (bytes/TSP) x 8 (bits/byte) x 1/comprimento do quadro.

Layer A - QPSK, 2/3

1 Segment - 400Kbps

Maximum: 416.08kbps

Layer B – 64QAM, 3/4

8 Segments – 11.2Mbps

Maximum: 8 x 1404.29 = 11.23Mbps

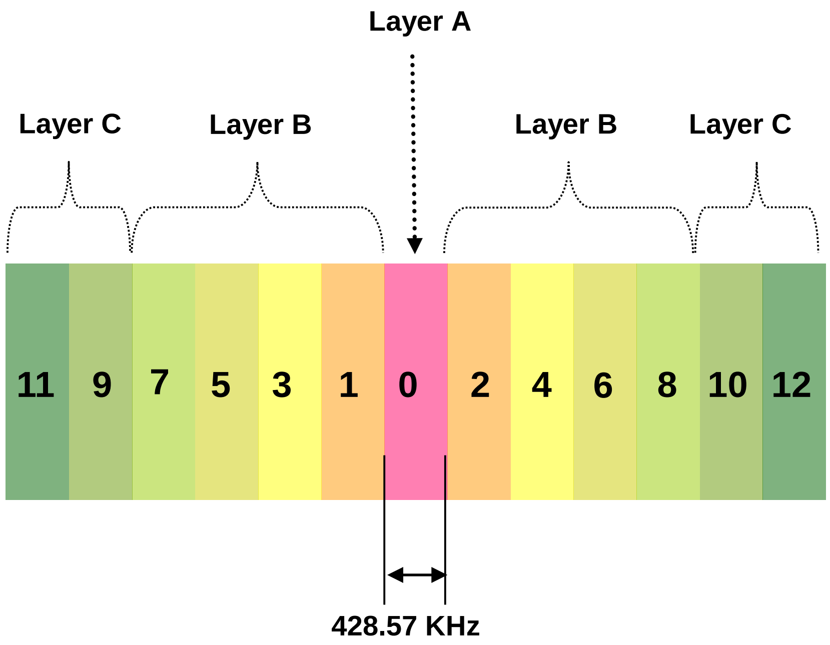
Layer C – 16QAM, 7/8

4 Segments – 4.3Mbps

Maximum: 4 x 1092.22 = 4.37Mbps

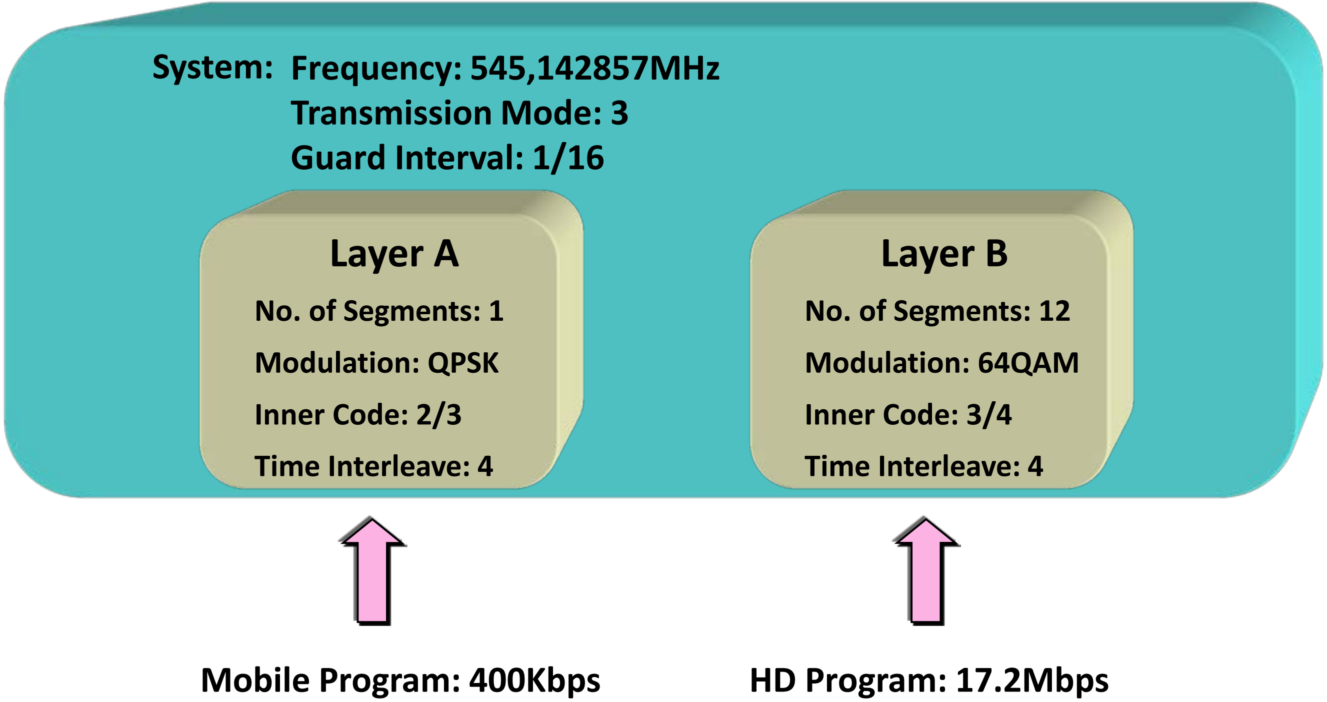
ISDB-Tb - Structure

Example # 1 – Segment Utlization



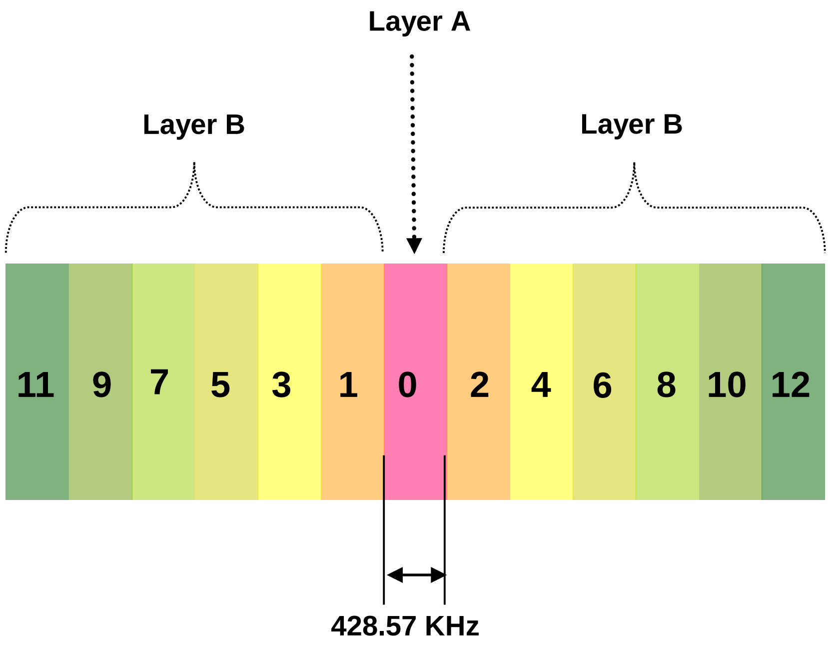
ISDB-Tb - Structure

Example # 2 – Hierarchical Modulation – 2 Layers



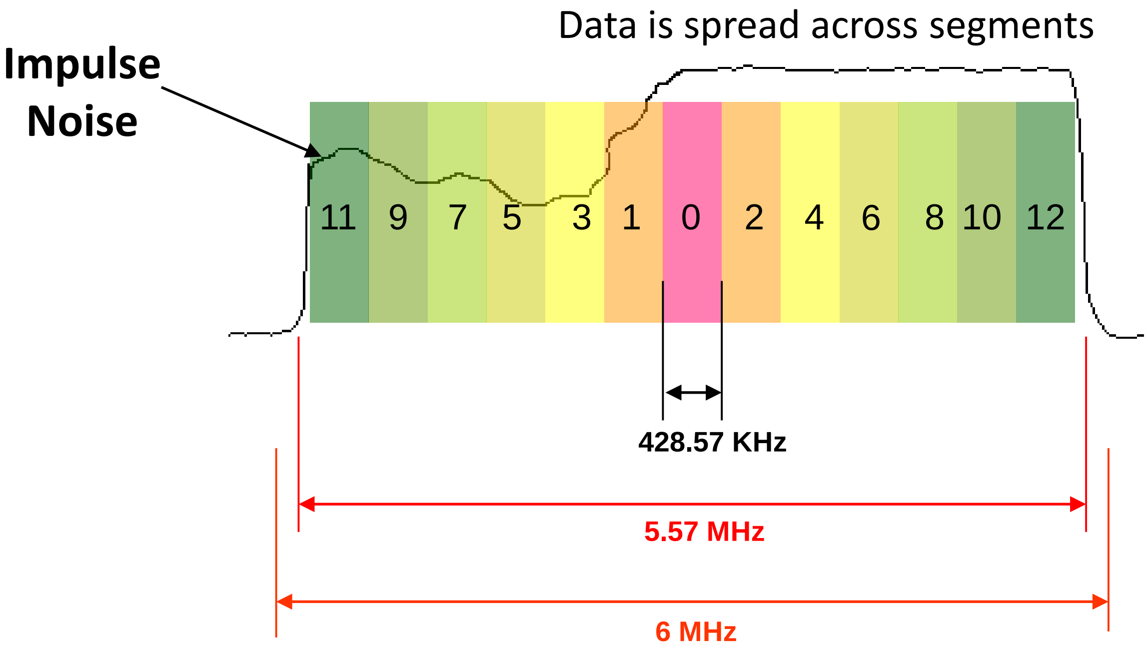
ISDB-Tb - Structure

Example # 2 – Segment Utilization



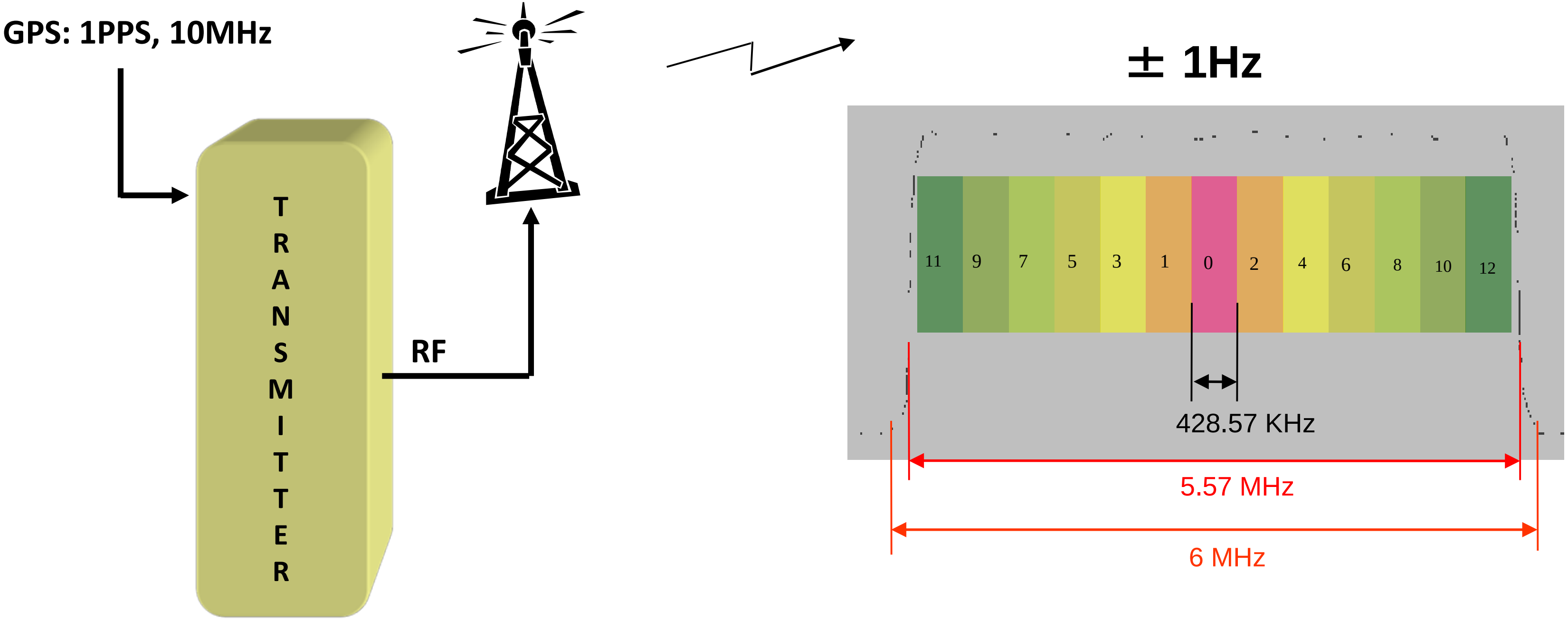
ISDB-Tb - Structure

OFDM – Reducing Multipath Problems



ISDB-Tb - Structure

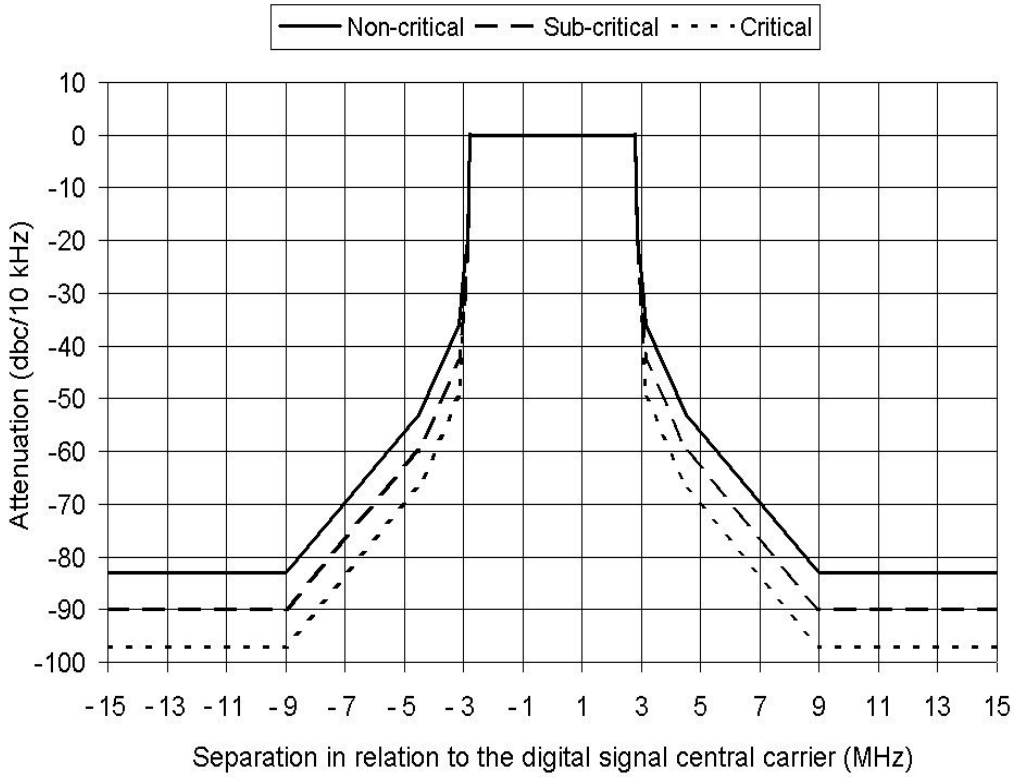
Synchronization



ISDB-Tb - Structure

Transmission Masks (Brazil):

- **Non-Critical: - 36dB@ ± 3.15MHz**
- **Sub-Critical: - 43dB@ ± 3.15MHz**
- **Critical: - 50db@ ± 3.15MHz**



ISDB-Tb - Structure

GATESAIR

Classes of Operation (Brazil)

Same class of operation as for the analog channel

Class	Maximum ERP (kW)	
	VHF High	UHF
Especial	16	80
A	1,6	8
B	0,16	0,8
C	0,016	0,08

ERP = Power of TX – Line Losses + Antenna Gain

ISDB-Tb Max Bit Rates

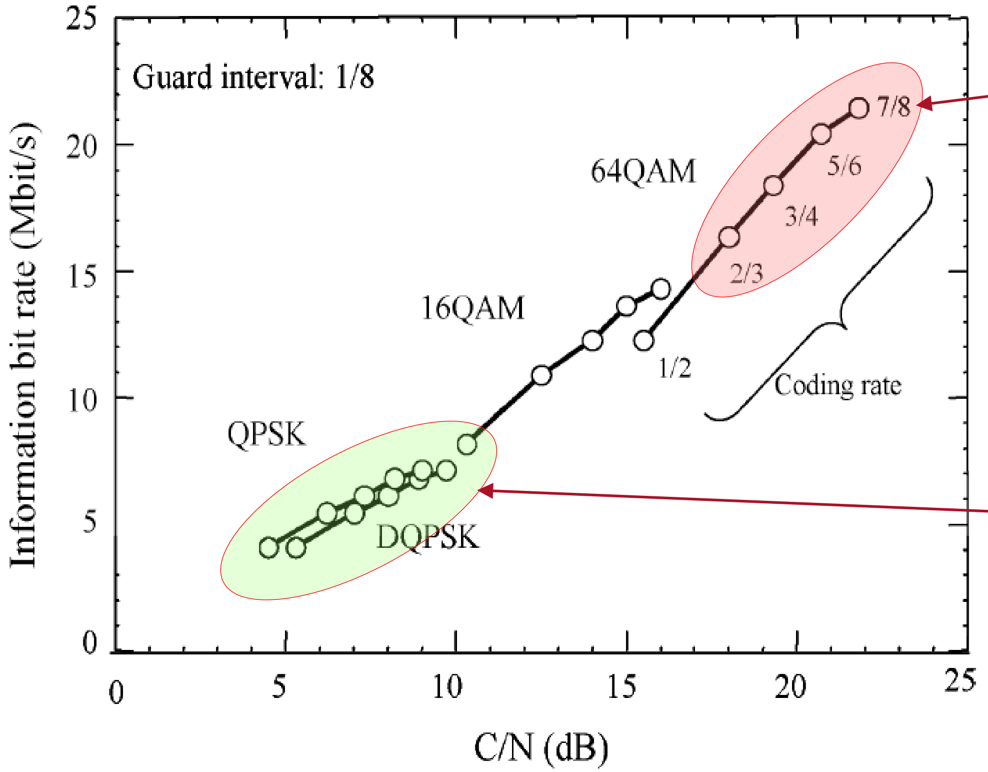


Fig. 6. CN ratio versus transmission capacity determined by channel coding.

Higher bit rates:
Best for HD, or multiple SD programs per tx but less robust (harder to receive)

Lower bit rates:
Best for Mobile or fewer programs per tx but more robust (easier to receive)

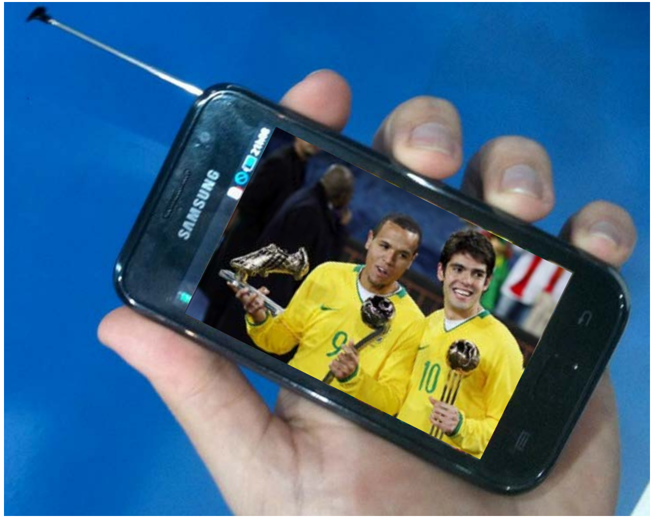
ISDB-Tb – Receivers

GATESAIR

Set Top Boxes

ISDB-T Receive Devices

Portable Receivers & Dongles



ISDB-Tb – Receivers

Flat Panel TV's

70" LED Smart TV (Sharp)

Emergency Broadcast Warning System

GATESAIR

The Philippines has firmly rejected Europe's DVB television transmission standard and instead selected Japan's ISDB scheme. A last ditch effort from Europe which talked of its widely adopted standard being cheaper to install and maintain, the nation's President Benigno Aquino has confirmed to Japan's Prime Minister Shinzo Abe that it will migrate to Japan's Integrated Service Digital Broadcasting (ISDB-T) transmission system.

"We are migrating to the Japanese digital standards... The clincher is the emergency broadcast feature or the ability to turn on television sets to broadcast a warning even if the television set is turned off. We are told that it was used during the Fukushima incident," the President said, confirming an earlier decision by the nation's National Telecommunications Commission.

Connecting What's Next

ISDB-T

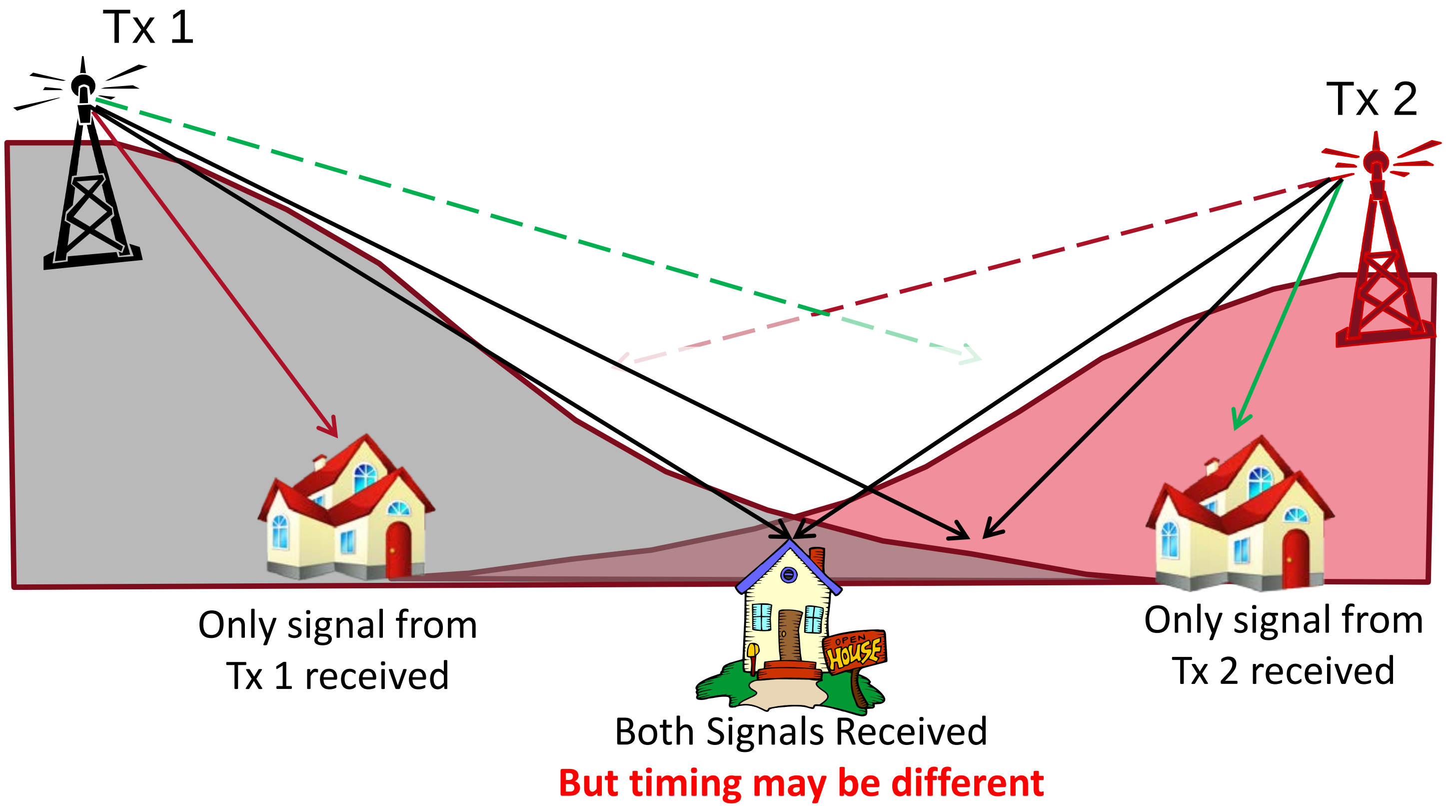
Single Frequency Network (SFN) and GatesAir Solution

Mayon Volcano, Albay Povince, Philippines

Single Frequency Network Operation

- In an SFN, each transmitter must radiate:
  - The same signal (the same bit)
  - At the same time
  - On the same frequency
- Since the Transmitter sites in the network are positioned at different locations usually the BTS is not available at all sites at the same time
- To solve this problem several methods have been implemented in the ISDBT Standard, most practical is called "Reference Synchronization"

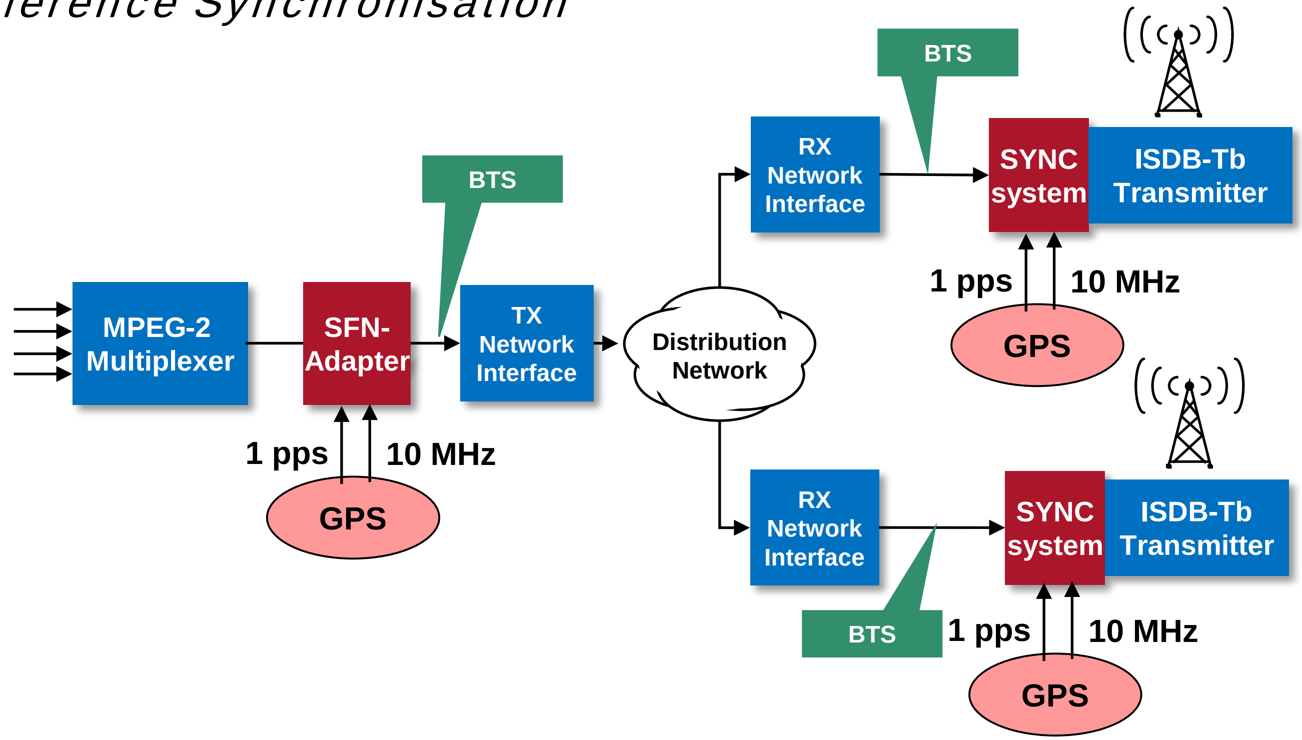
SFN Basics



Tx 1
Tx 2
Only signal from
Tx 1 received
Only signal from
Tx 2 received
Both Signals Received
But timing may be different

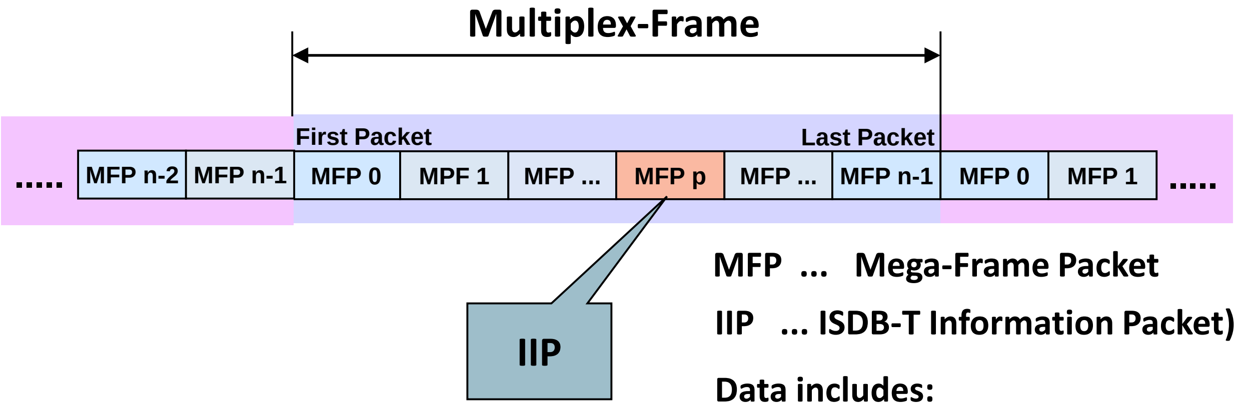
ISDB-Tb Network Structure

Using Reference Synchronisation



Multiplex-Frame

In the SFN Adapter Multiplex-Frames are built from the incoming MPEG-TS.



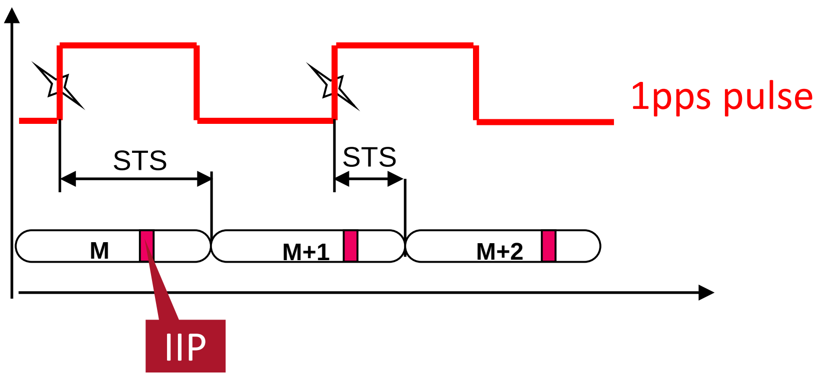
MFP ... Mega-Frame Packet

IIP ... ISDB-T Information Packet)

Data includes:

- No. of segments
- Code rate
- Modulation
- Time interleaver
- Information for SFN timing

Synchronisation Time Stamp (STS)



Synchronisation Timestamp (STS)
The synchronisation timestamp value is the difference in time between the rising edge of the 1pps Symbol and the beginning of a mega-frame

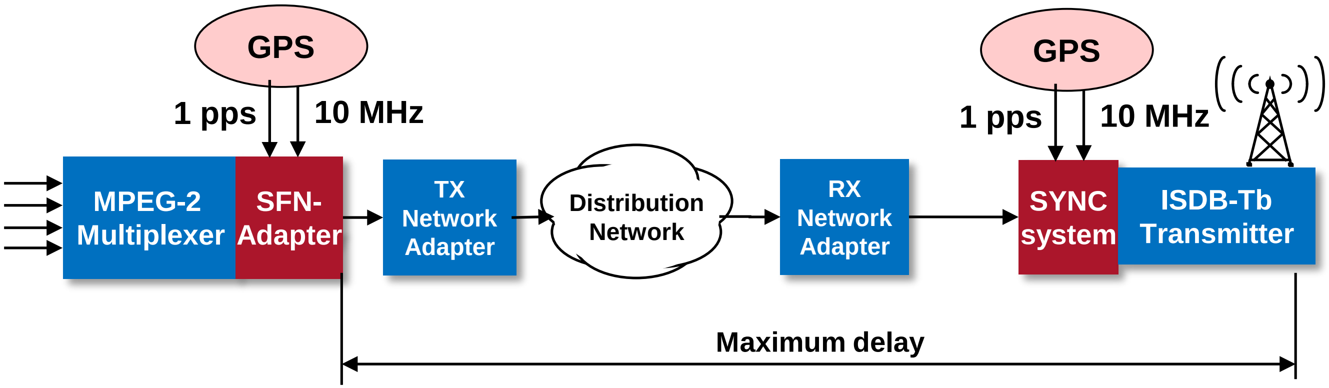
The STS is carried in the IIP of each Multiplex-Frame.

The STS carried in the Multiplex-Frame M describes the beginning of the Multiplex-Fame M+1

The STS carried in the Multiplex-Frame M+1 describes the beginning of the Mega-frame M+2

etc.

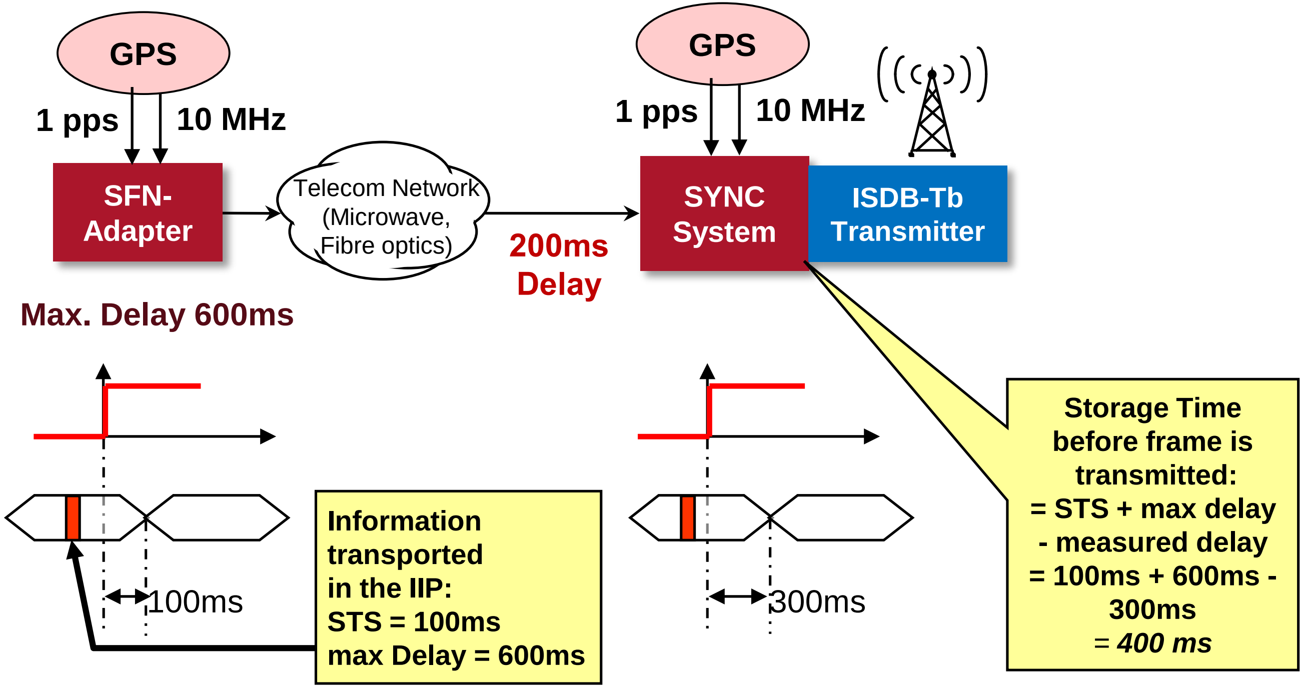
Maximum Network Delay



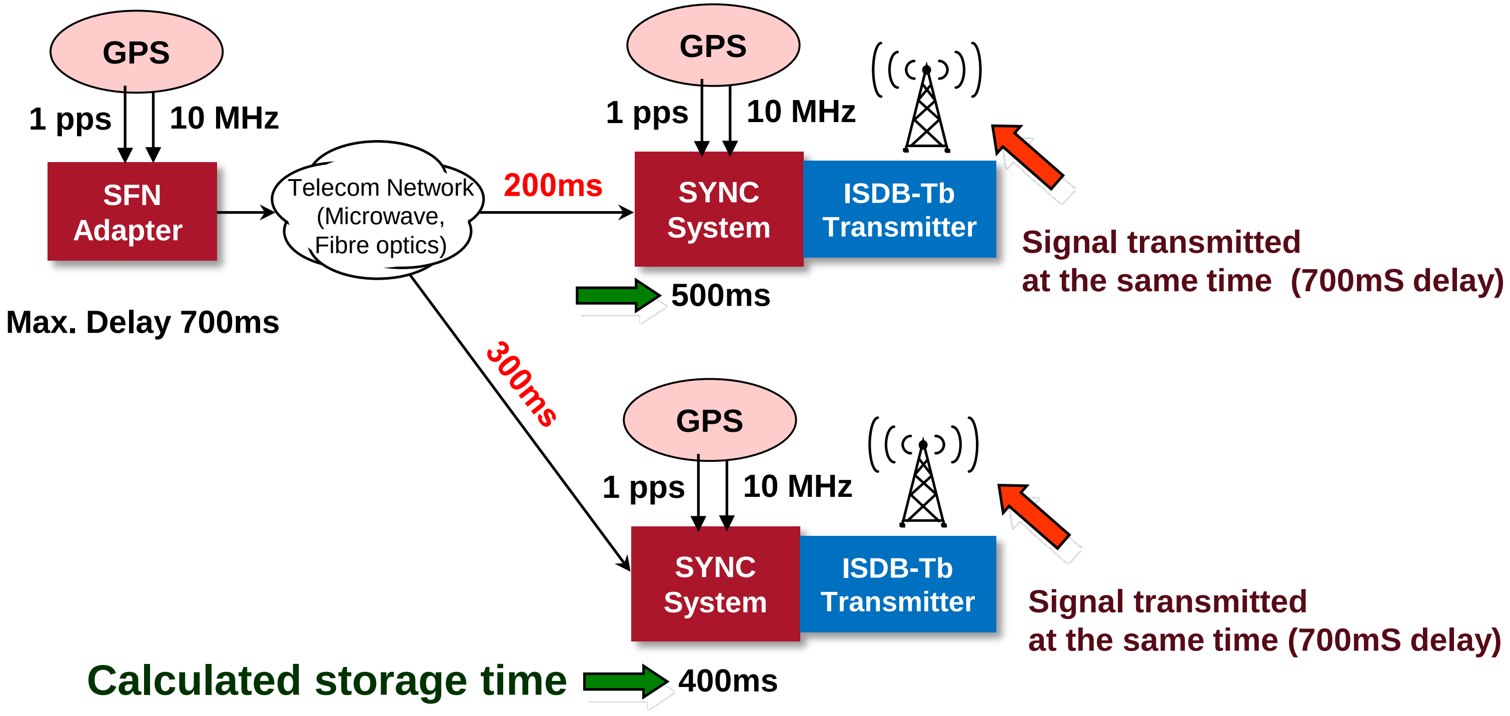
Maximum delay: (reference synchronisation)
The maximum delay describes the difference in time between a specific Multiplex-Frame leaving the SFN adapter and the corresponding COFDM Mega-frame available at the antenna output of each Transmitter in the SFN.

The maximum delay is a value adjustable in the SFN-Adapter. The set value has to be always higher than the longest actual network delay. The value is transported in each IIP

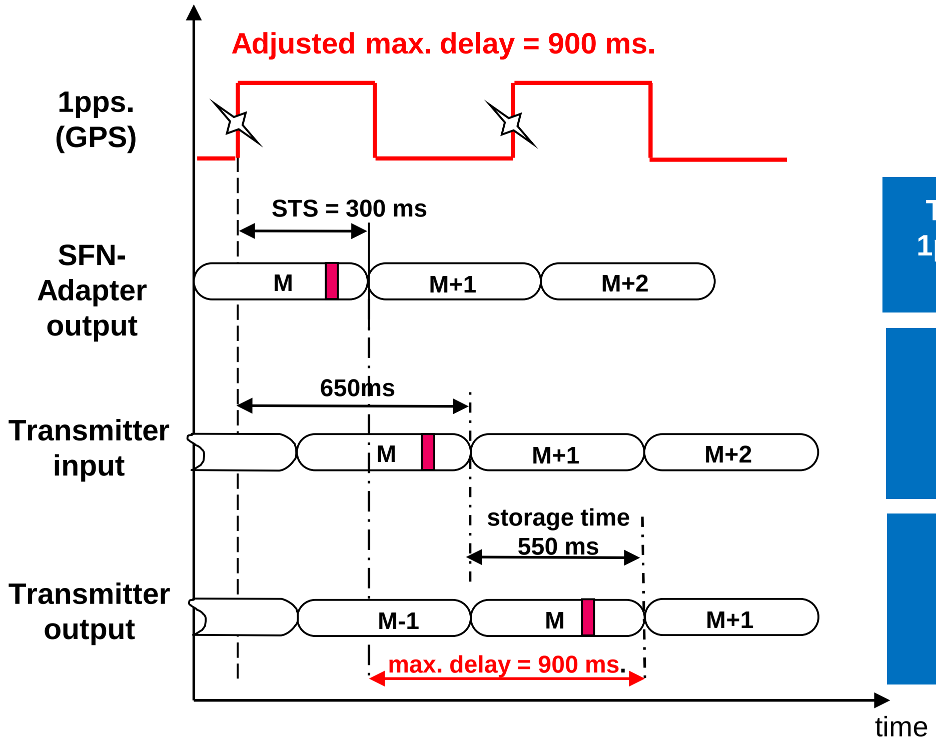
The Principle of Reference Synchronisation



Transmitter Synchronisation with Reference Synchronisation



Functional Description of SFN Synchronisation

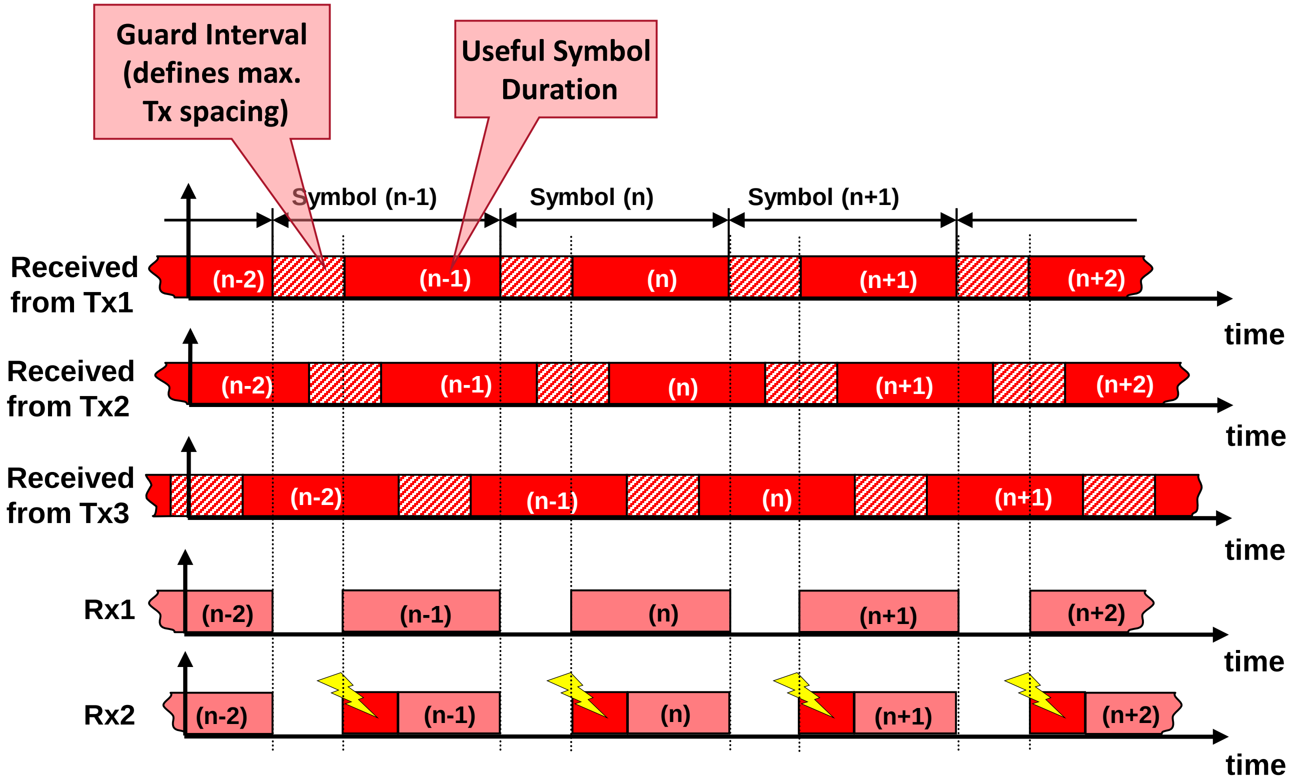


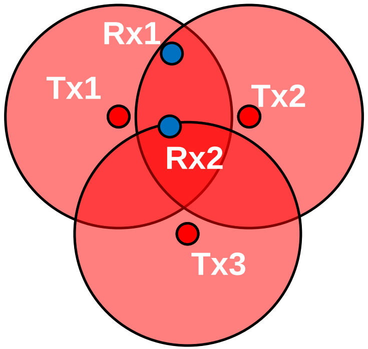
The difference in time between the latest pulse of the 1pps signal and the start of the Multiplex-Frame M+1 is copied into the IIP of Mega-Frame M

The actual delay of the M+1 frame at the input of the Transmitter is calculated like this:
Arrival time of frame (M+1) - STS value
= 650 ms - 300 ms = 350 ms

The time a frame has to be stored in the transmitter before it is sent is calculated like this:
Max. delay - actual delay
= 900 ms - 350 ms = 550ms

Reception Scenarios in a SFN





Distance Between SFN Transmitters

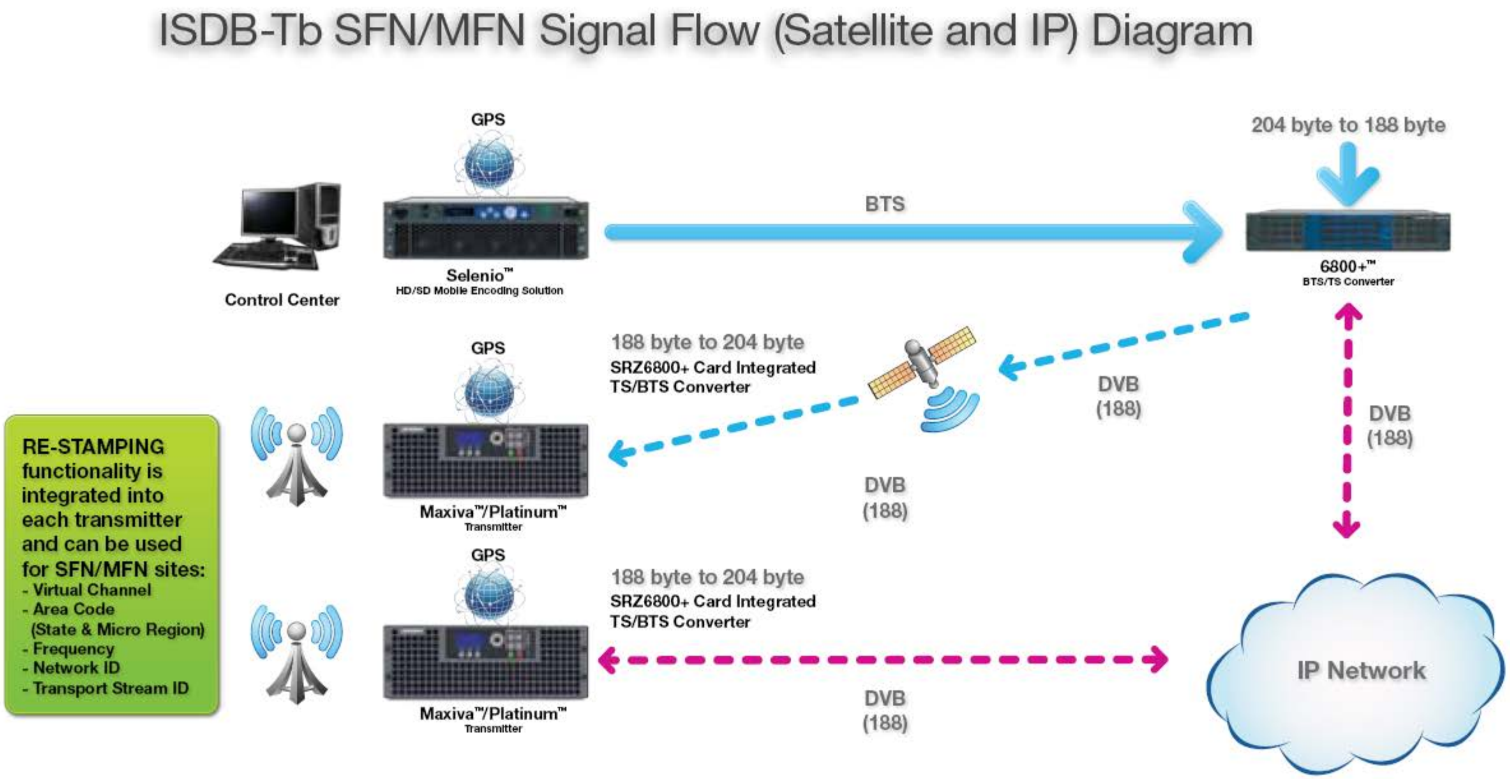
- Maximum distance between SFN transmitters is determined by the Guard Interval
  - Also determines maximum difference between direct path and multipath lengths
  - Distance = Guard Interval x V_o
    - V_0 = velocity of light in free space
    - V_0 = 300,000 km/second
    - V_0 = 186,000 miles/second
- Note: Time per unit distance = $1/V_o$
    - D/T = 1/300,000 = 3.33 µs/km
    - D/T = 1/186,000 = 5.38 µs/mile

Distance Between Transmitters SFN (ISDB-Tb)

Maximum tolerated distance and delay for several Modes and Guard Interval rates

GI Rate	Mode 1 (2k)		Mode 2 (4k)		Mode 3 (8k)	
	Δ (µs)	Dmax (km)	Δ (µs)	Dmax (km)	Δ (µs)	Dmax (km)
1/4	63	18.9	126	37.8	252	75.6
1/8	31.5	9.45	63	18.9	126	37.8
1/16	15.75	4.725	31.5	9.45	63	18.9
1/32	7.875	2.3625	15.75	4.725	31.5	9.45

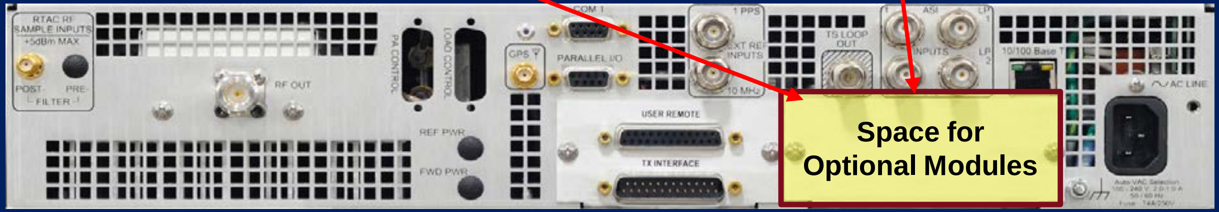
ISDB-T SFN / MFN Signal Flow (SAT & IP)



ASI-IP and Satellite Rx Modules

Satellite Receiver/Decoder Module
(SRD, SRZ)

ASI over IP Module
(IPA / IPZ)



Rear of Apex M2X, UAXT, or UAX Compact Series Tx

ISTB-Tb Re-Mux (option)

- Remote Control Key (Virtual Channel)
- Channel (The frequency is set into the Mux)
- Generating Station (Station Letters)
- Region
- State
- Micro Region
- Network ID
- Transport Stream ID

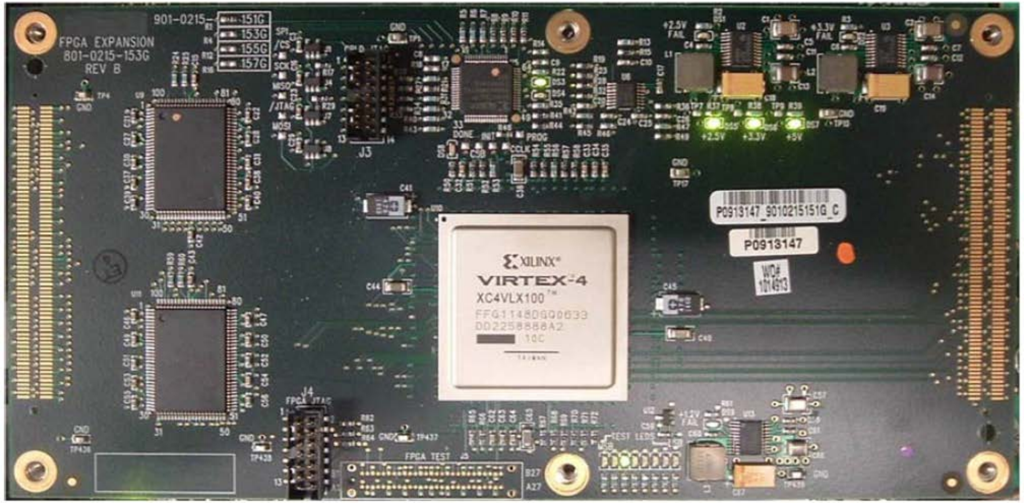
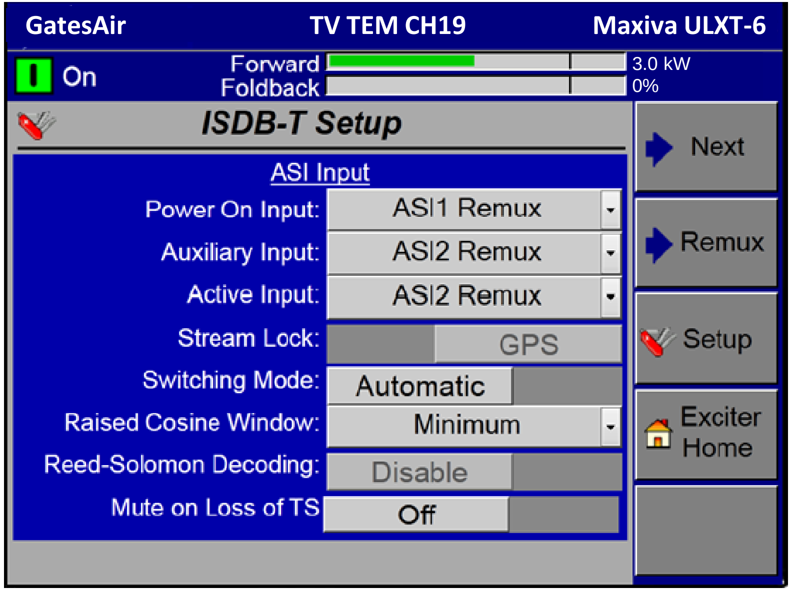
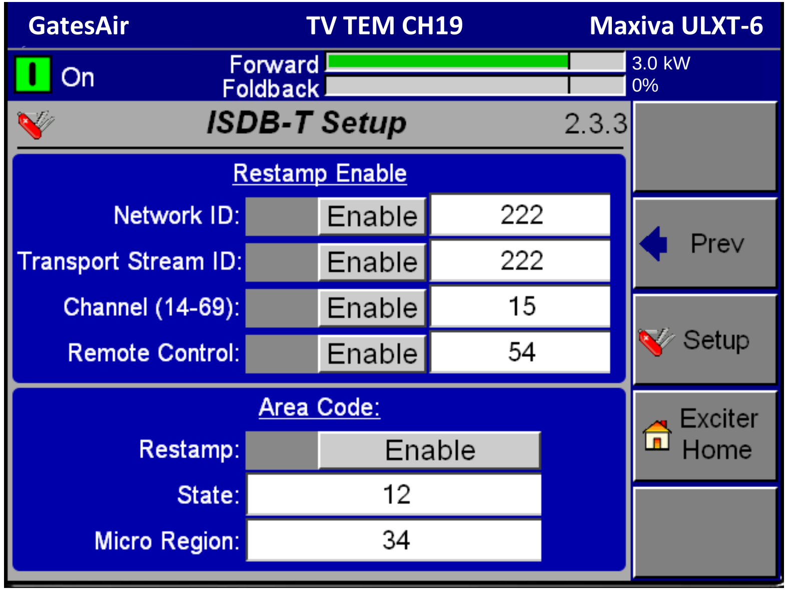


Figure 1-1 Remux FPGA Expansion Board (top view 901-0215-151GT)

The remux option allows input of a 188-byte multiplexed transport stream into one or both rear panel ASI BNC (female) connectors. The added remux hardware uses the multiplexed transport stream input to create a 204-byte BTS (Broadcast Transport Stream) based on user defined broadcast parameters. The resulting BTS is then fed to the host ISDB-Tb modulator.

ISTB-Tb Re-Mux – Exciter GUI Screens





GatesAir Tx SFN References Worldwide

ISDB-T
Brazil - Sistema Clube de Televisao, Ribeirao Preto
Brazil - TV TEM
Argentina – INVAP

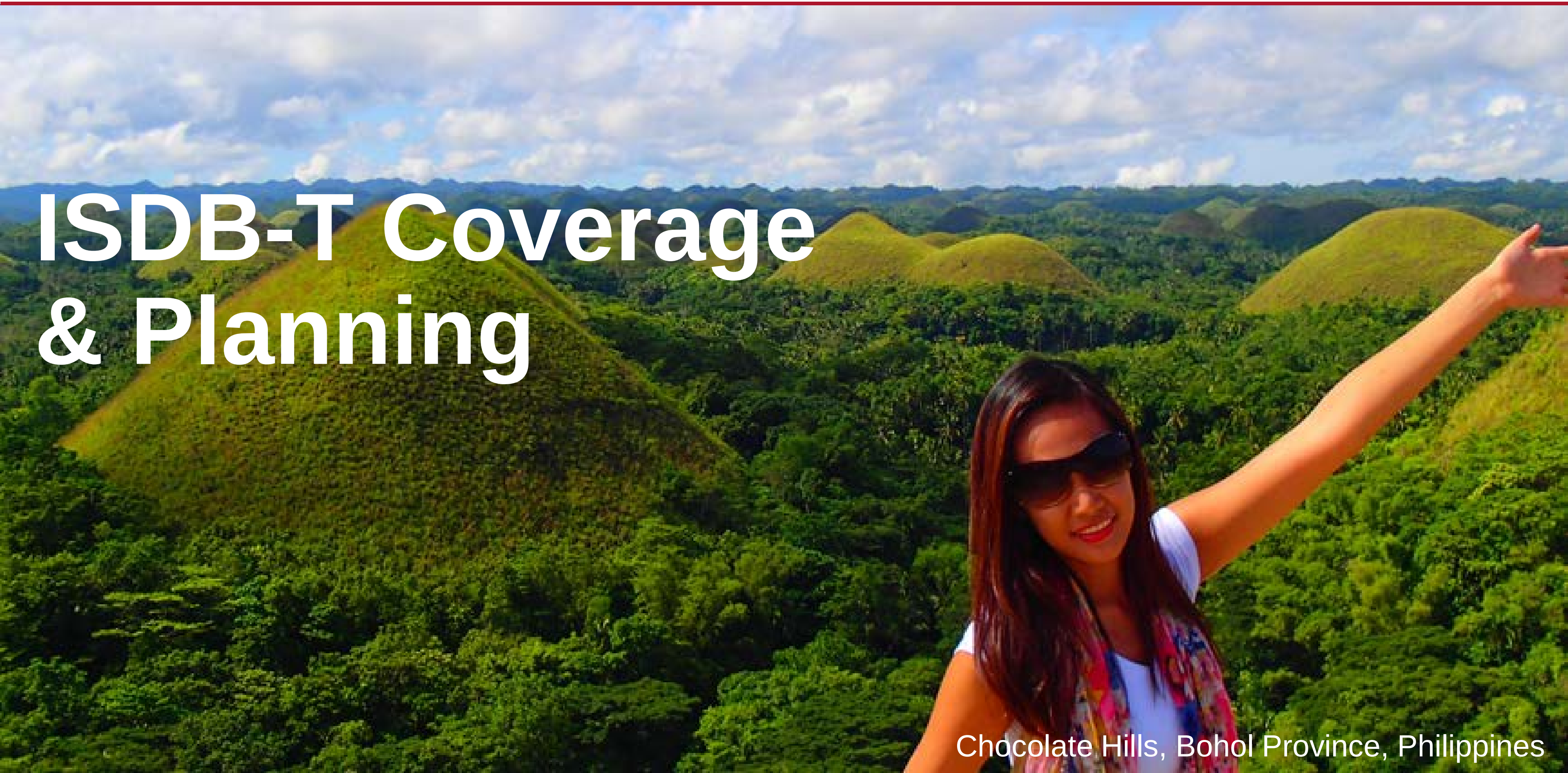
DVB-T/T2

UK	NTL/Arqiva (DVB-H)
Australia	Broadcast Australia
Australia	TX Australia
Switzerland	Swisscom*
Germany	T Systems – Media broadcast*
Poland	Info FM-TV (DVB-H)
Luxembourg	BCE
Singapore	TCS
Taiwan	PTS
Netherlands	Nozema/KPN*
Russia	RTRS

*transmitters work in SFN together with other brands

Connecting What's Next

ISDB-T Coverage & Planning



Chocolate Hills, Bohol Province, Philippines

Propagation Models For Coverage Estimation

Gaussian Channel

- The **Gaussian channel** is often used as a channel model in which the only impairment to communication is a linear addition of wideband or white noise with a constant spectral density (expressed as Watts per Hertz of bandwidth) and a Gaussian distribution of amplitude.

Ricean Fading Channel

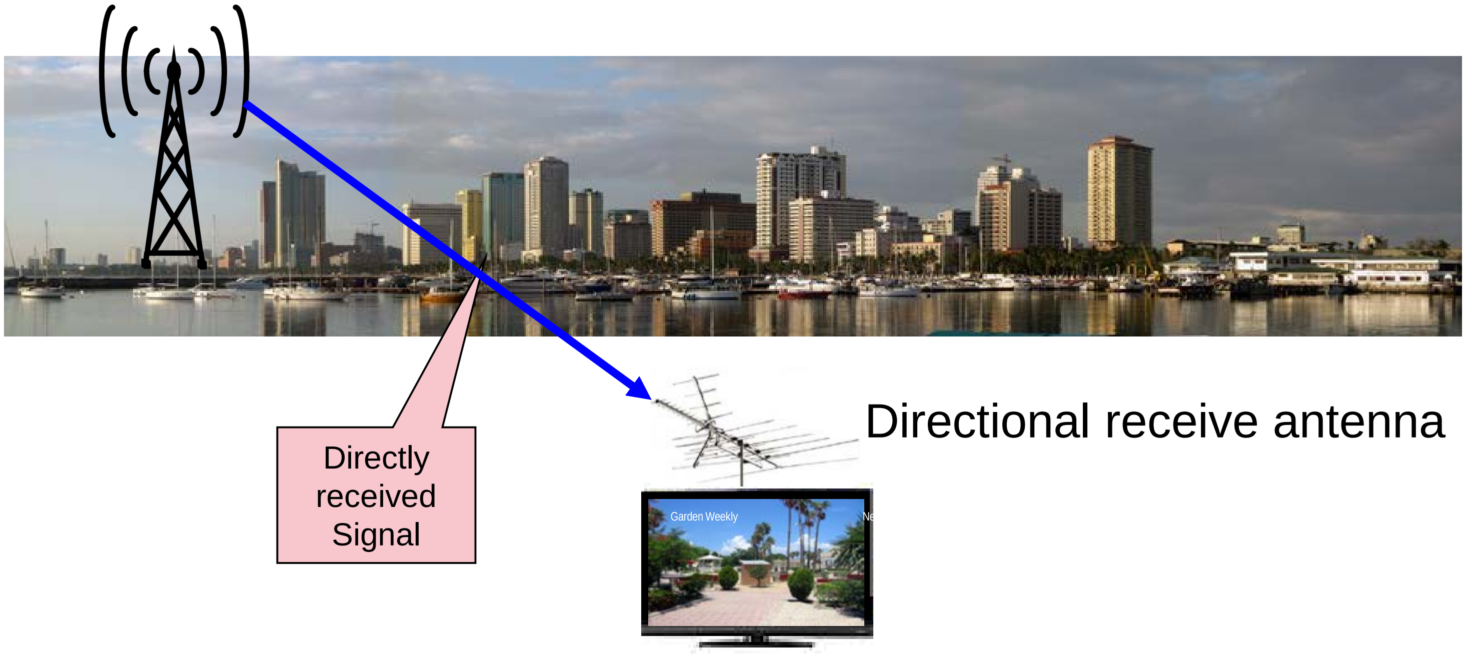
- **Rician fading** is a stochastic model for TV/Radio propagation anomalies caused by partial cancellation of a TV/Radio signal by itself — the signal arrives at the receiver by several different paths (hence exhibiting multipath interference), and at least one of the paths is changing (lengthening or shortening). Rician fading occurs when one of the paths, typically a line of sight signal, is much stronger than the others.

Rayleigh Fading Channel

- **Rayleigh fading** is viewed as a reasonable model for tropospheric and ionospheric signal propagation as well as the effect of heavily built-up urban environments on radio signals. Rayleigh fading is most applicable when there is no dominant propagation along a line of sight between the transmitter and receiver.

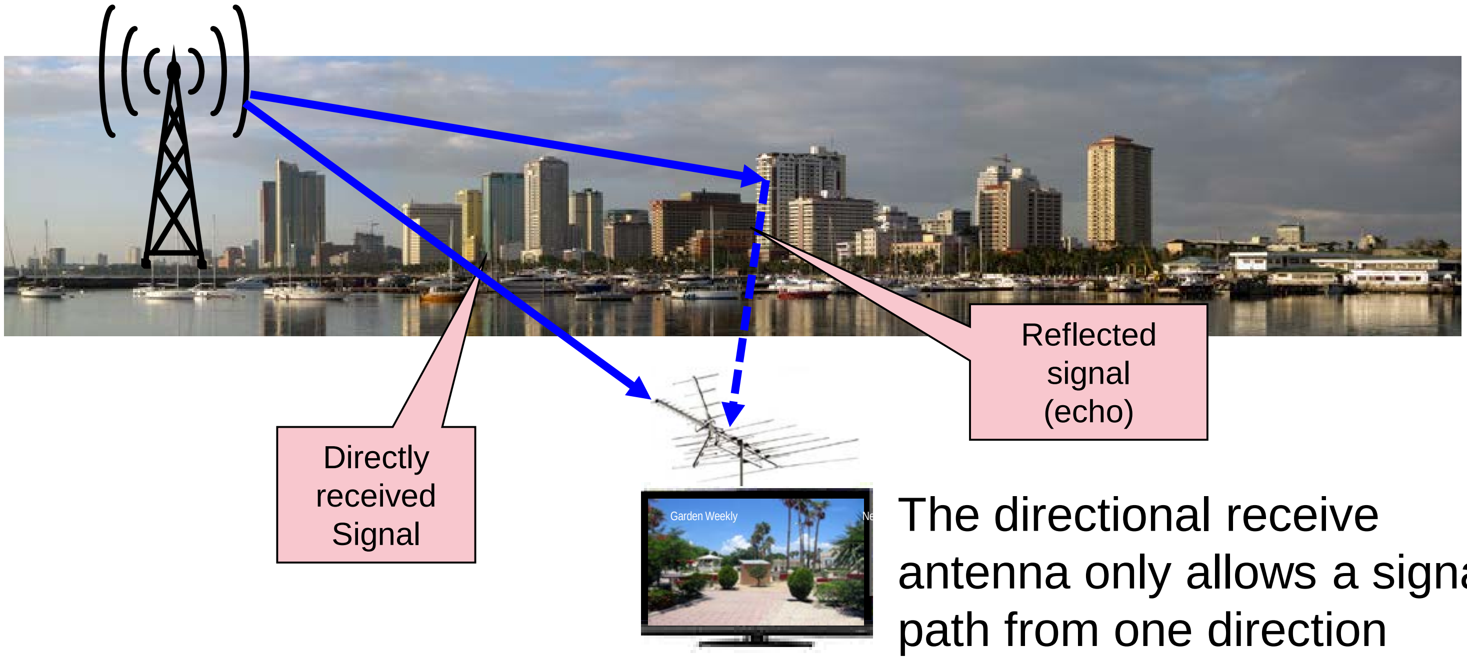
Gaussian Channel

- Directional antenna used
- Direct reception



Ricean Fading Channel

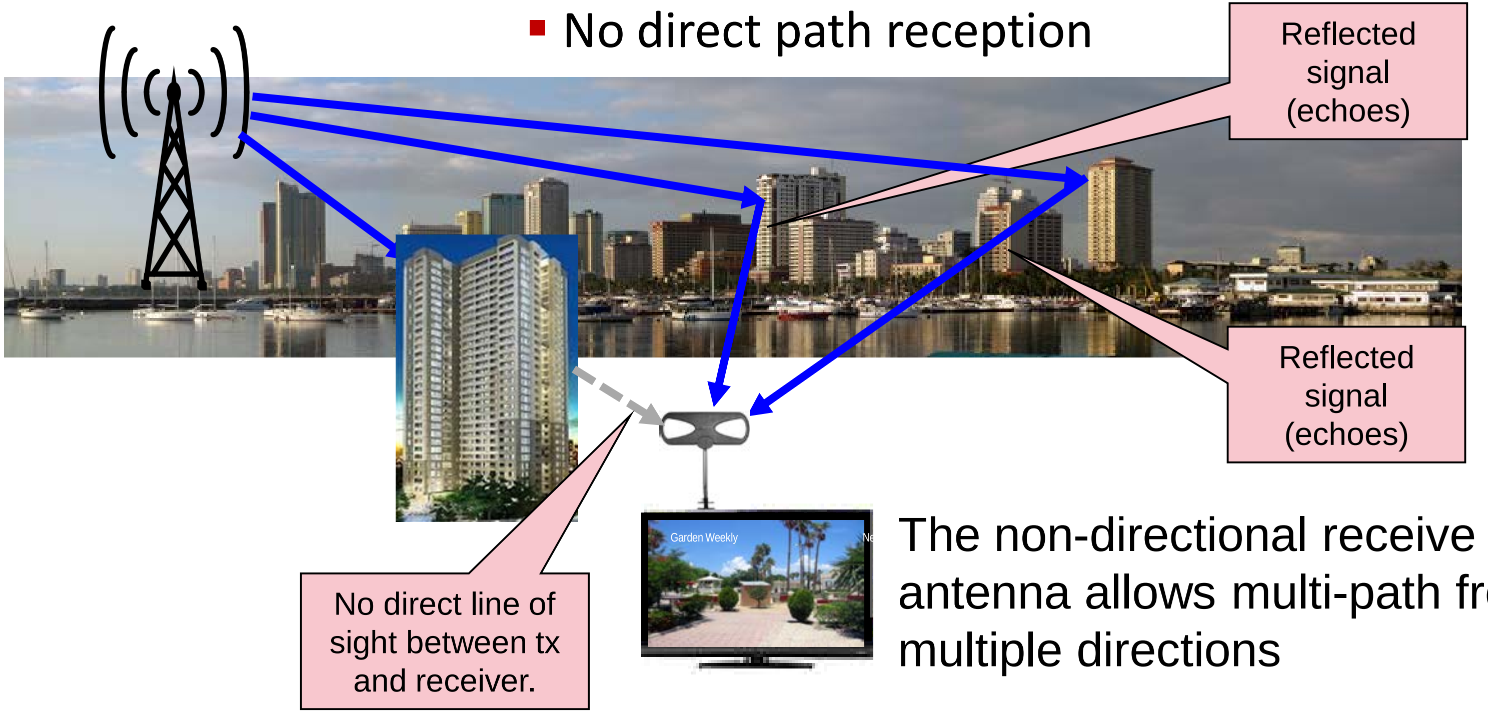
- Directional antenna used
- Multi-path reception



The directional receive antenna only allows a signal path from one direction

Rayleigh Fading Channel

- Non-directional antenna used
- Multi-path reception
- No direct path reception



The non-directional receive antenna allows multi-path from multiple directions

Coverage Prediction/Evaluation (Brazil)

- The main goal was to replicate the analog coverage area with the new digital signal
- Mackenzie university developed a means to predict the reception of ISDBT under real conditions
- Coverage also verified by collecting field data of the signal received at various locations:
  - With settings for HD fixed antenna and SD reception mobile device
  - Used the “Okumura Hata” model to predict propagation of signals
  - The National Telecom Agency (ANATEL), established a value of 51 dBmV/m for the field intensity of protected outline in the UHF band in the limit of coverage area. This figure became the target value that stations were to meet to replicate analog coverage.

Brazil Signal Measurement Equipment

- A field test van was equipped with:
  - Retractable antenna up to 10m (5dB gain)
  - Spectrum Analyzer
  - Receivers (STB)
  - Notebook
  - GPS
  - Measuring equipment (MER, C/N, BER, etc.)

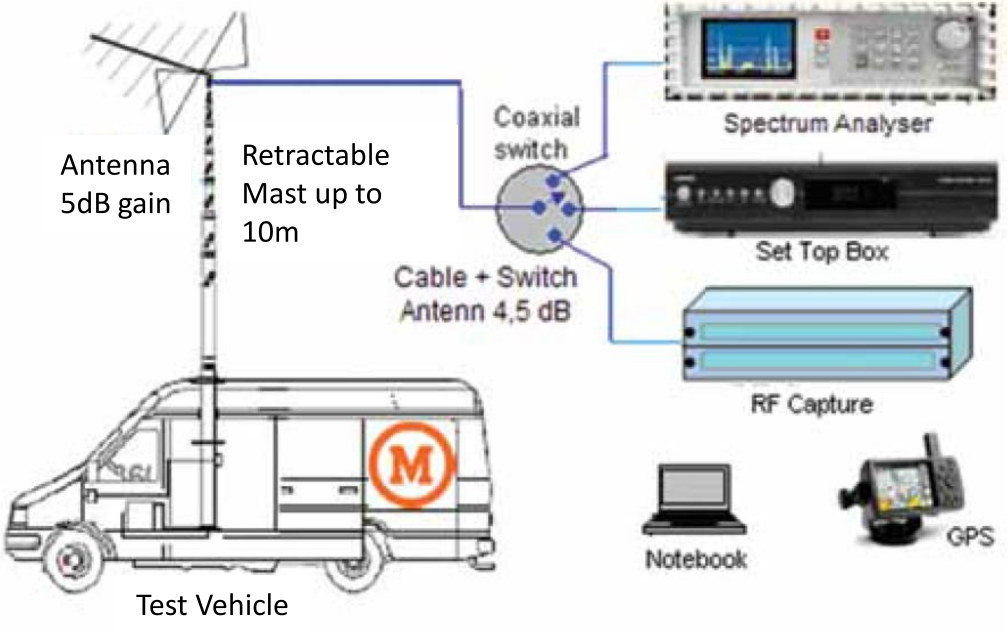


Figure 3–Diagram Figure 3–Diagram of System Field test of System Field test

Measured signal strength vs. predicted

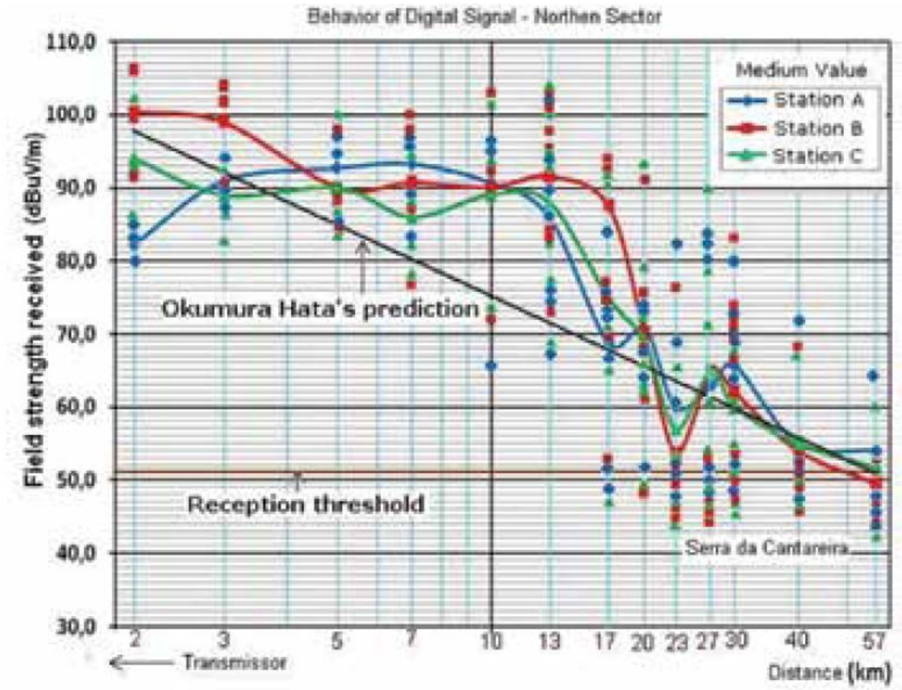


Figure 5 –Graph of signal strength in the northern sector

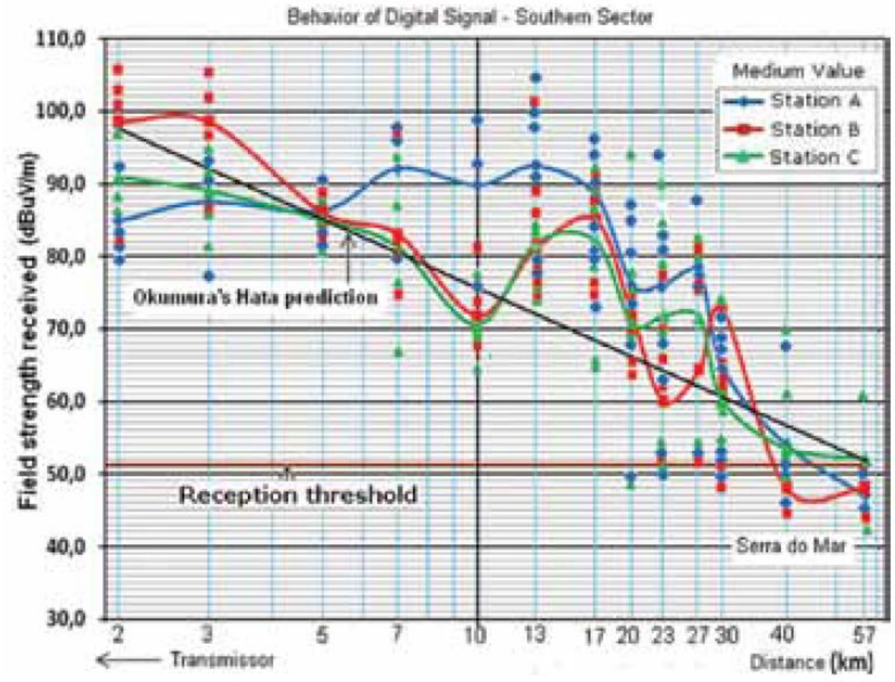


Figure 7 – Graph of signal strength in the Southern sector

Lichtenau, Germany

ISDB-T/Tb

ISDB-T/Tb network coverage planning

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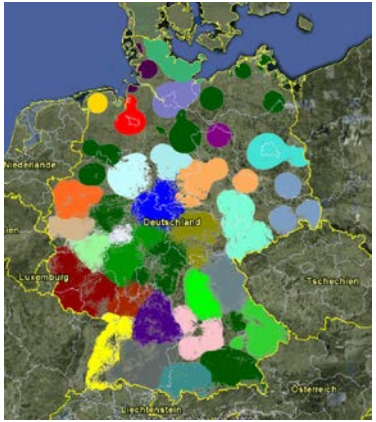
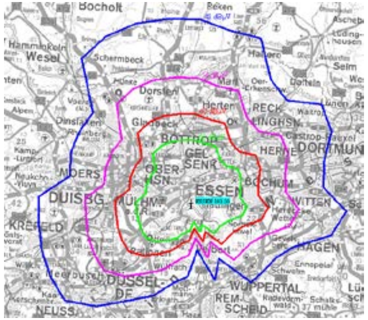
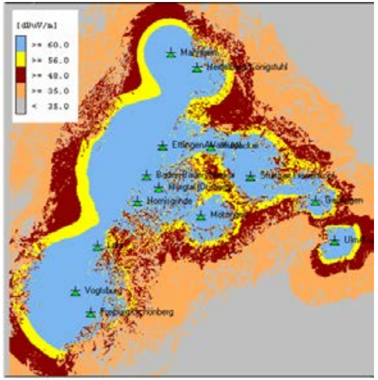
Planning Tool: CHIRplus_BC from LS telcom AG

- Planning and Coordination of Terrestrial Broadcasting services
  - FM, TV, **ISDB-T**, ATSC, DVB-T/T2 (-H), T-DAB (-DMB), LF/MF, HF, DRM(+)
  - Protection ratio (e.g. ISDB-T vs. ISDB-T, ISDB-T vs. TV analogue)
  - Powerful database system
  - GIS and graphical user interface
  - Field strength and interference prediction
  - Support of international frequency plans (GE84, ST61, GE75, GE06, NTFD …)
  - Contour Based Calculations
  - Coordination functions and macros
  - Network planning and optimization
  - Frequency Planning (Frequency Scan)
  - Population Analysis







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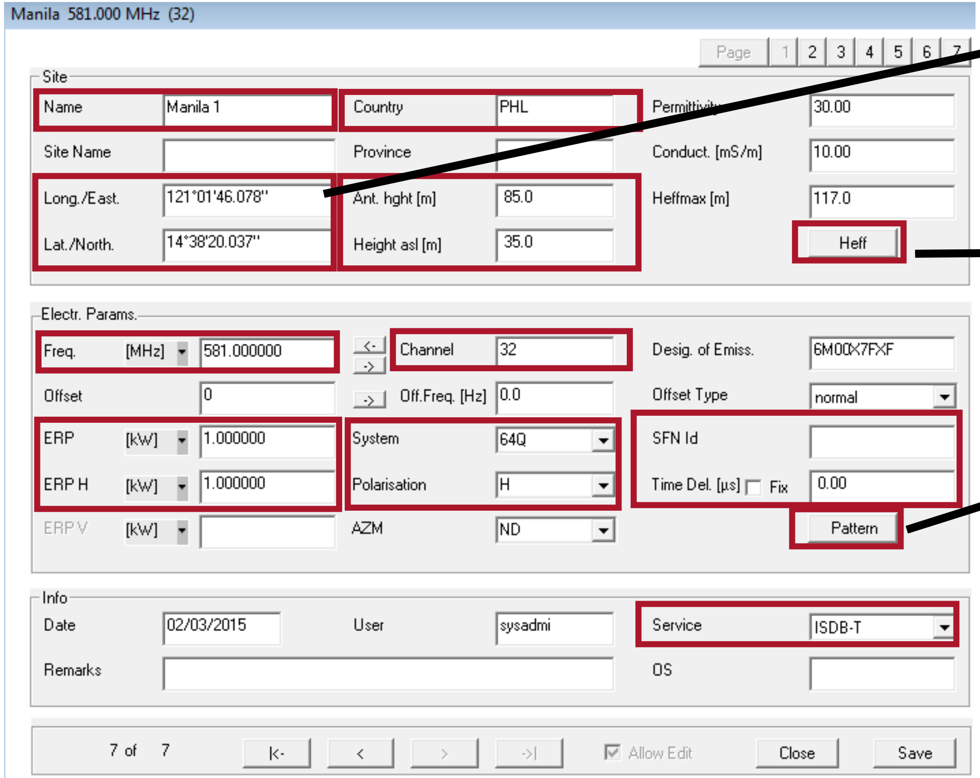
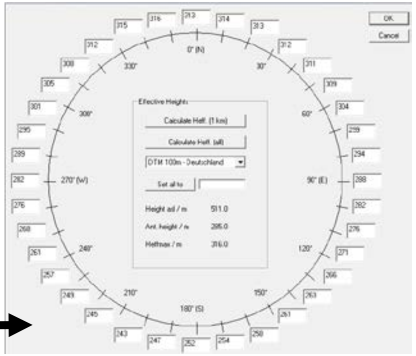
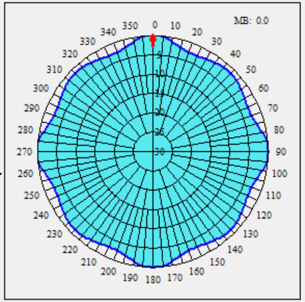
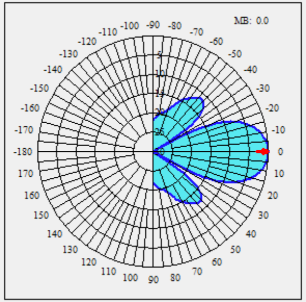
Planning Parameter – TX data

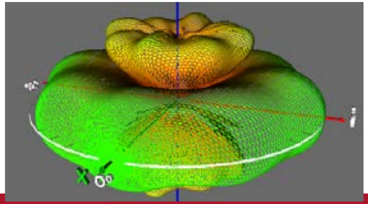
- Transmitter data quality





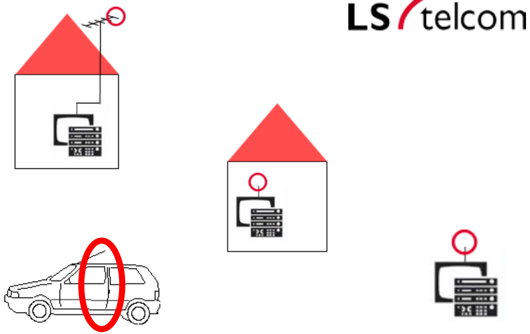






How to handle planning parameters

- What kind of network?
  - SFN (Single Frequency Network)
  - MFN (Multiple Frequency Network)
- Is the network to design local or nationwide?
  - transmitter distance ➔ guard interval
- How many and what kind of Programs (SD,HD) to distribute?
  - Code rate, modulation
- What kind of service is needed?
  - Fixed
  - Mobile
  - Portable (indoor/ outdoor)



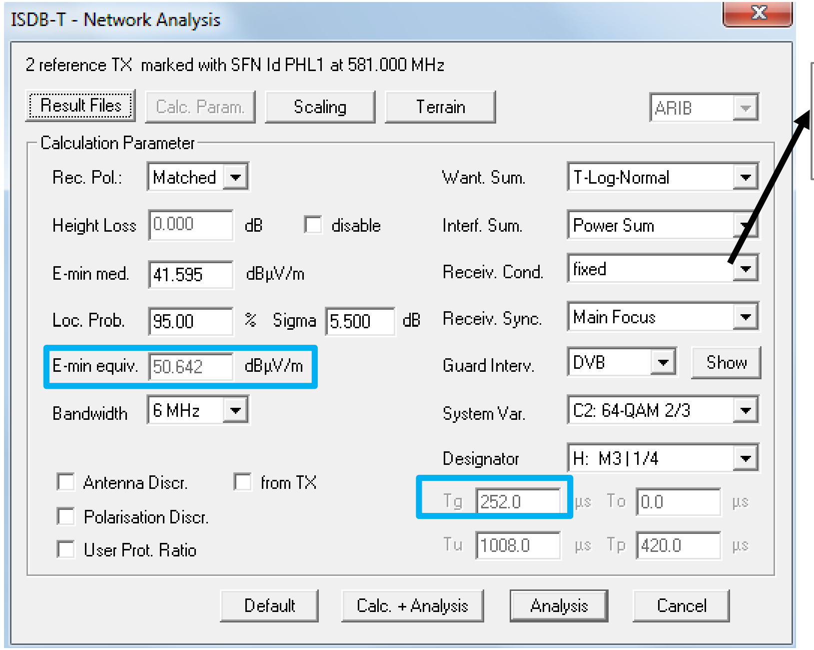
Carrier modulation	Convolutional code	Number of TSPs transmitted (Mode 1/2/3)	Data rate (Mbps)			
			Guard ratio: 1/4	Guard ratio: 1/8	Guard ratio: 1/16	Guard ratio: 1/32
DQPSK / QPSK	1/2	156/312/624	[illegible]	4.056	4.295	4.425
	2/3	208/416/832	[illegible]	5.409	5.727	5.900
	3/4	234/468/936	[illegible]	6.085	6.443	6.638
	5/6	260/520/1040	[illegible]	6.761	7.159	7.376
	7/8	273/546/1092	6.389	[illegible]	7.517	7.744
16QAM	1/2	312/624/1248	7.302	[illegible]	8.590	8.851
	2/3	416/832/1664	9.736	[illegible]	11.454	11.801
	3/4	468/936/1872	10.953	[illegible]	[illegible]	13.276
	5/6	520/1040/2080	12.170	13.522	[illegible]	14.752
	7/8	546/1092/2184	12.779	14.198	[illegible]	15.489
64QAM	1/2	468/936/1872	10.953	12.170	[illegible]	13.276
	2/3	624/1248/2496	14.604	16.227	[illegible]	[illegible]
	3/4	702/1404/2808	16.430	18.255	19.329	[illegible]
	5/6	780/1560/3120	18.255	20.284	21.477	[illegible]
	7/8	819/1638/3276	19.168	21.298	22.551	[illegible]

Increase of robustness

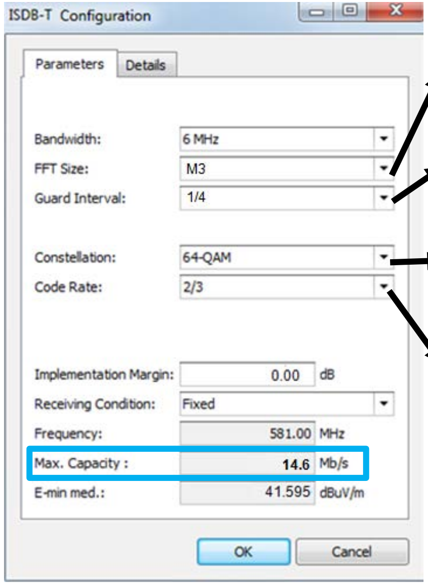
Increase of capacity

Planning Parameter – ISDB-T Configuration

- Challenge to find the most fitting configuration (Capacity vs. robustness)



Fixed
Portable outdoor
Portable indoor
Mobile



M1
M2
M3

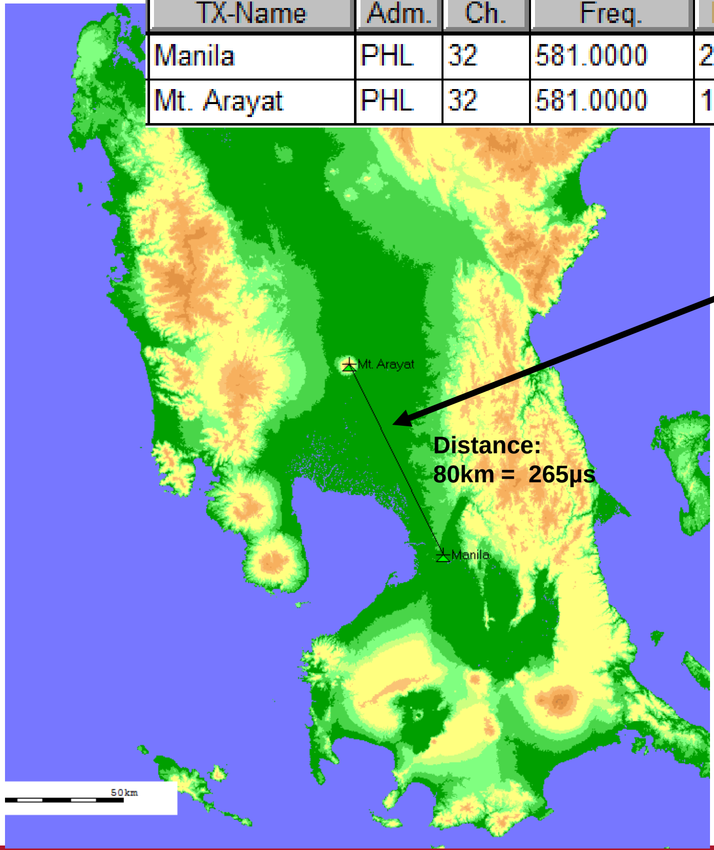
1/4
1/8
1/16
1/32

QPSK
16-QAM
64-QAM

1/2
2/3
3/4
5/6
7/8

Network Coverage planning (SFN optimization)

TX-Name	Adm.	Ch.	Freq.	Height	Ant.H.	Longit.	Latit.	ERP
Manila	PHL	32	581.0000	23	85	121°04'38.112"	14°33'44.058"	25.0000
Mt. Arayat	PHL	32	581.0000	1001	40	120°44'30.299"	15°12'19.480"	50.0000



TX distance (265µs) > Guard Interval (252µs) !!!

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Network Coverage planning (SFN optimization)

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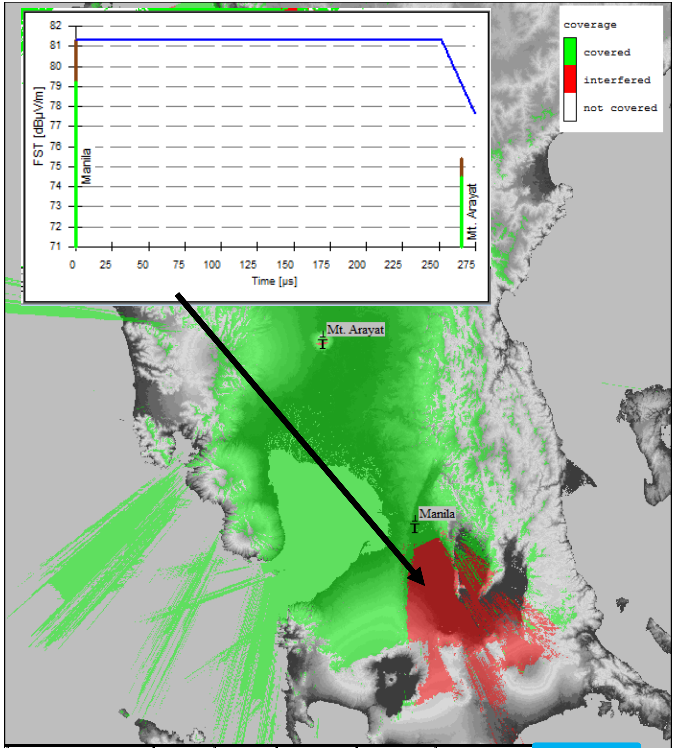
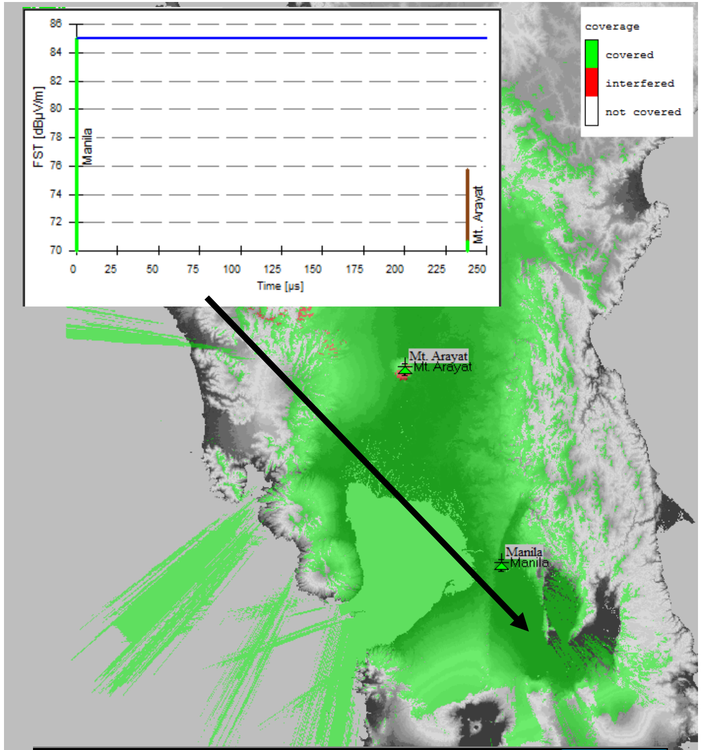


TX-Name	Adm.	Ch.	Height	Ant.H.	ERP	Time Del.
Manila	PHL	32	23	85	25.0000	0
Mt. Arayat	PHL	32	1001	40	50.0000	0



TX-Name	Adm.	Ch.	Height	Ant.H.	ERP	Time Del.
Manila	PHL	32	23	85	25.0000	25
Mt. Arayat	PHL	32	1001	40	50.0000	0

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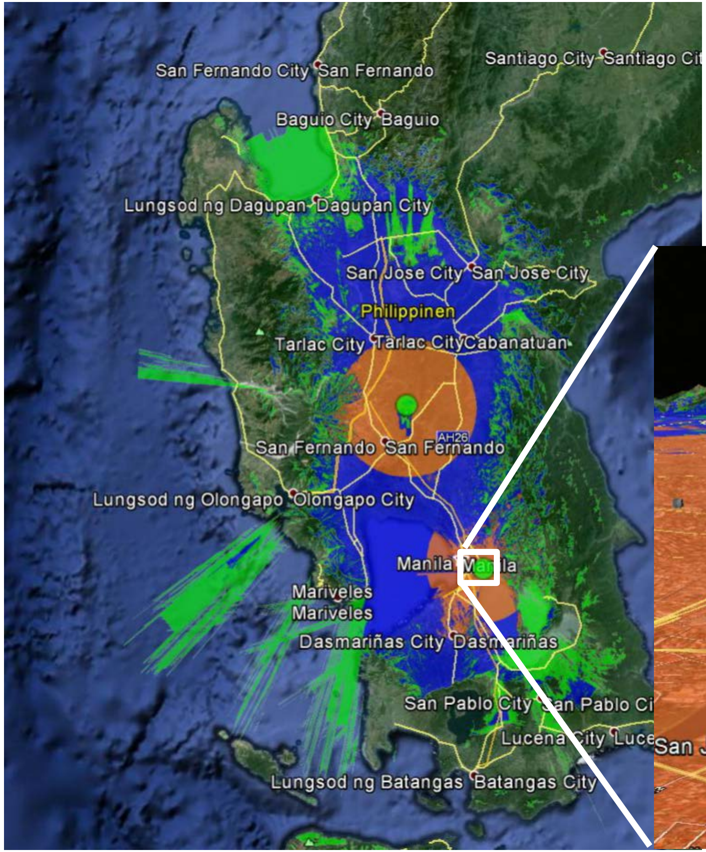
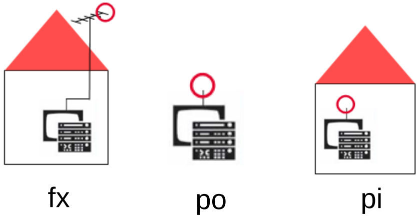
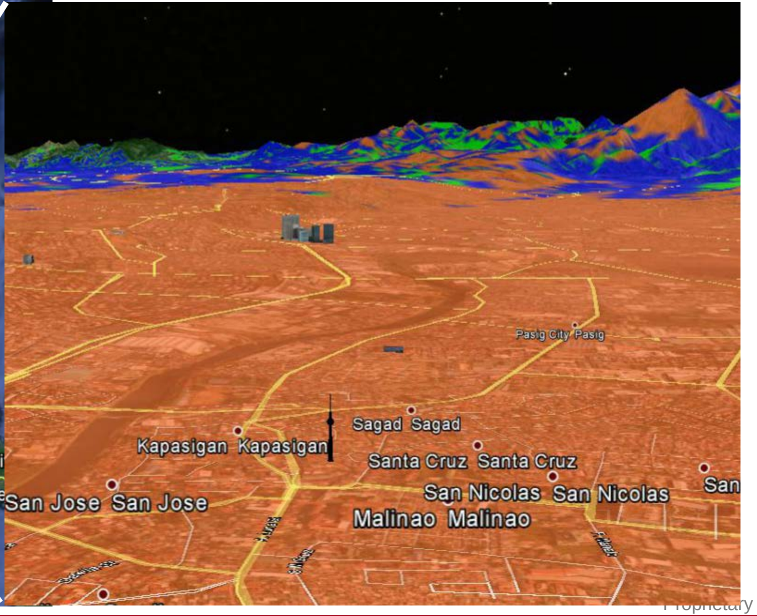
Network Coverage planning (Visualization)



Reception

- fx, po, pi
- fx, po
- fx
- no coverage





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Network Coverage planning (Benefits)

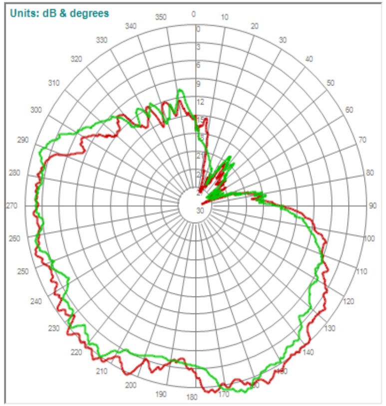
- Professional network planning saves time and money and prevents problems
  - Professional predictions ensure optimized CAPEX and OPEX
  - Makes possible to analyse various options to find the best
  - Ensure interference optimized network
    - Self interferences in case of SFN
    - Protection of analogue TV in case of simulcast phases
    - Interferences between ISDB-T and other services (LTE, PMSE…)
    - Analysis of coordination requirements
    - Analysis of bi-multilateral agreements

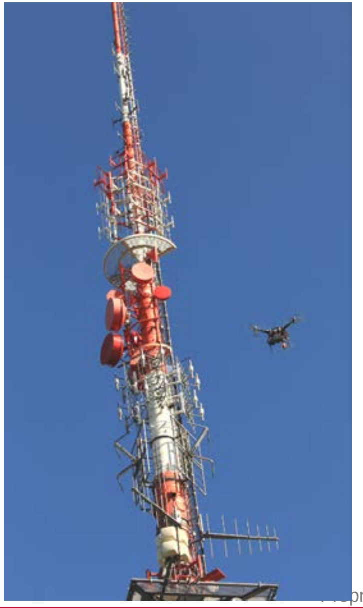
Planning & Coverage Verification

GATESAIR

- Despite the extensive possibilities of proper planning with an adequate professional tool (like ChirPlus_BC), coverage analysis and verification are recommended when launching a new broadcast service
- Complementary to field or drive tests, airborne measurements offer fruitfull information about the broadcast antennas and the radiation patterns (real vs licenced)
- Remotely piloted aircrafts enable a new approach for airborne measurement with many additional benefits

Colibrex
Member of the LS telcom Group





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Connecting What’s Next

New High-Efficiency Transmitters For ISDB-T

Maxiva Product Family - Television

	Low Power Air Cooled	High Power Liquid Cooled	Super High Power

UHF


UAXT Overview

Click for Presentation

Maxiva™ UAX-UC , UAXT-MC, UAXT-C & UAXT

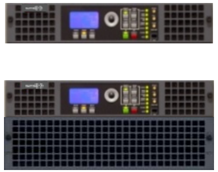

ULXT Overview

Click for Presentation

Maxiva™ ULX & ULXT


Maxiva™ ULXT & Power CD (IOT)

VHF




Maxiva™ VAX-3D

(High Band TV and DAB Digital radio)

Maxiva™ VLX

All TV transmitters support all standards, Including:

ISDB-T

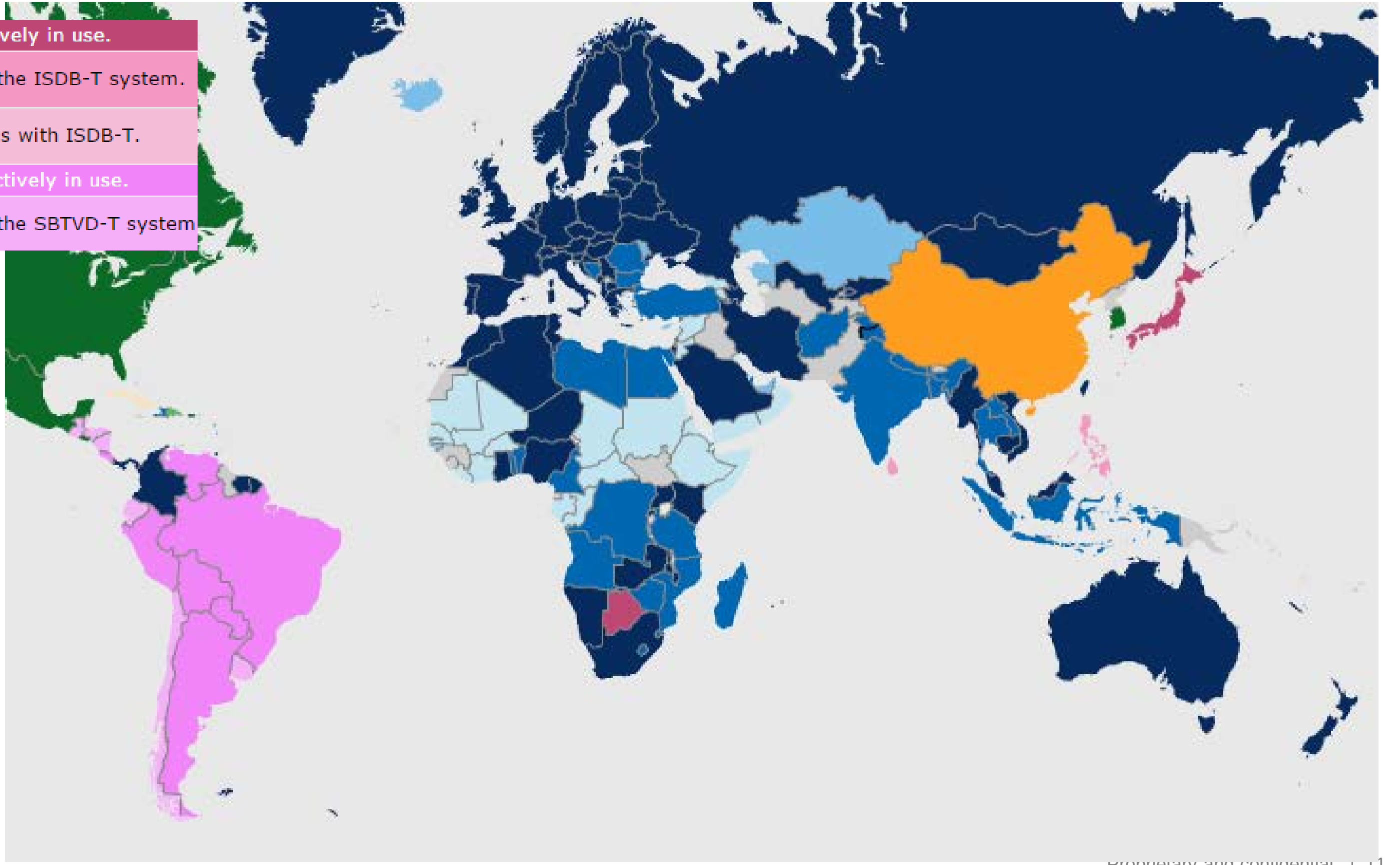
108

GA experience and Site References for ISDB-T Deployments

Countries Adopting ISDB-T (so far)

ISDB-T	Broadcasting via ISDB-T is actively in use.
ISDB-T adopted	Countries which have adopted the ISDB-T system.
ISDB-T trial broadcasts	Those countries undertake trials with ISDB-T.
SBTVD-T	Broadcasting via SBTVD-T is actively in use.
SBTVD-T adopted	Countries which have adopted the SBTVD-T system

SBTVD:
Sistema **B**rasileiro de **TV** **D**igital) - Also called "ISDB-T International“ and "ISDB-Tb"

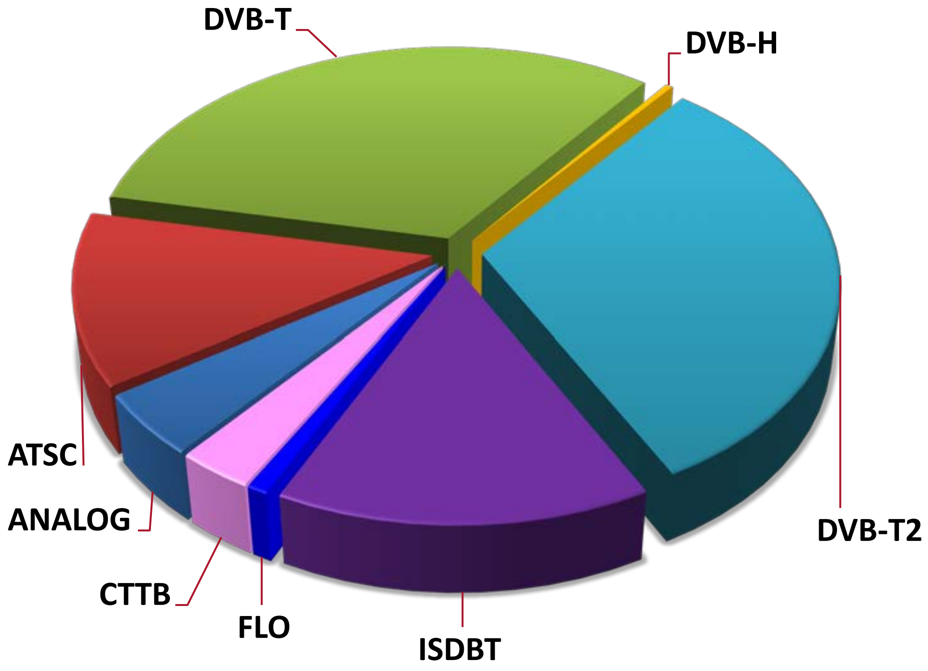


Countries Adopting (or have Adopted) ISDB-T

	Country	ISDB-T Adopted	ISDB-T Started	GatesAir Tx's Shipped
1	**Japan**	------	December 2003	-
2	**Brazil**	June 2006	December 2007	509+
3	**Peru**	April 2009	March 30, 2010	7
4	**Argentina**	August 2009	April 28, 2010	138
5	**Chile**	September 2009		6
6	**Venezuela**	October 2009	June 2011	-
7	**Ecuador**	March 2010		2
8	**Costa Rica**	May 2010	May 1, 2014	-
9	**Paraguay**	June 2010	August 15, 2011	-
10	**Philippines**	June 2010 (reconfirmed in 2013)		3
11	**Bolivia**	July 2010	September 2011	-
12	**Uruguay**	December 2010		7
13	**Maldives**	October 2011 (national broadcasting) April 2014 (decided as national standard)		-
14	**Botswana**	February 2013	July 29, 2013	-
15	**Guatemala**	May 2013		1
16	**Honduras**	September 2013		-
17	**Sri Lanka**	May 2014 (*Initially DVB-T2*)		-

Source: DiBEG

GatesAir TV Shipments – By Modulation Type



- TV Transmitters Shipped: 4,536
  - April 2009 to December 2014
- 678 ISDB-T transmitters shipped
  - Third place
- Total Shipments
  - DVB-T: 32.2% (1,460)
  - DVB-T2: 31.5% (1,430)
  - ISDB-T: 15% (678)
  - ATSC: 12.5% (568)
  - Others: 8.8% (400)

A Few GatesAir Customer References – ISDB-T

- Brasil
  - TV Band
  - TV Gazetta
  - TV TEM
  - TV Aliança Paulista S.A.
  - TV Bauru S.A.
  - TV Sao Jose do Rio Preto
  - TV Luziania LTDA
  - TV Taubate
  - TV Vanguardia
  - + Over 40 more stations/networks
- Argentina
  - INVAP
  - Telecentro
  - Producciones Dragon
- Chile
  - Television Nacional de Chile
  - Compania Chilena de TV
  - Rede Televisiva Megavision
- Ecuador
  - TV y Radio de Ecuador S.A.
- Peru
  - Andina de Radiodifusion
  - Assoc. Las Manos de Dios

Case Study – TV TEM, Brazil

- **Background information:**
  - TV TEM is a major Rede Globo affiliate in Brazil: 318 cities in São Paulo state
    - Project – to increase coverage to 8 million viewers
- **Why they chose GatesAir:**
  - Met stringent technical requirements
  - GatesAir guaranteed that the SFN will work flawlessly
  - Competitive commercial package
  - Excellent pre- and post-sales support
  - A excellent long-term customer relationship – repeat buyer!
- **Anchor products:**
  - Maxiva ULX, UAX, high-efficiency ULXT

Challenges and Lessons Learned

Super Typhoon Haiyan

Brazil Experience

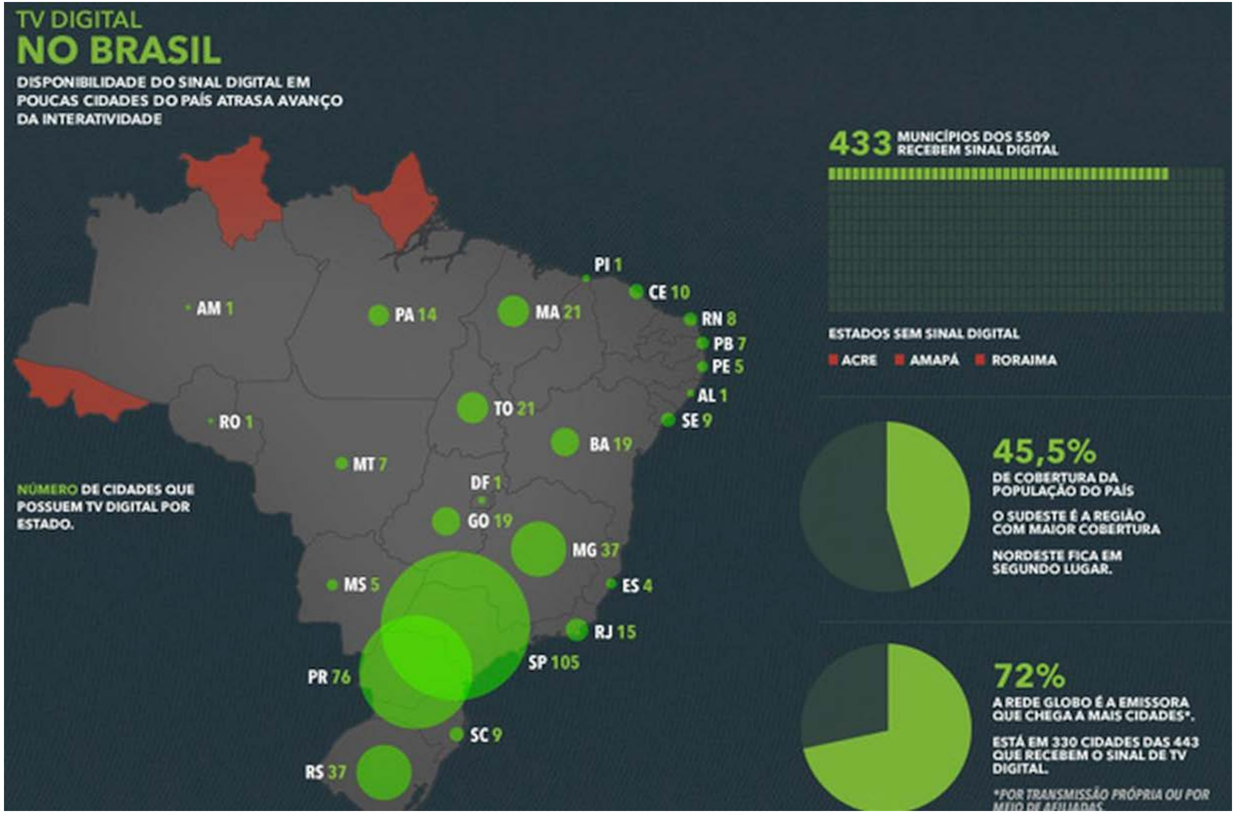
- A lot of testing and planning was done before the roll out of ISDB-T
- Field tests conducted in Rio de Janeiro to test the robustness of the 1-Seg mobile system
- Public awareness was key to the success
  - By 2012 there were DTV transmissions in 433 municipalities across Brazil
  - Coverage to almost 45.5% of the population
- Analog switch-off plans for Brazil
  - Analog shut down in 2 cities – April 3rd, 2016 (Brasilia and Rio verde)
  - Four more cities will shut off analog by end of 2016
  - Entire country shuts off analog by end of 2018

Lessons Learned (Brazil)

- Coverage planning was a good approximation….
- However, there were "holes" in the coverage areas with received signals below the predicted levels
  - Some additional low power transmitters, transposers, or on-channel gap fillers were needed to reduce these coverage gaps
- Many early receivers and STB's did not correctly apply tables (Like PID, PAT, etc.)
  - This resulted in receivers not having correct channel or program information
  - If a broadcaster made changes, added a program, etc. the receiver did not recognize this unless all channels were re-scanned
- Early STB's and receivers were very expensive but prices have since greatly reduced
  - Limited affordability for early viewers of ISDB-T

Brazil ISDB-T coverage in 2012

- By 2012 Brazil had DTV coverage into 433 municipalities
- Only three states were without DTV signals
- 72% of these stations were in the populated regions
- 45.4% of the population could receive Digital TV



The End – Questions?

El Nido, Palawan, Philippines

Martyn Horspool

GatesAir