



# Speakers



**Jeff Welton**

Sales Manager - Central USA  
Nautel



**John Abdnour**

India Territory Sales Manager



**Philipp Schmid**

Chief Technology Officer  
Nautel

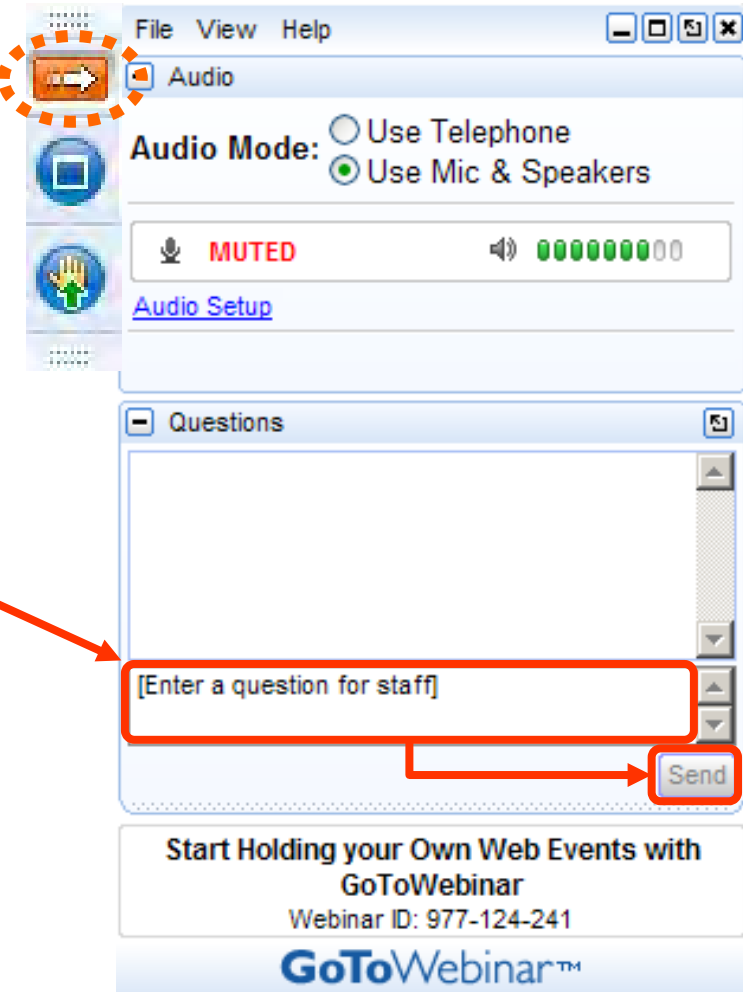
# Agenda

- What is DRM?
- Features and benefits
- Things to know
- Configurations and options
- Where is it all going – future talk

# Your Questions Please?

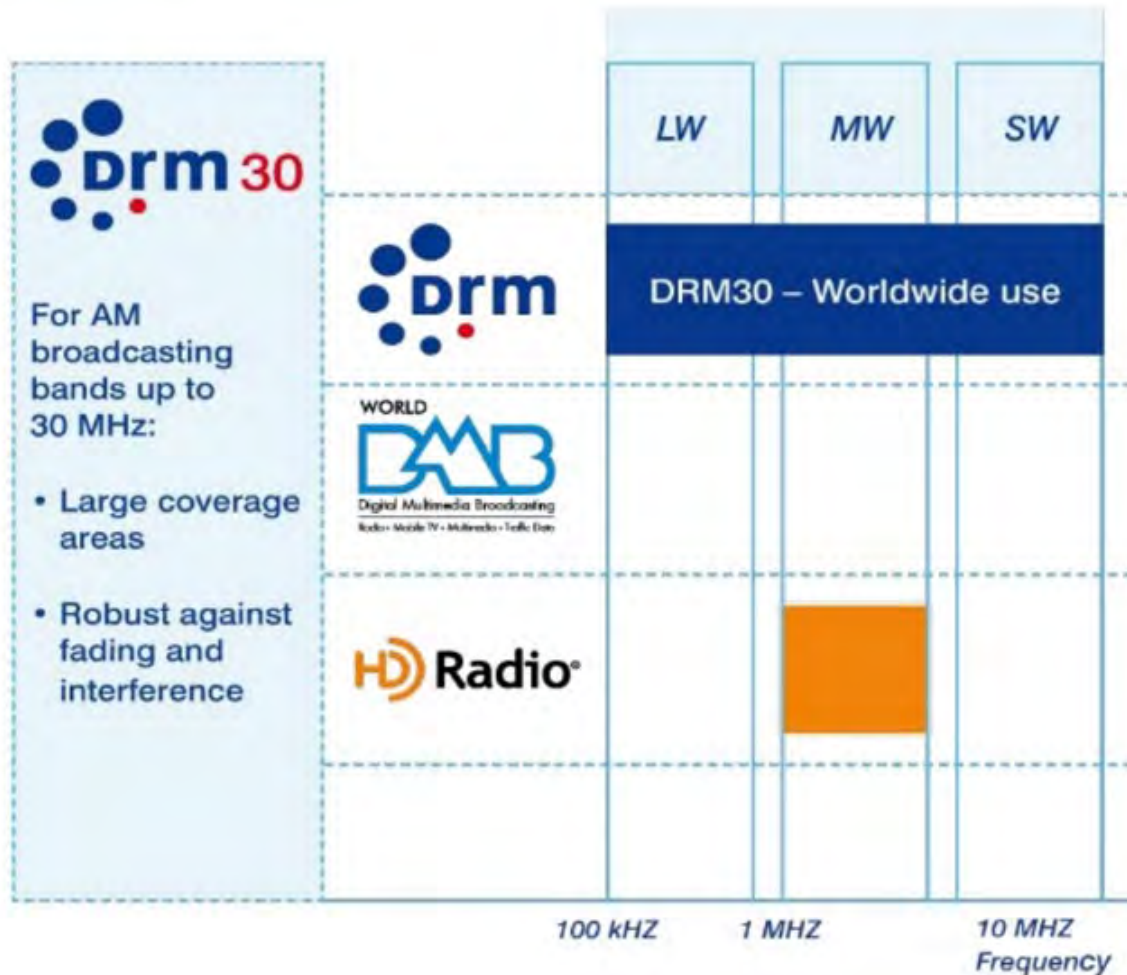
If you don't see the control panel, click the orange arrow icon to expand it.

Enter your questions in the text box of the webinar control panel and press "Send"



**Remember:** The completion of a Nautel webinar qualifies for ½ SBE re-certification credit, identified under Category I of the Re-certification Schedule for SBE Certifications.

# DRM30: Ideal for Vast Geographic Coverage



- Transmission efficiency
- FM quality + data
- Coexist with analog MW stations
- Emergency warnings

# NXSeries: Scalable to 2 MW

- All DRM capable
- High power building blocks:  
100, 200, 300 or 400 kW systems
- Combiners: 2, 3, 4 or 5 port
- Replace older 70% efficient 400 kW transmitter:
  - Save up to € 524,000/year ( 0.18 €/kWhr)



AUI (Advanced User Interface)

“Nautel has shipped over 4,000 MW transmitters, to 89 countries, totalling over 70 MW of power”



# DRM Ready NXSeries Worldwide



# Over 26 Million Watts of NX ON-AIR

# What is DRM?



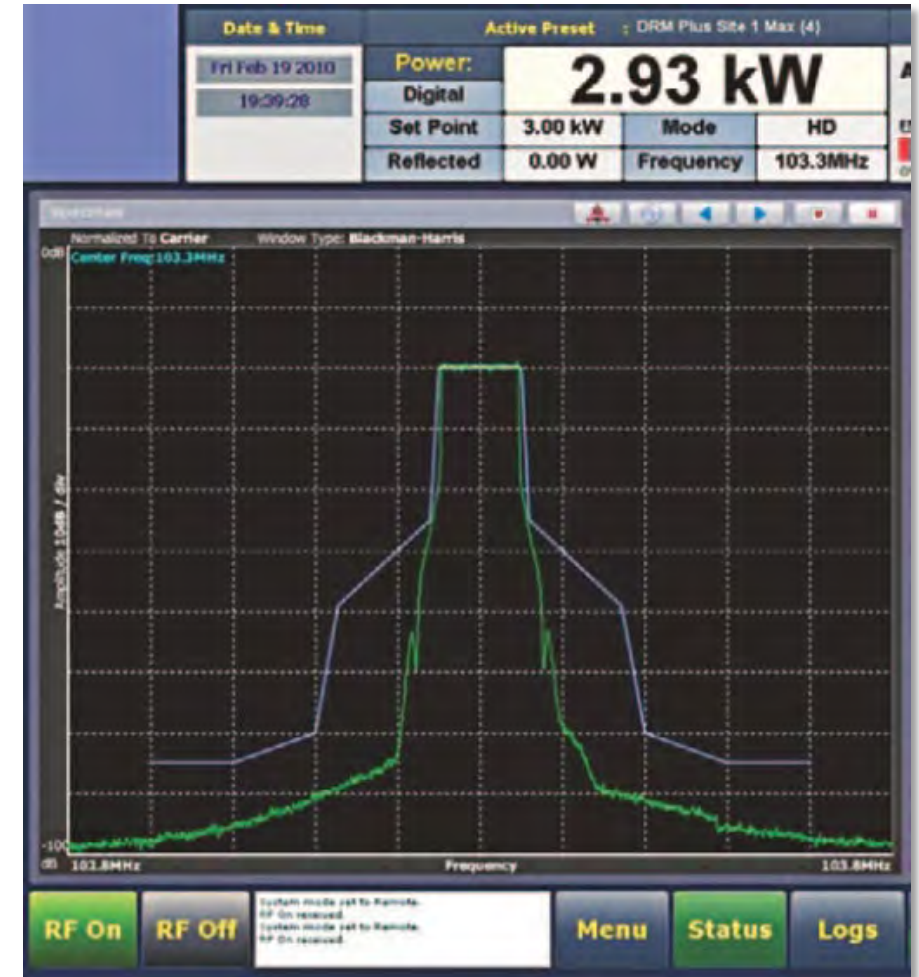
## DRM Handbook

<https://www.drm.org/wp-content/uploads/2020/05/DRM-Handbook-Version-5.pdf>



# What is DRM?

- A form of digital modulation for existing radio frequency bands (AM, shortwave and VHF – bands I through III).
- Works with existing infrastructure (antenna systems, STLs) with minimal change required.
- Early AM DRM was digital only, however there are now hybrid options, for FM can be digital or hybrid.



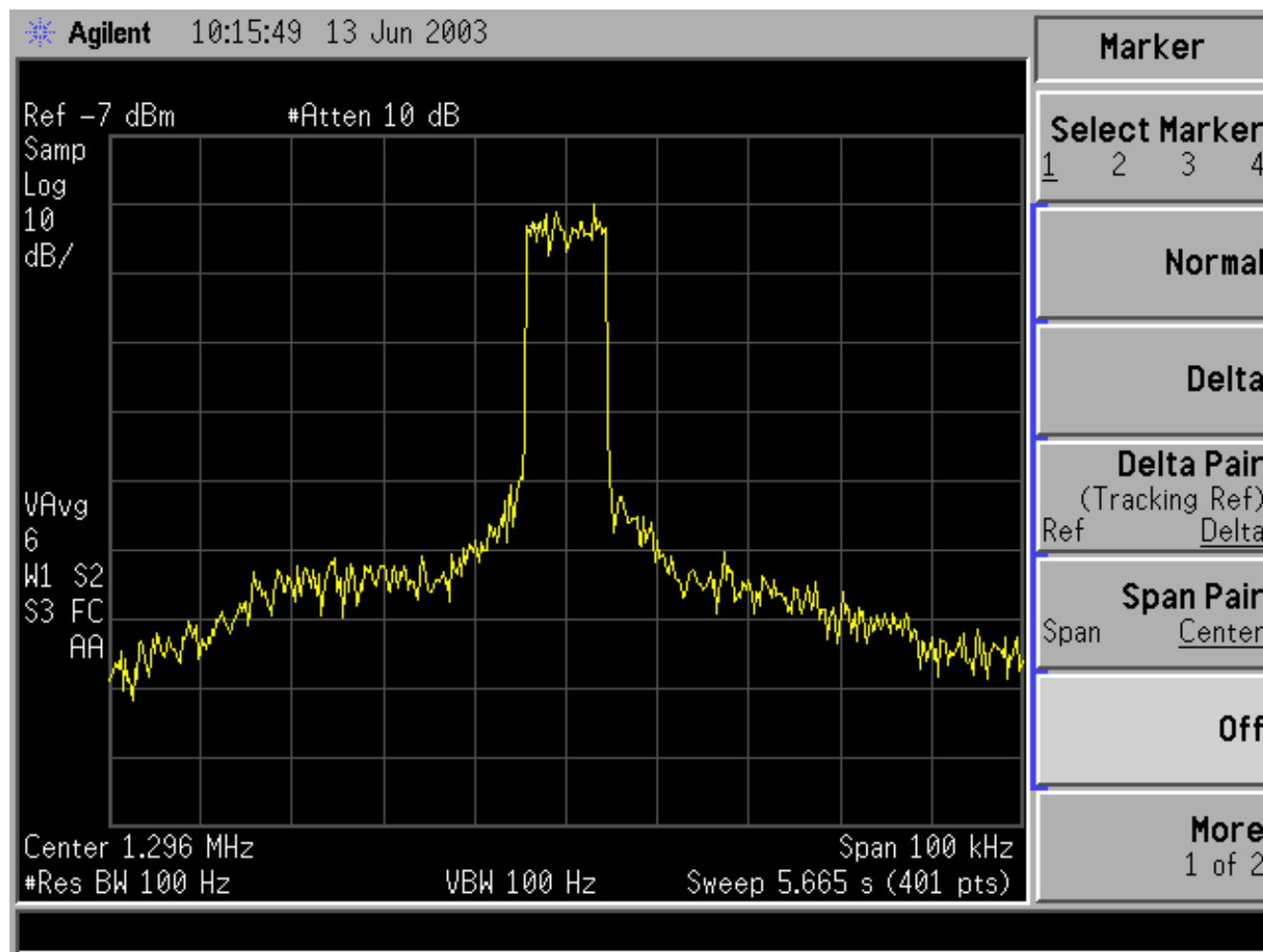


# What is DRM?

- Originally was DRM30 (below 30 MHz) or DRM+ (above 30 MHz)
  - Below 30 MHz has 4 different modes of operation (A through D), allowing the signal to be configured for propagation conditions
  - Above 30 MHz has one mode (mode E). Fixed bandwidth of 96 kHz.
  - Available bit rates of 37 kbps through 186 kbps for FM, 4.5 kbps through 32 kbps for AM, depending on mode and occupied bandwidth.
  - Up to three audio services, plus data.
  - Uses COFDM and AAC (specifically xHE-AAC, with HE-AACv2 legacy support).

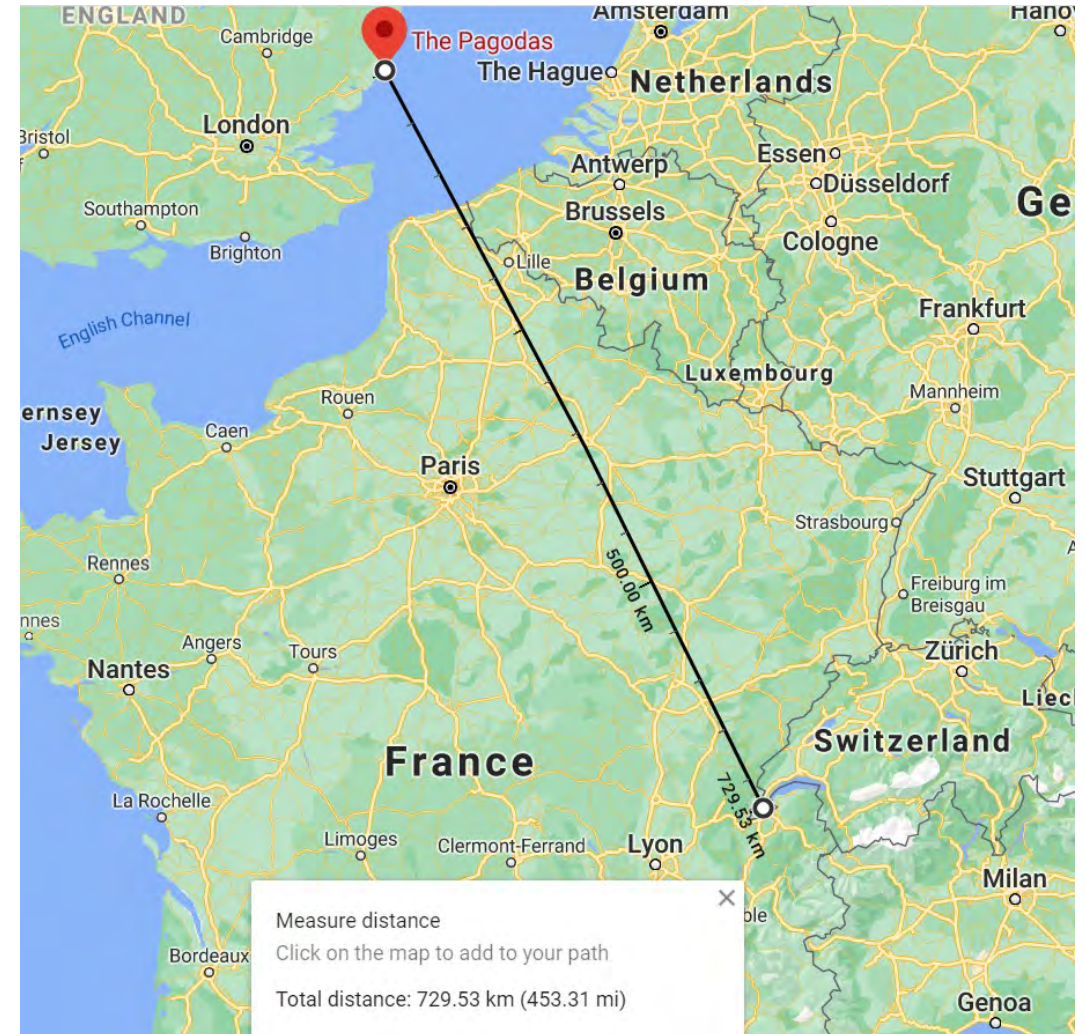
# History

- Originally configured for medium and shortwave only
- Inaugural broadcast was June 16, 2003 in Geneva during the ITU World Radio Conference



# History

- Nautel NA200 at 1296 kHz, using Telefunken modulator, installed in Orford Ness, UK. Received in Geneva in DRM mode.
- Transmitter power was 80 kW



# Features and Benefits

- Improved audio quality over analog
- Provides ability for additional channels of audio
- Data services, such as Journaline (text based information service), TPEG (traveller information), slideshow and program guide, among others
- Supports AMSS (AM Signaling System) and Automatic Frequency Switching (AFS) – the ability to hand a listener over to other frequencies or networks.
- EWF – Emergency Warning Functionality



# Components

- **Content Server** – encodes the audio, incorporates data, creates the multiplex signal to feed the modulator
- **Modulator** – interleaves the digital signal from the content server and modulates it onto the RF signal for amplification and transmission

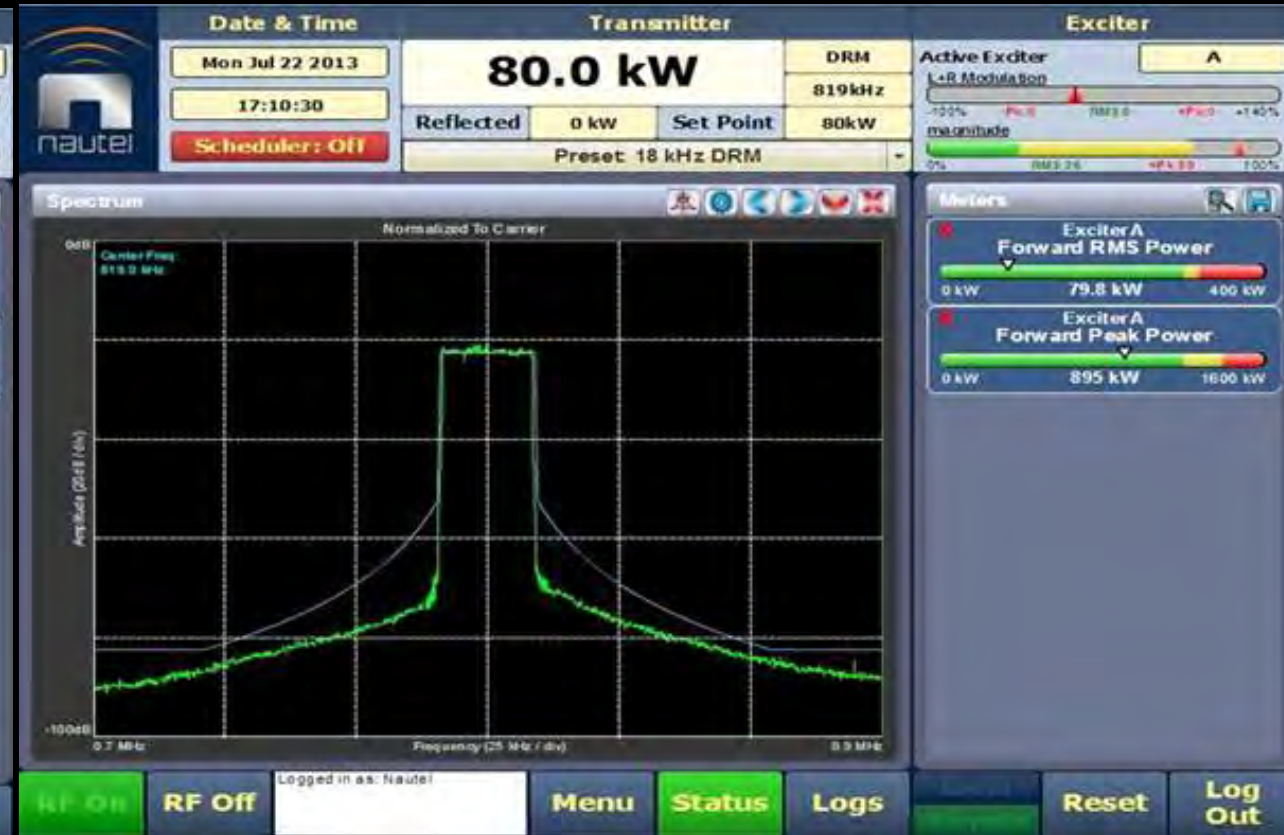
# AM Configuration

- Originally, AM was digital only, thus setup was content server, modulator, transmitter, antenna system. Hybrid mode is now supported, so there can be similar combining modes to FM, with digital and analog transmitters, or one in hybrid mode.
  - Because of the flexibility in modes, concessions can be made for sub-optimal antenna systems. These concessions do come at the expense of bitrate.
  - Similar to HD Radio, antenna linearity across bandwidth and proper phase rotation (asymmetric sidebands) will improve performance.
  - Recommendation is typically to put content server at studio end.

# Digital Broadcast

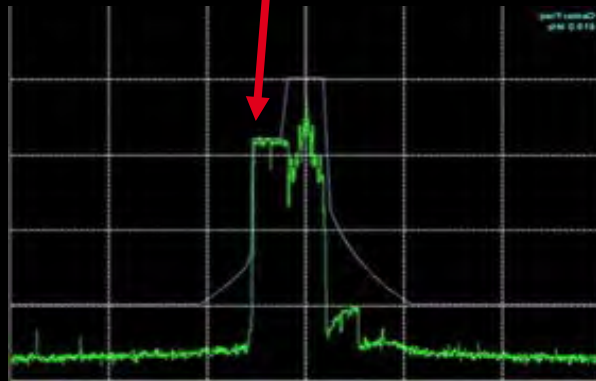
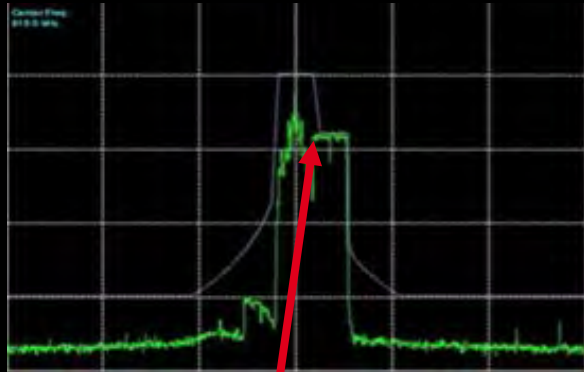


Simulcast

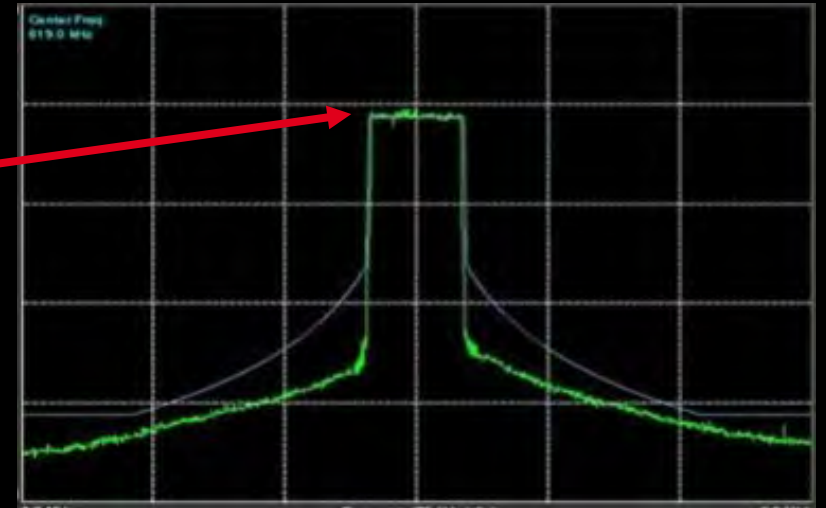


20 kHz DRM

# Simulcast as a path to full digital:



Consistent  
leading edge  
frequency



**20 kHz DRM**

**Simulcast**



# NXSeries Digital Radio leadership

- Advanced PAPR and linearization algorithms
  - provide more RMS power from a given power transmitter
  - with better MER
- Continuing development has improved all-digital performance.
- Feeds the transmitter with true digital I/Q signals for best performance.
- All modes and bandwidths supported



# AM Configuration

- For each mode of operation, there are several options for channel bandwidth, ranging from plus and minus 4.5 to 10 kHz from carrier. Each of these provides different numbers of digital carriers. As well, each mode provide different spacing between carriers. Mode A works well for short range, mode D for very long range.

# AM Configuration

Table 5.3.2: The DRM system Bit Rates

			Nominal Signal Bandwidth (kHz)						
Mode	MSC Modulation (nQAM)	Robustness level	4.5	5	9	10	18	20	100
			Approx. available bit rate kb/s (equal error protection, standard mapping)						
A	64	Min.	14.7	16.7	30.9	34.8	64.3	72.0	
		Max.	9.4	10.6	19.7	22.1	40.9	45.8	
	16	Min.	7.8	8.8	16.4	18.4	34.1	38.2	
		Max.	6.3	7.1	13.1	14.8	27.3	30.5	
B	64	Min.	11.3	13.0	24.1	27.4	49.9	56.1	
		Max.	7.2	8.3	15.3	17.5	31.8	35.8	
	16	Min.	6.0	6.9	12.8	14.6	26.5	29.8	
		Max.	4.8	5.5	10.2	11.6	21.2	23.8	
C	64	Min.				21.6		45.5	
		Max.				13.8		28.9	
	16	Min.				11.5		24.1	
		Max.				9.2		19.3	
D	64	Min.				14.4		30.6	
		Max.				9.1		19.5	
	16	Min.				7.6		16.2	
		Max.				6.1		13.0	

# AM Configuration

For each mode of operation, there are also different levels of protection level (different amounts of error correction – lower protection level, higher error correction)

Table 10.5.2.2a

Minimum usable field strength (dB( $\mu$ V/m)) to achieve BER of  $1 \times 10^{-4}$  for DRM robustness mode A with different spectrum occupancy types dependent on protection level and modulation scheme for the LF frequency band (ground-wave propagation)

Modulation scheme	Protection level No	Average code rate	Robustness mode/Channel bandwidth	
			A/0 (4.5 kHz)	A/2 (9 kHz)
16-QAM	0	0.5	39.3	39.1
	1	0.62	41.4	41.2
64-QAM	0	0.5	44.8	44.6
	1	0.6	46.3	45.8
	2	0.71	48.0	47.6
	3	0.78	49.7	49.2



# FM Configuration – high level injection

- Less transmitter cost than hybrid
- No additional antenna required
- Higher injection level may impact the analog TPO capability
- Much higher cost of operation, due to losses in injector (lower efficiency)
- Much bigger footprint
- Overall project cost could exceed other options significantly
- Requires a reject load



# FM Configuration – space combined

- More efficient
- Digital transmitter/antenna can be used as backup
- Takes up more space
  - In site
  - On tower
- **Pattern replication issues**
- Can also be combined into a single, circularly polarized antenna, with analog driving vertical elements and digital driving horizontal. Requires a hybrid coupler to drive the antenna elements.

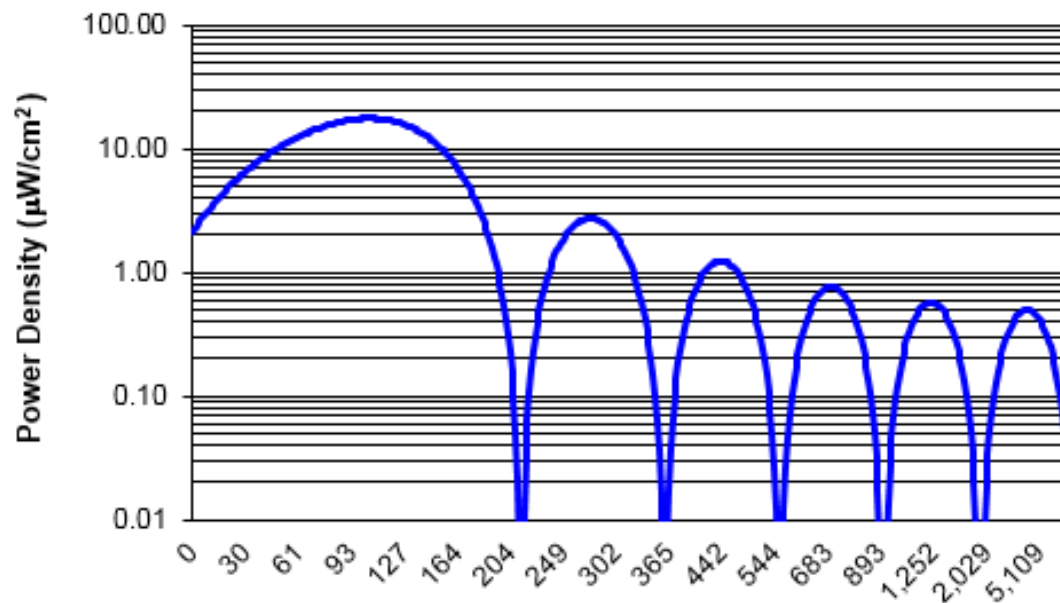


# FM Configuration – space combined

Antenna: Dielectric  
Bay Spacing: 1 wavelength  
Element Field @ -90: 11% (avg)  
Far-field Pattern Assumed

R/C Height AGL: 328 feet  
Max. ERP per polarization: 25.000 kW Analog  
0.000 kW Digital (avg)  
Date of Study: 28-Feb-18 / ID# 1

**Theoretical Power Density per OET Bulletin 65**  
**Calculated for 2 meters (6.56 feet) Above Level Terrain**  
FCC limits: Uncontrolled Access =<200; Controlled Access =<1,000.



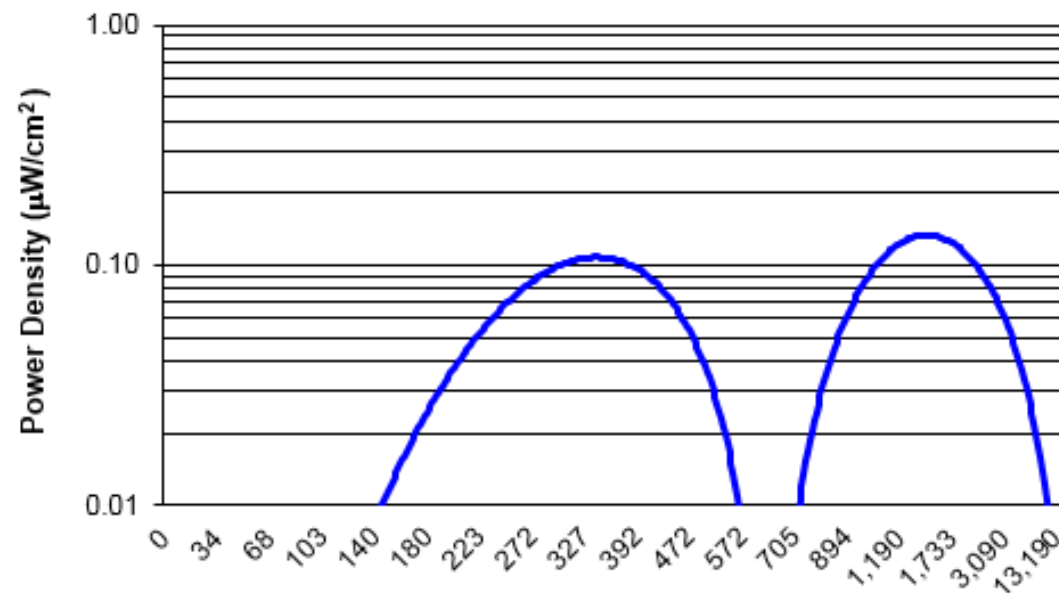
Horizontal Distance from Tower Base (feet)

*Calculation only for review and acceptance of station engineer or consultant.*

Antenna: Dielectric  
Bay Spacing: 0.5 wavelength  
Element Field @ -90: 11% (avg)  
Far-field Pattern Assumed

R/C Height AGL: 375 feet  
Max. ERP per polarization: 0.000 kW Analog  
1.000 kW Digital (avg)  
Date of Study: 28-Feb-18 / ID# 1

**Theoretical Power Density per OET Bulletin 65**  
**Calculated for 2 meters (6.56 feet) Above Level Terrain**  
FCC limits: Uncontrolled Access =<200; Controlled Access =<1,000.



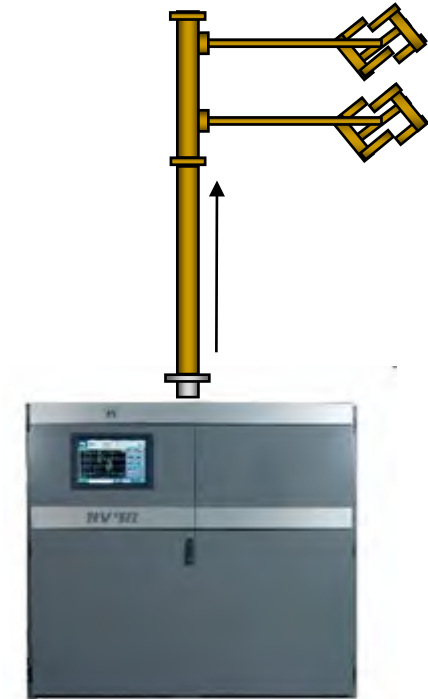
Horizontal Distance from Tower Base (feet)

*Calculation only for review and acceptance of station engineer or consultant.*

# FM Configuration – low level combined

- Simple architecture
- Single box installation
- Higher HD injection level may reduce the analog TPO capability
- May need to replace your transmitter or combine another for higher total power
- Higher injection levels reduce efficiency\*

\* HD PowerBoost increases digital injection and efficiency of an existing transmitter.





# FM Configuration

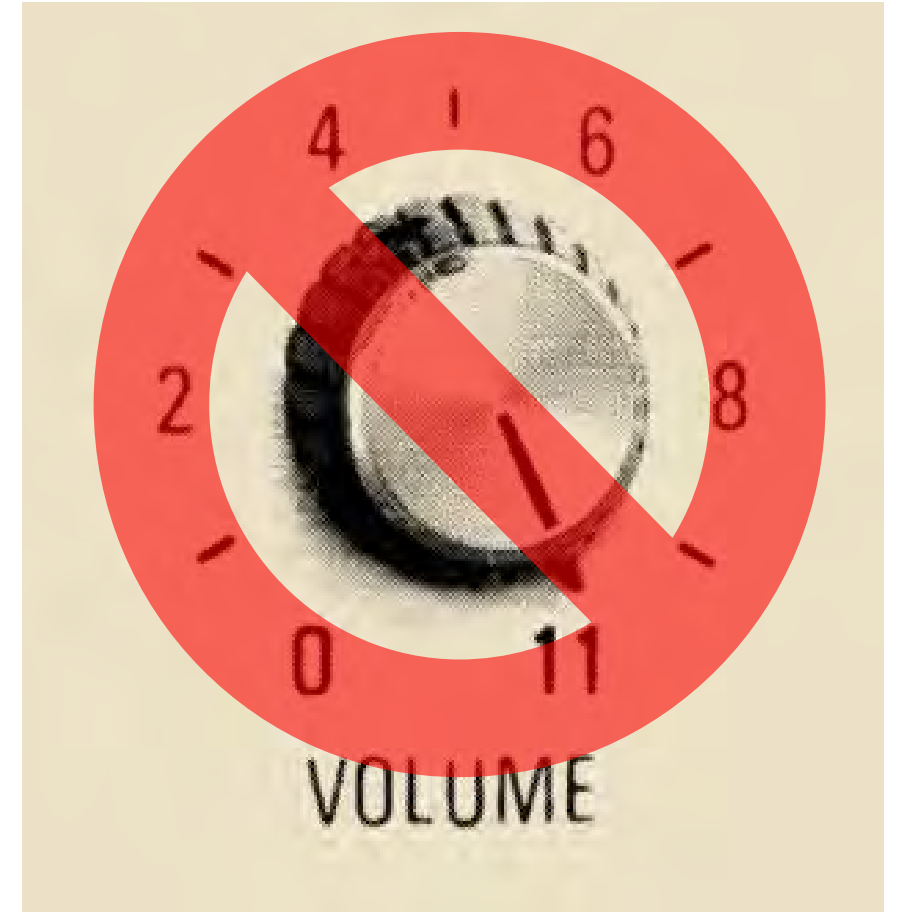
As with AM, higher bitrates can be achieved with less robustness. Depending on site parameters, it may be advisable to go to a lower bitrate and improve the robustness level.

DRM+ bitrates [kbit/s]			
Mode	MSC modulation	Robustness level	Bandwidth 100 kHz
E	4-QAM	Max	37.2
		Min	74.5
	16-QAM	Max	99.4
		Min	186.3

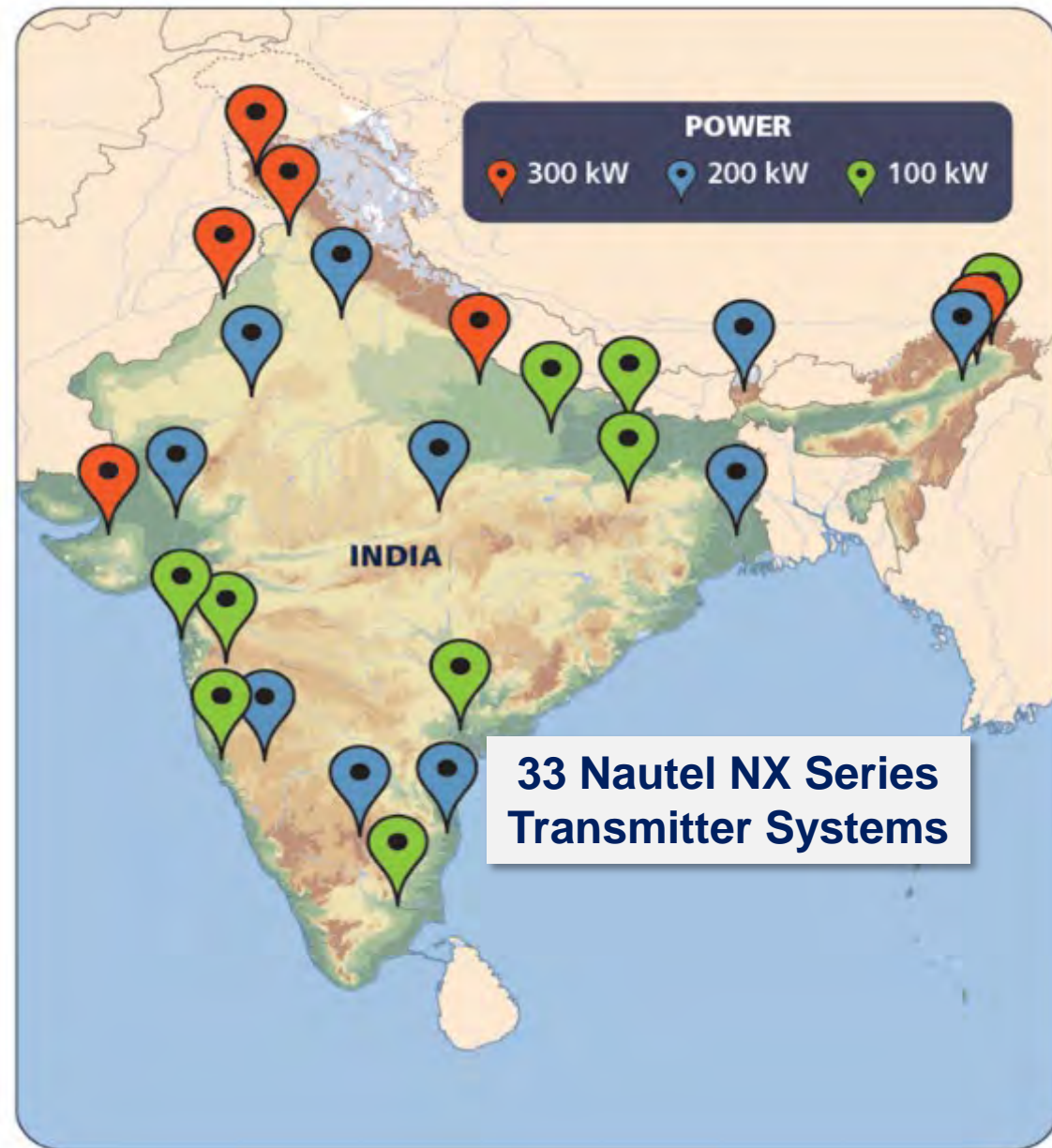
[https://en.wikipedia.org/wiki/Digital\\_Radio\\_Mondiale](https://en.wikipedia.org/wiki/Digital_Radio_Mondiale)

# Suggestions...

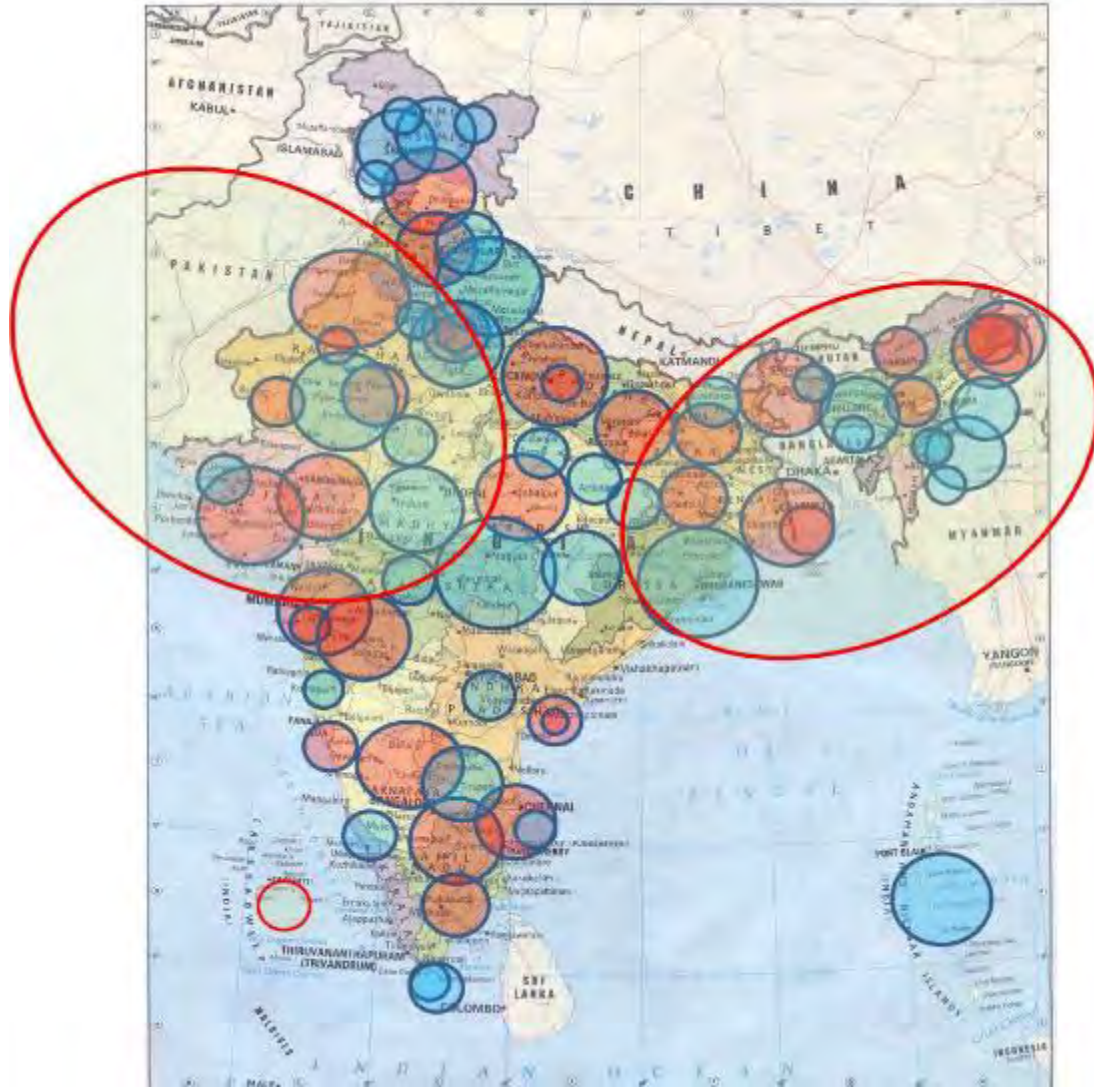
- Don't overprocess
- Based on 48 kHz sample rate
- Streaming processors work well



# World's Largest DRM30 Deployment



Over **>70%** of India &  
**99%** of the Population  
Receive DRM30  
Broadcasts







nautel

SuperPower MW



**NX** Series 3 – 2000 kW AM/MW/LW







# Mumbai A



# Mumbai B





# Mumbai C



# NX300 Main/Alternate



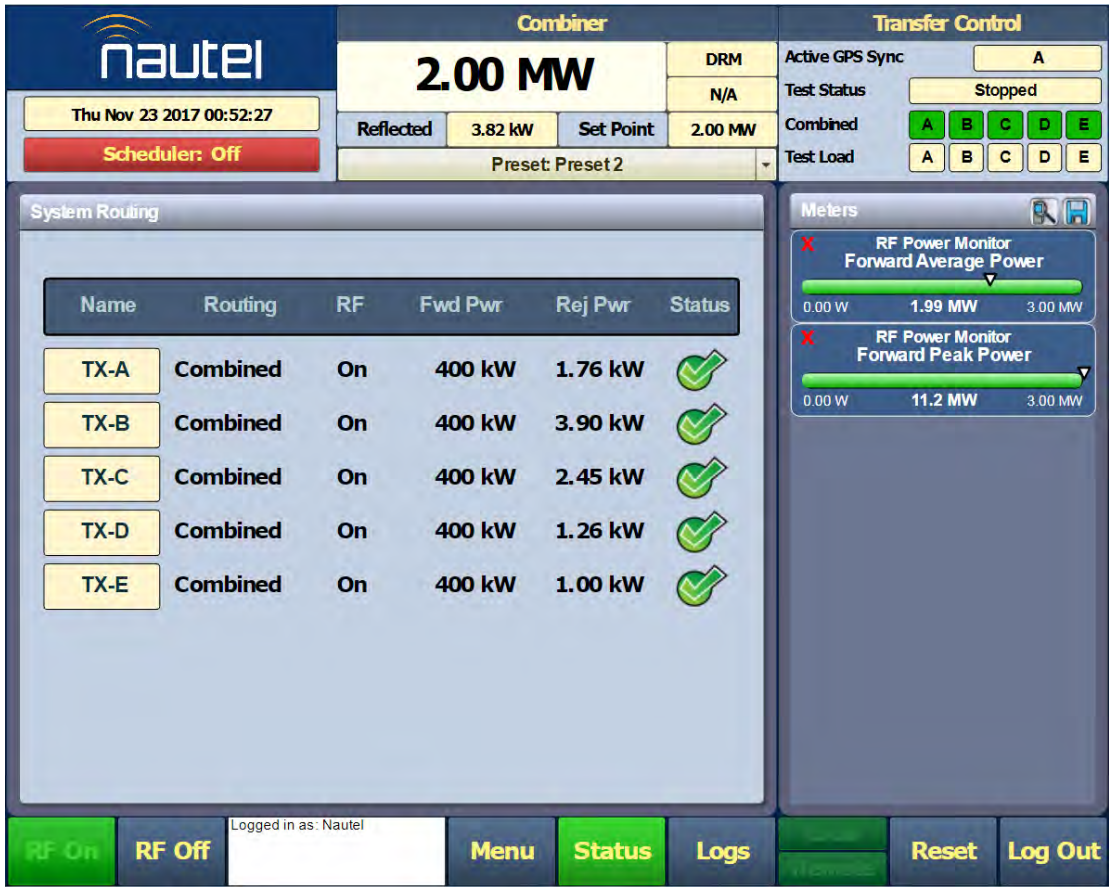
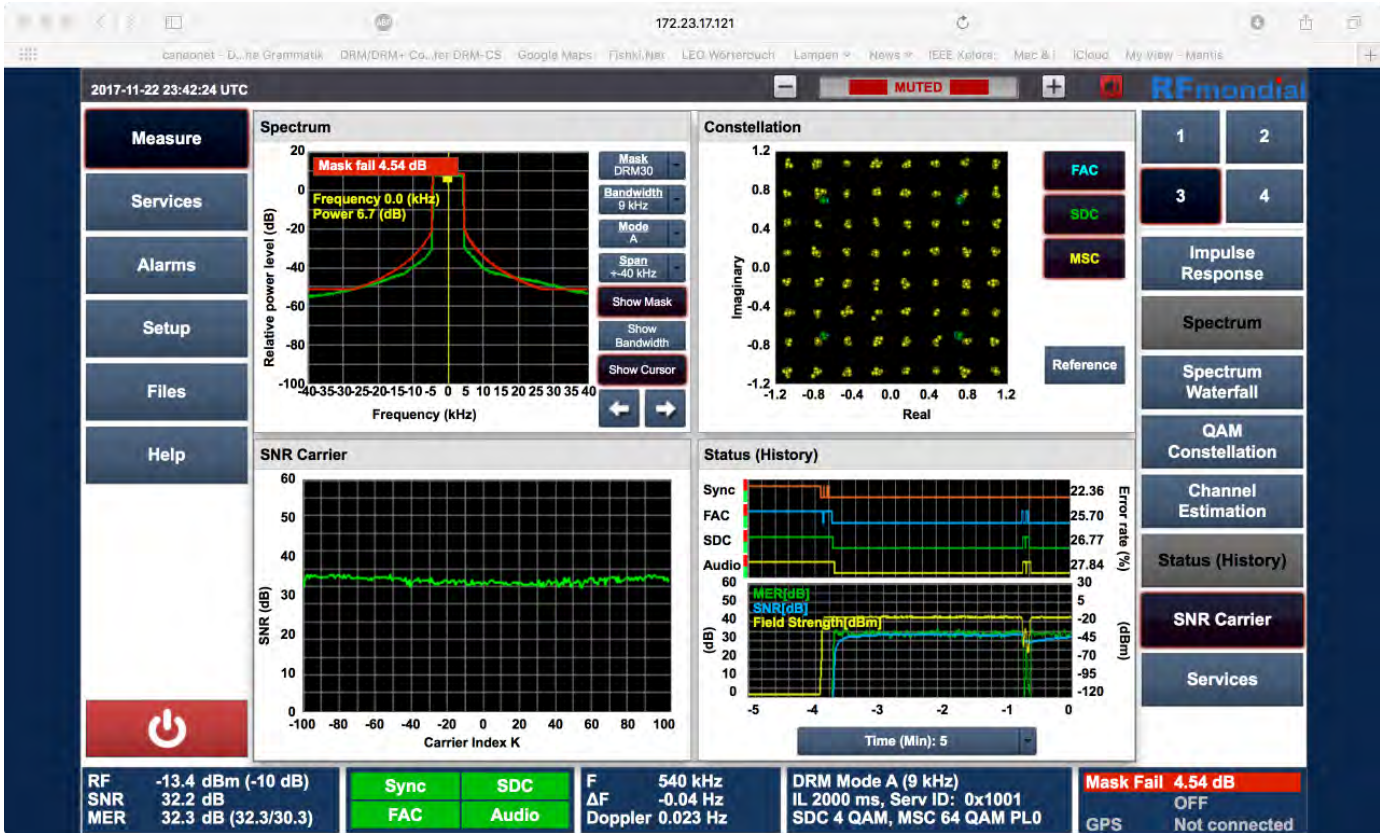


# 5 x 400 kW Transmitters Being Installed





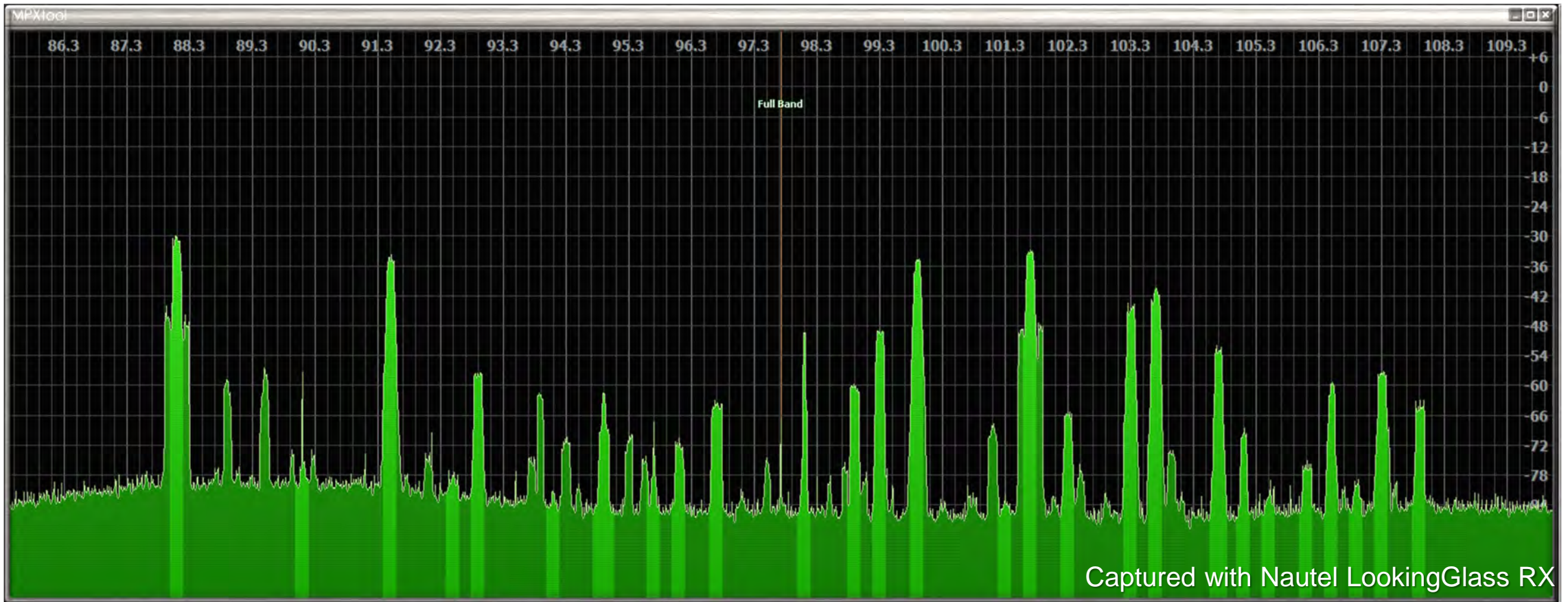








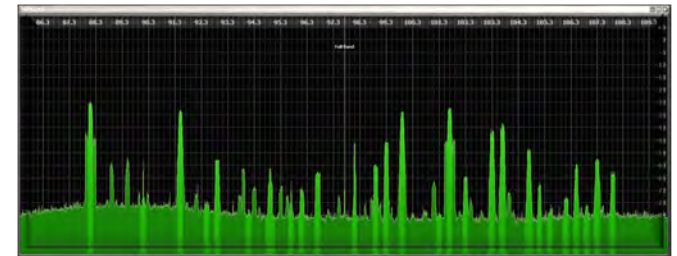
# The Problem: The FM Band is Full





# The Problem: The FM Band is Full

- Unable to add high power analog channels in existing FM band
  - 20-30 FM stations maximum, no new frequencies in big cities
- Expensive to add many new analog FM transmitters where possible
- Difficult to build out nationwide audio network
- Can we achieve multi-channel audio services
  - Option for spectrum or channel auction
  - Nationwide SFN
  - Regional, multi-lingual, education, new stations, ...

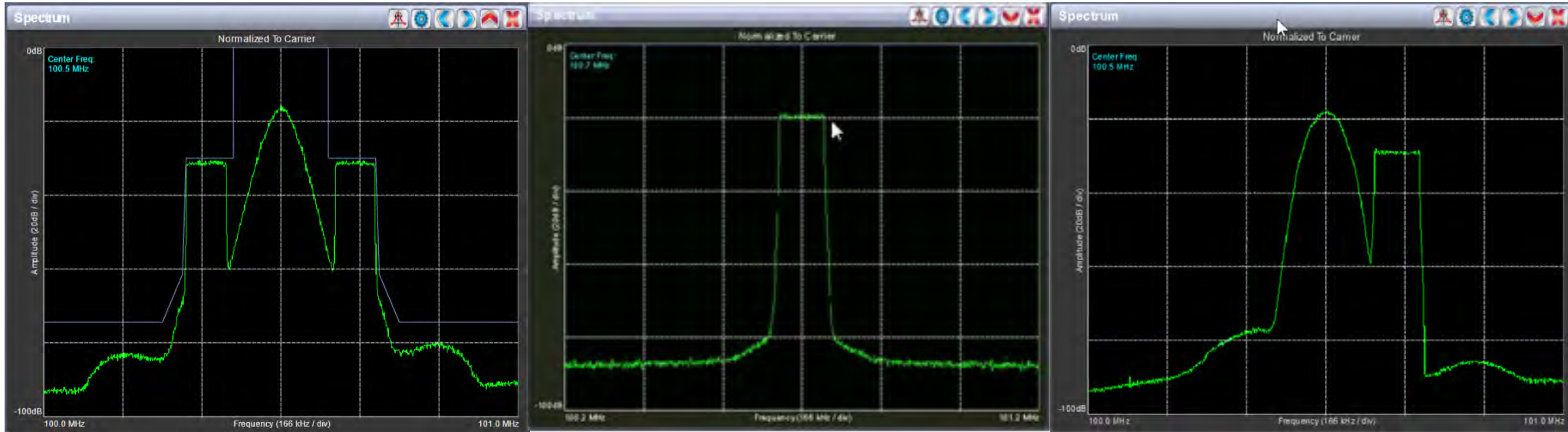


# Solution: Unlock NEW Digital Channels



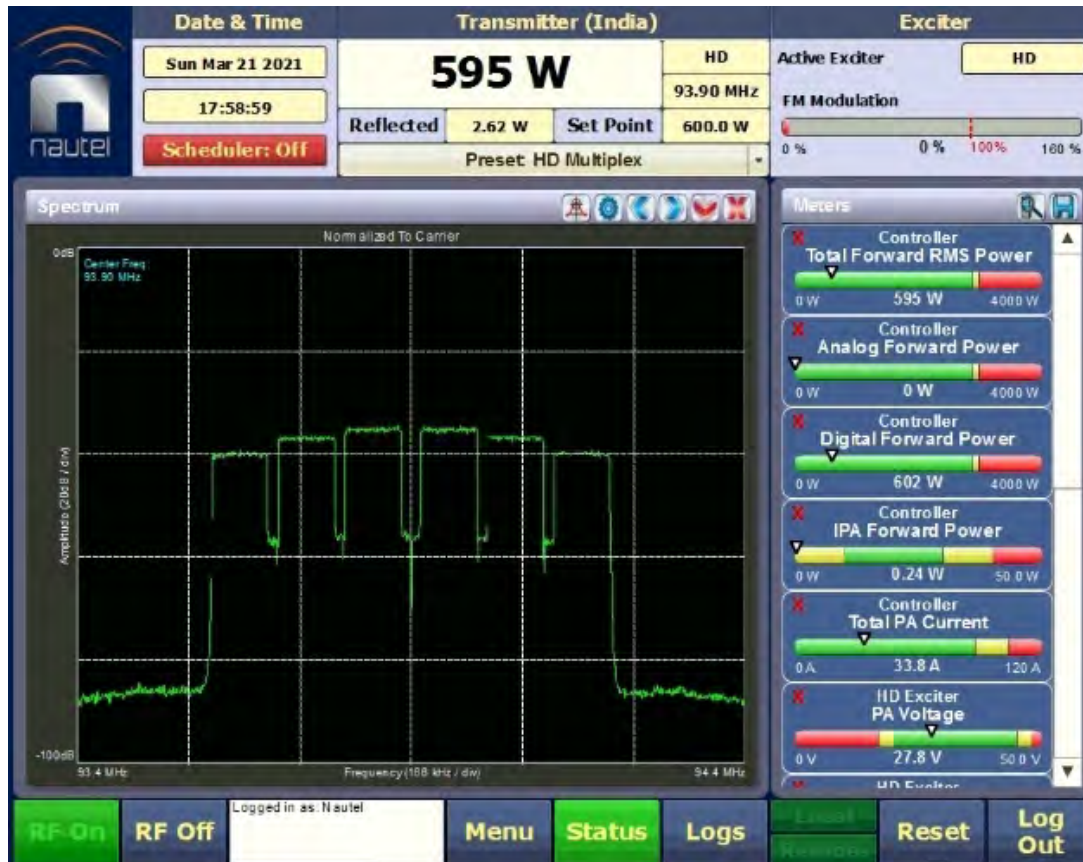
- Digital Radio Mondial and HD Radio can co-exist with FM allocations
- Digital allows 400 kHz interleaving of analog and digital stations
- Digital signals can be combined in single transmitter for efficient broadcast
  - 12 to 18 audio services within a single transmitter and antenna

# Standard HD Radio and DRM

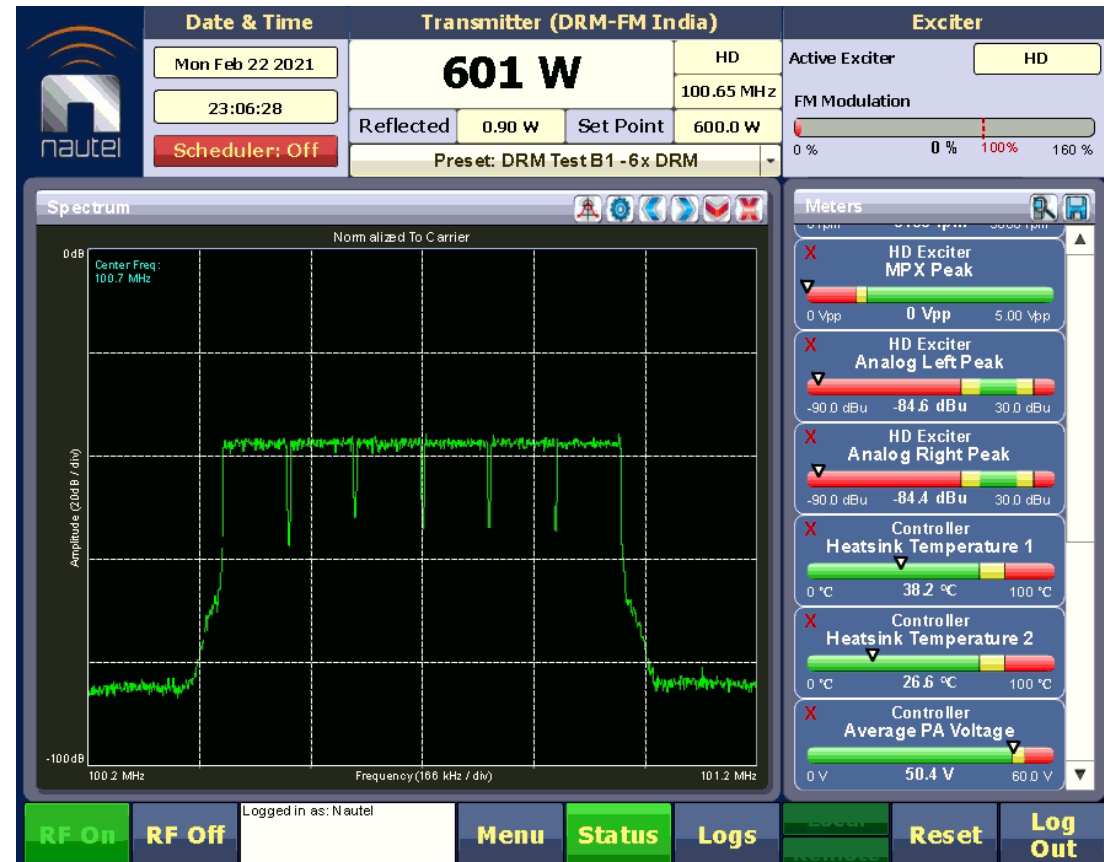


	HD Radio	DRM-FM	DRM Simulcast
Audio Services	1 analog + 4 audio services	3 audio services	1 analog + 3 audio services
Digital Power	Typ. 10% of analog FM	100%	10%-25% of analog FM

# Multiplexing Digital Radio Signals



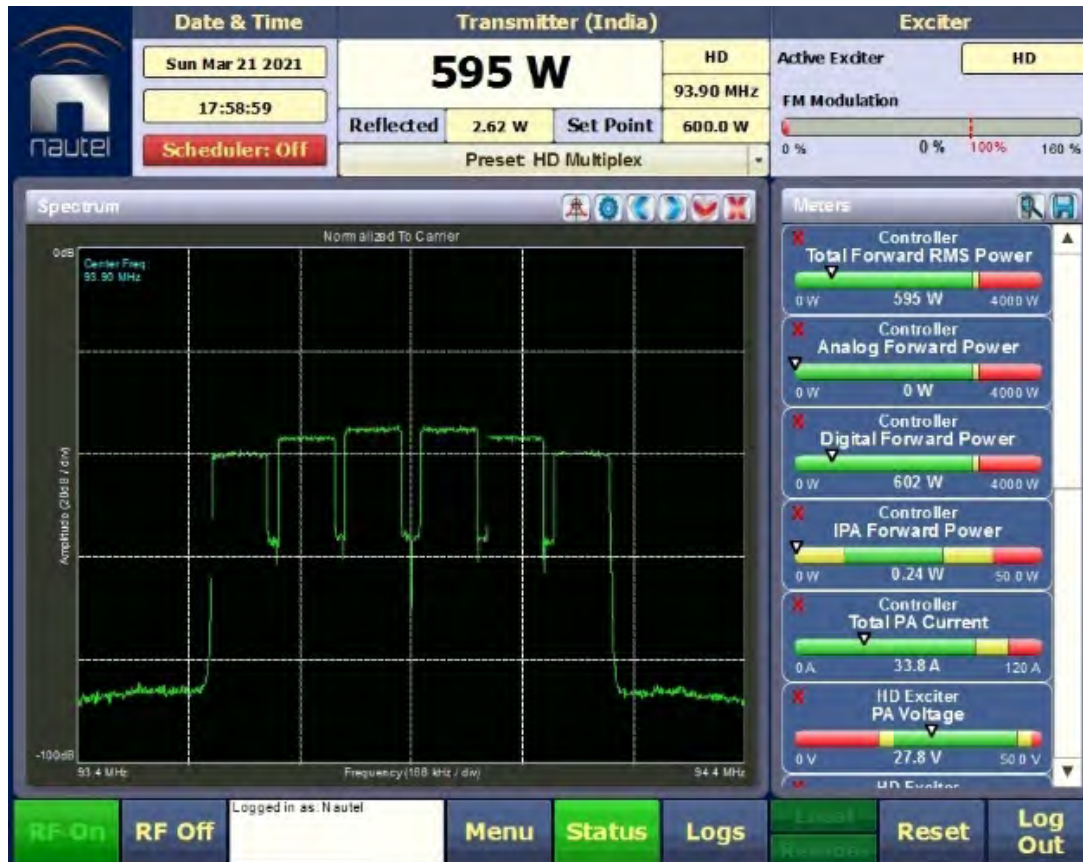
3 Multiplexed HD Radio Stations



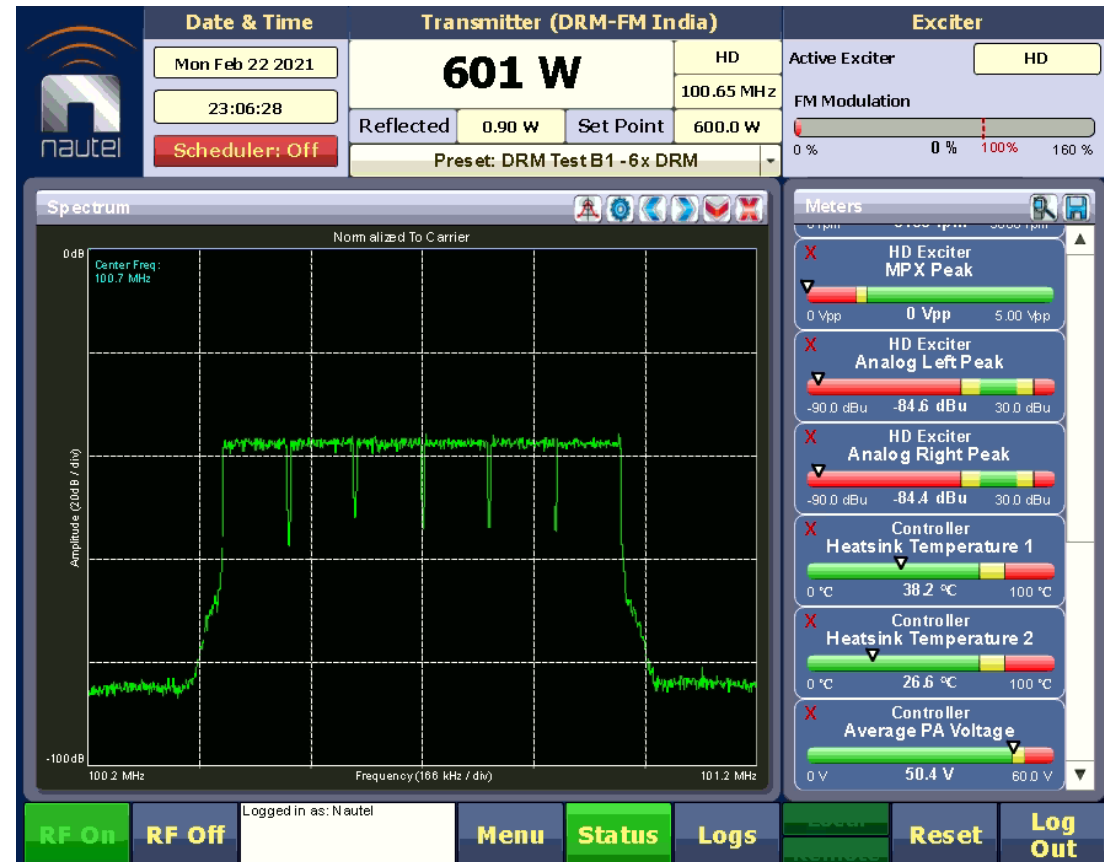
6 Multiplexed DRM-FM Stations



# Can this Multiplex coexist in the FM Band?



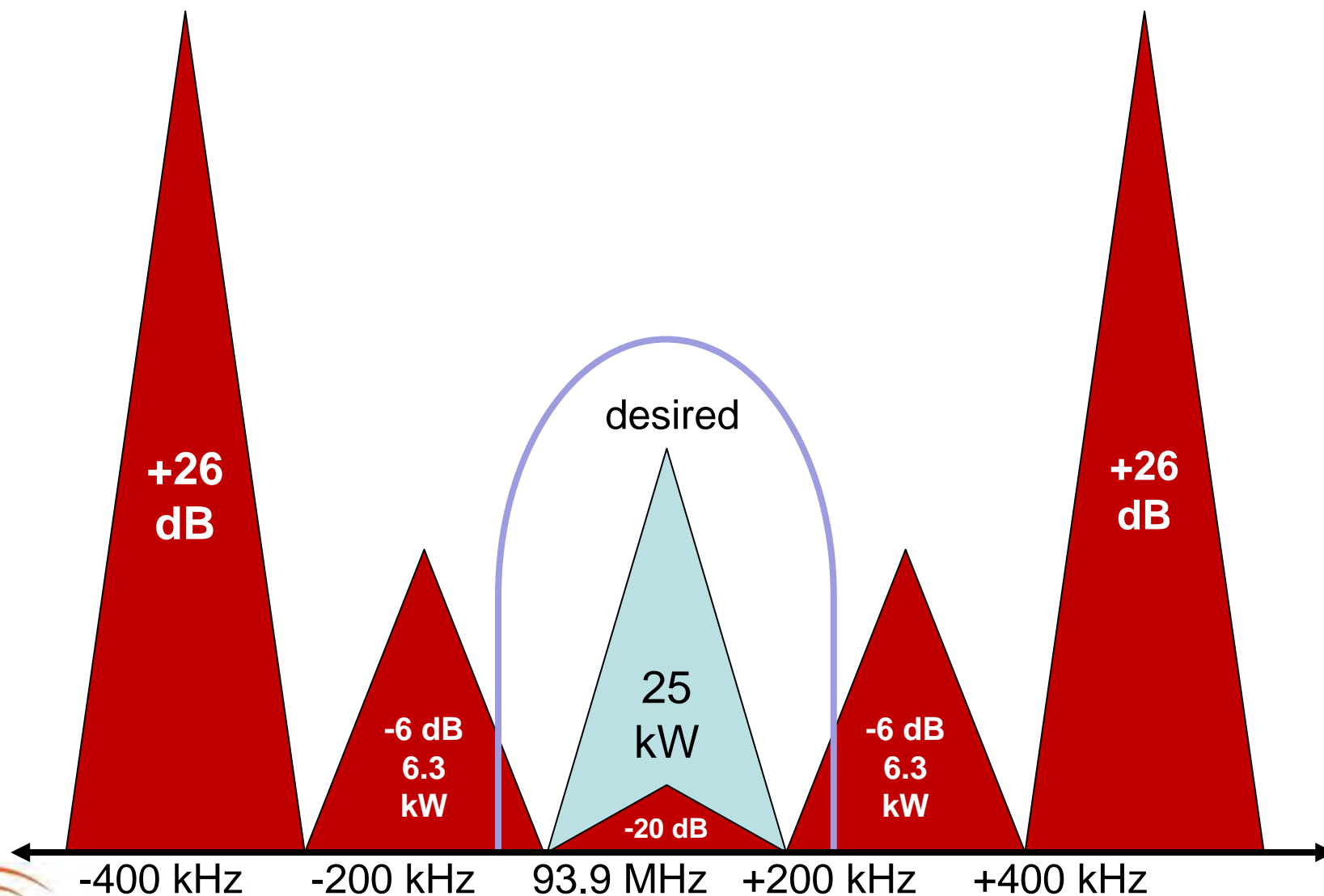
3 Multiplexed HD Radio Stations



6 Multiplexed DRM-FM Stations



# FM into FM Protection Ratios



0 kHz: -20 dB ( 1%)  
±200 kHz: -6 dB (25%)  
±400 kHz: +26 dB(400x)

Based on typical receiver channel selectivity

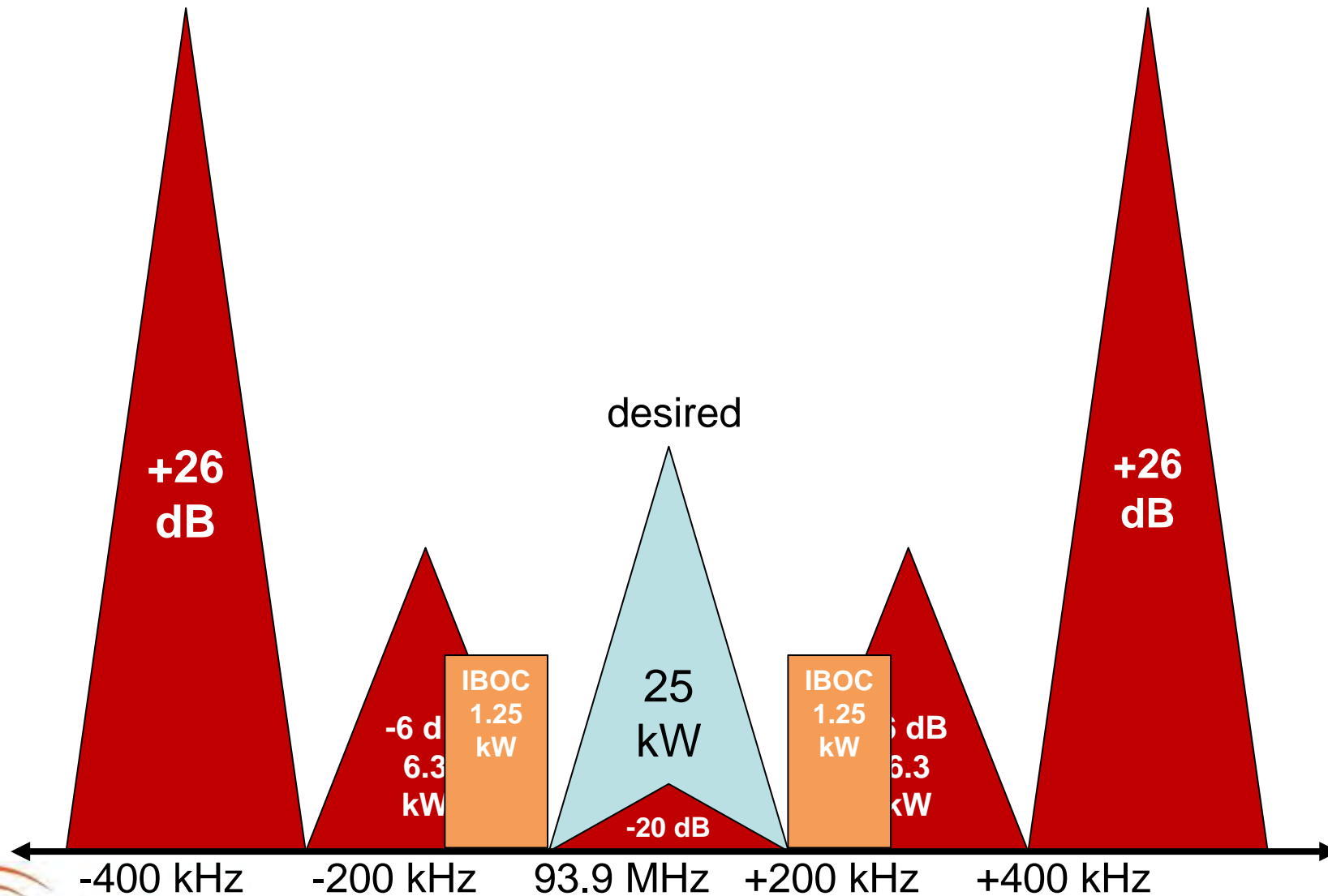
## Positive

We can add power at TX site

## Negative

Adjacent channels may already be allocated

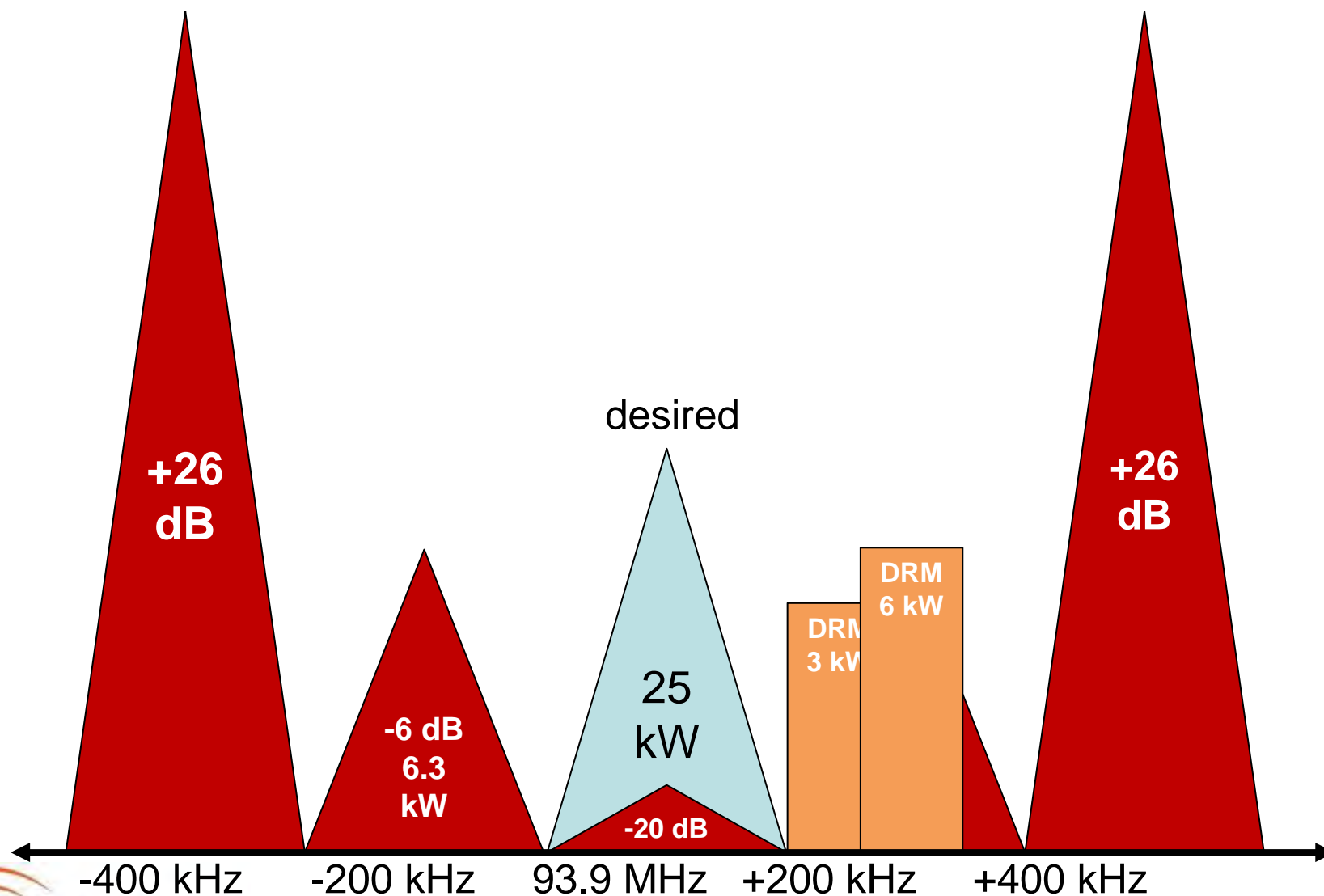
# HD Radio uses 200 kHz Whitespace



HD Radio places sidebands at 150 kHz offset at 10% to 12% total injection.

10% HD Radio provides comparable coverage.

# More power with DRM at 200 kHz



DRM Simulcast places the DRM at 150 kHz or 200 kHz offset.

All digital power is in a single block.

Power can be increased with greater frequency offset.

FM comparable coverage around 10% power in highest robustness mode.

# FM Whitespace ideal for 10% Digital Power

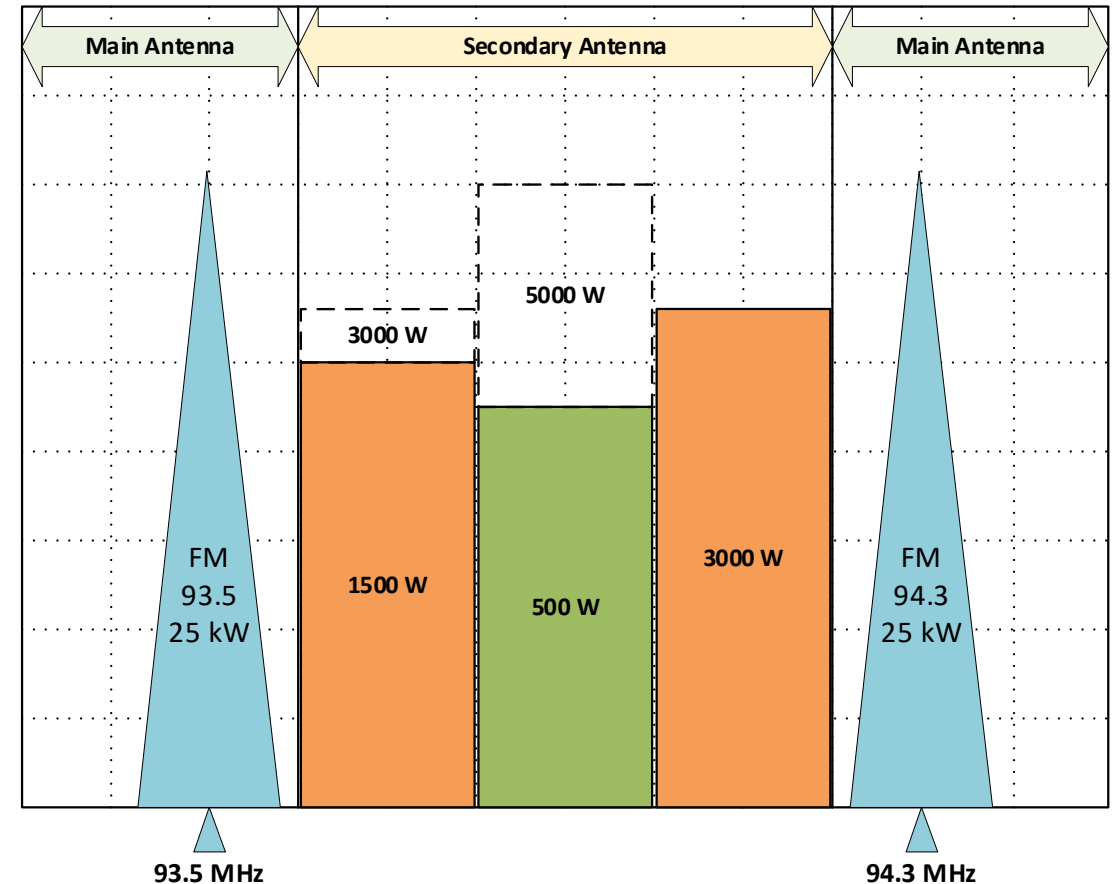
## Without adjacent FM stations

- Self interference from site is the only limit
- Match antenna gain and pattern
- 11 kW ERP or 4.4 kW TPO
- Budget for **28 kW peak transmitter**

## With nearby adjacent FM stations

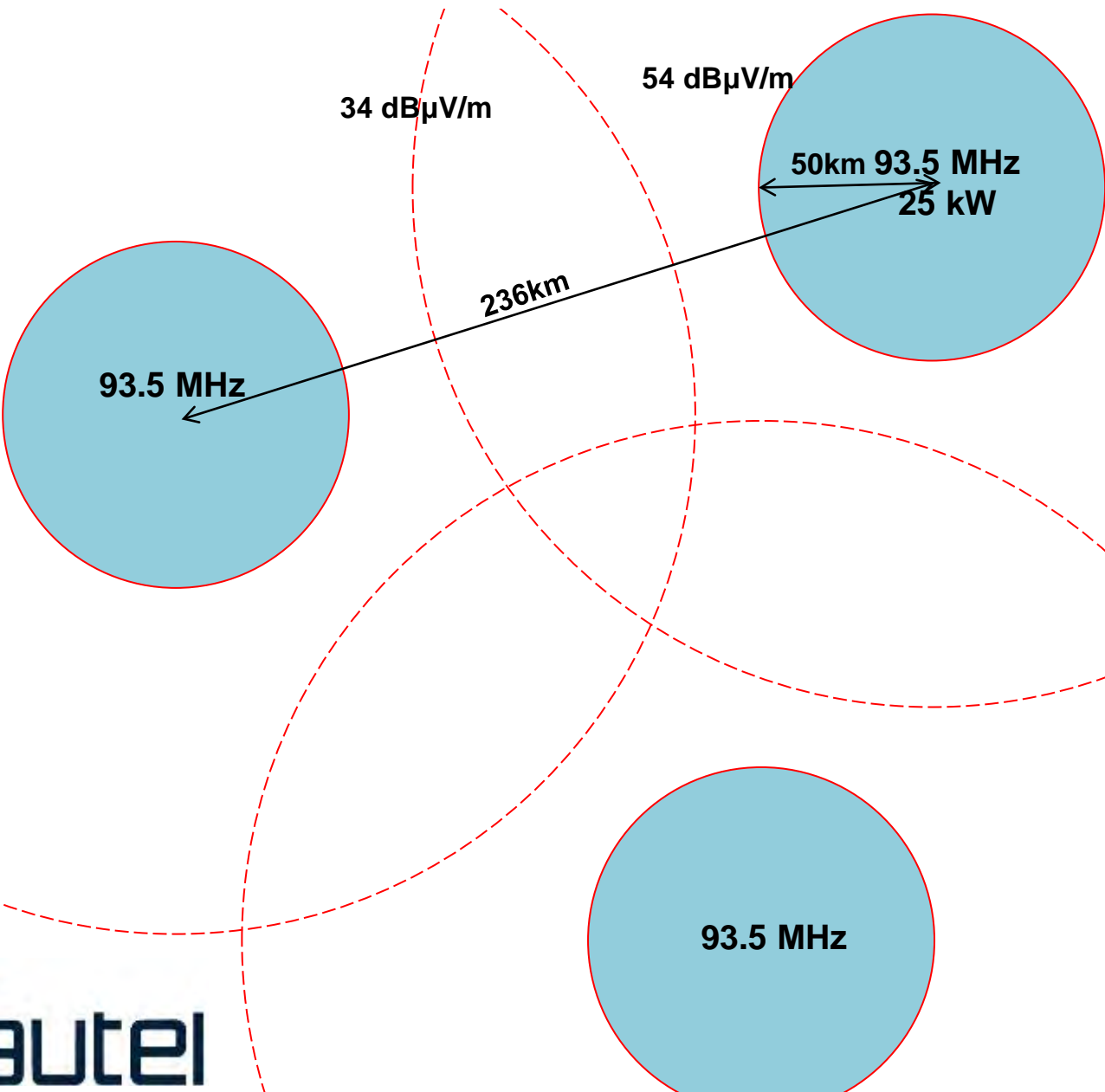
- Protection limited to other stations
- Reduce to 3.5 kW ERP/1.4 kW TPO
- Budget for **10 kW peak transmitter**

**Every situation is different  
analysis is required**

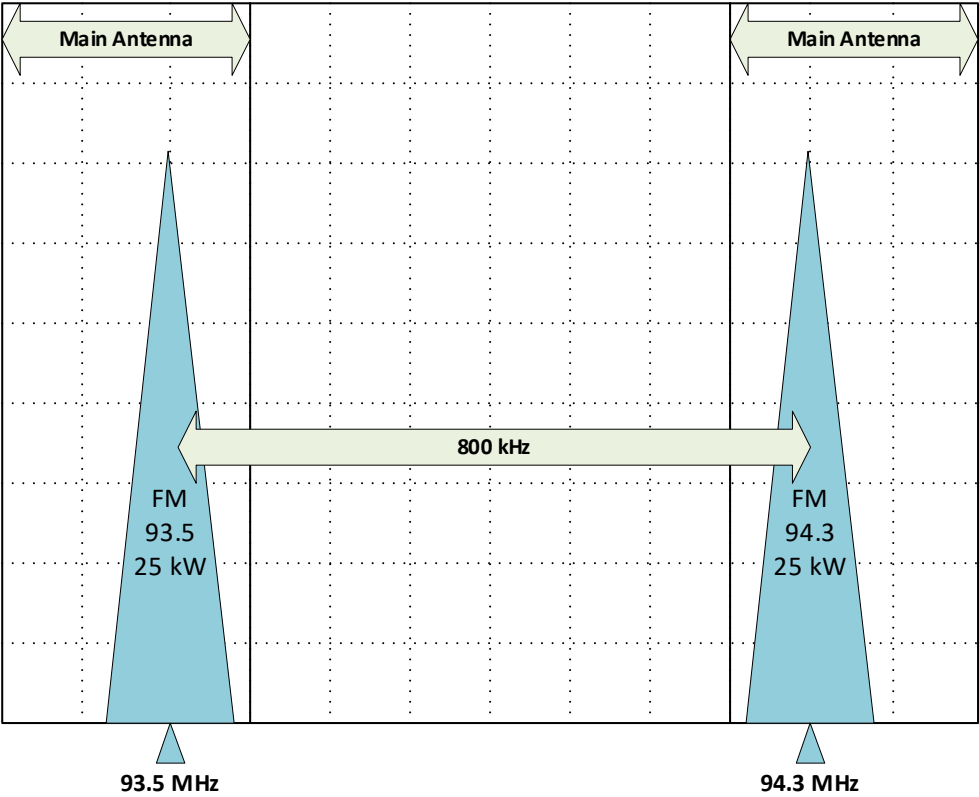




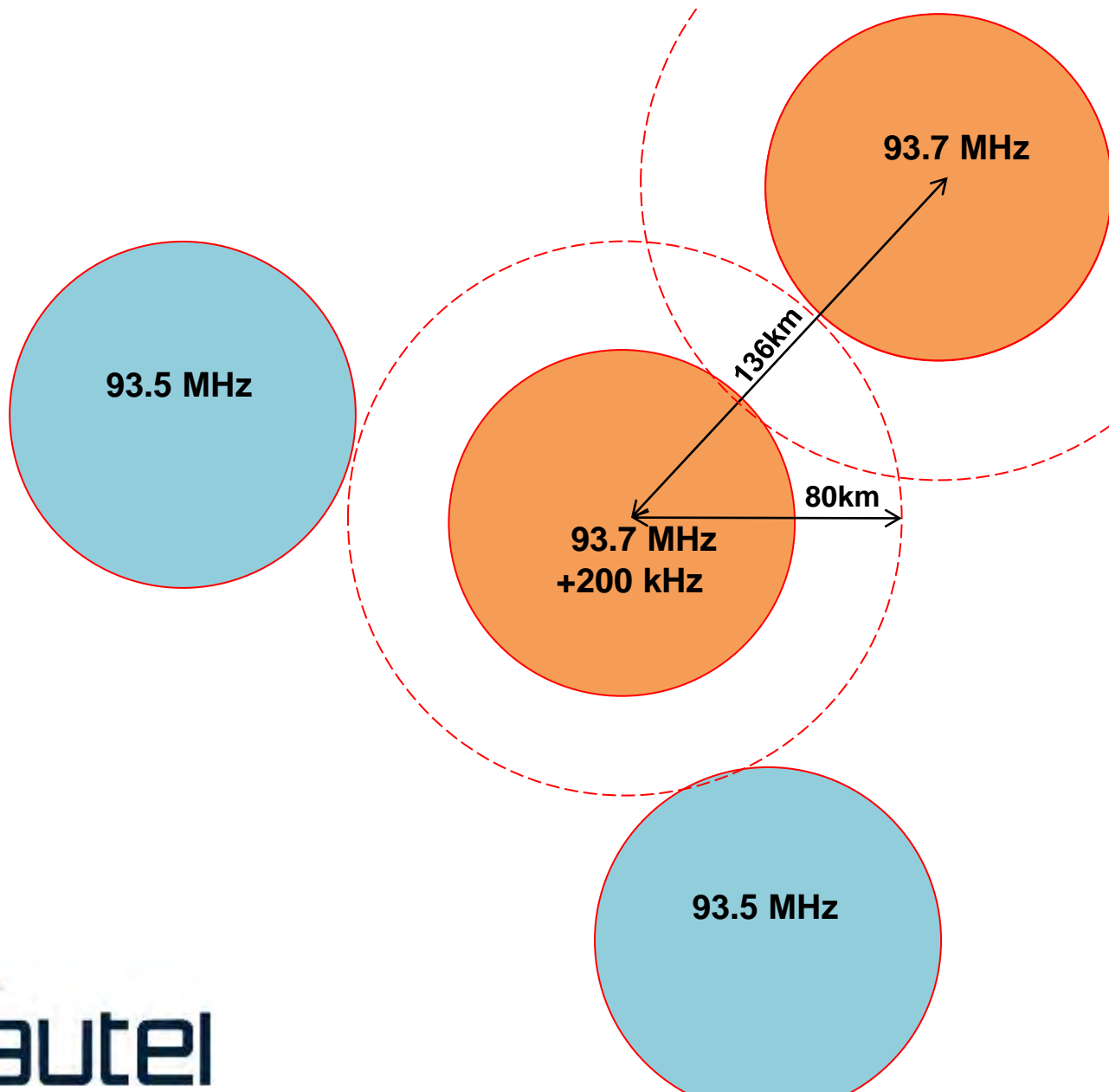
# Cochannel FM Allocations



ERP of 25 kW @100 m  
(10 kW TX + 4 dB antenna gain)  
**-20 dB (0.01x) protection**  
236 km separation => white space



# No Interference: 200 kHz Digital

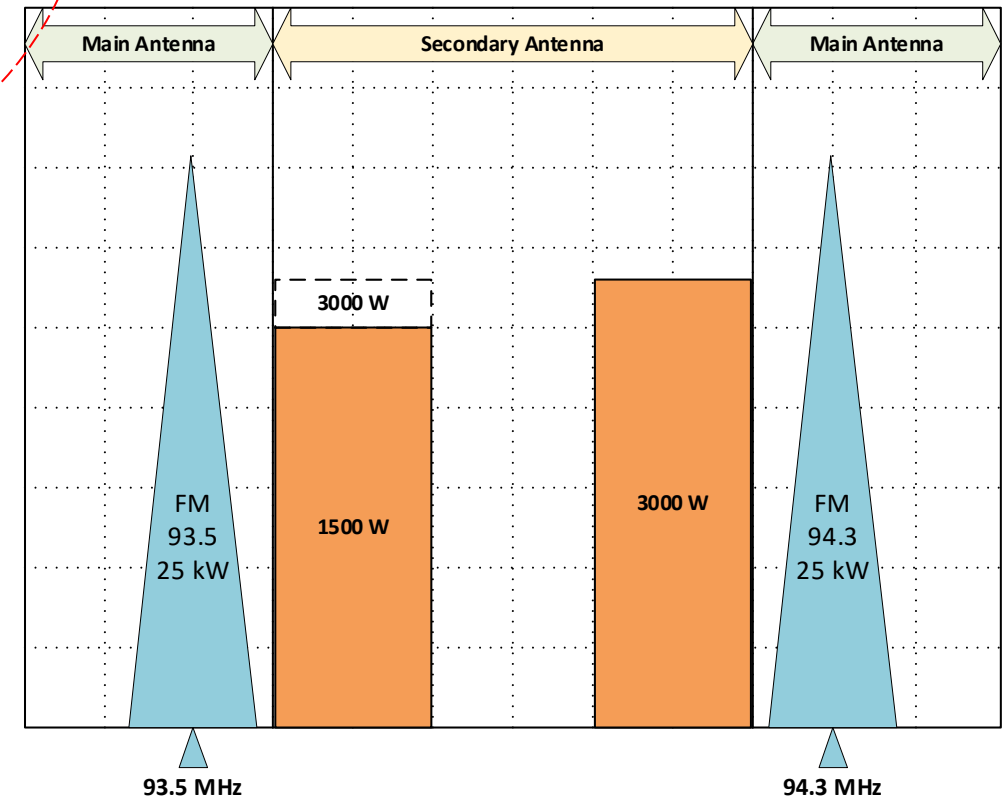


Better protection ratio:

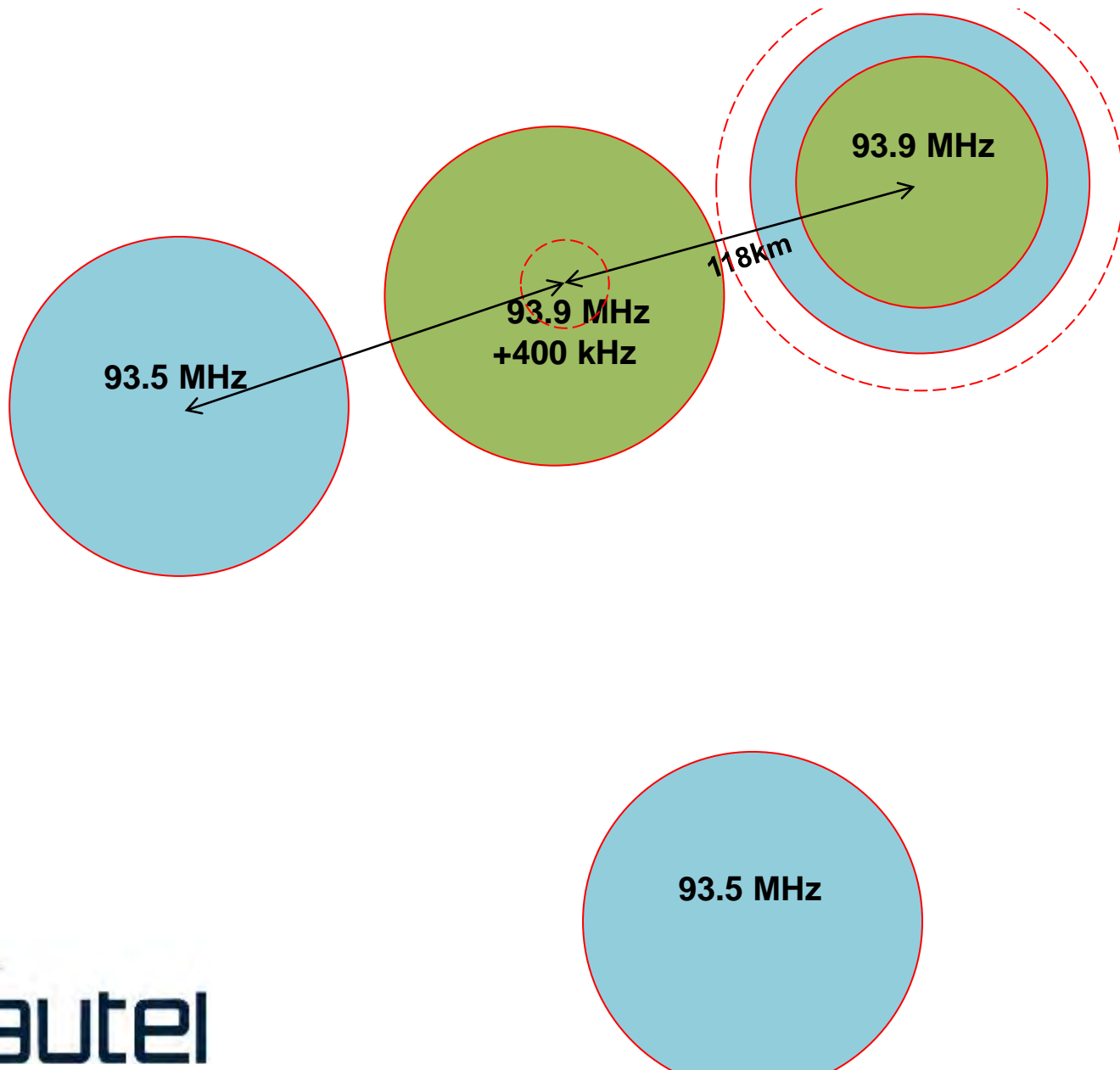
-20 dB (0.01x) to -6 dB (0.25x)

⇒ Limits minimum distance

Digital needs approx. 10% power



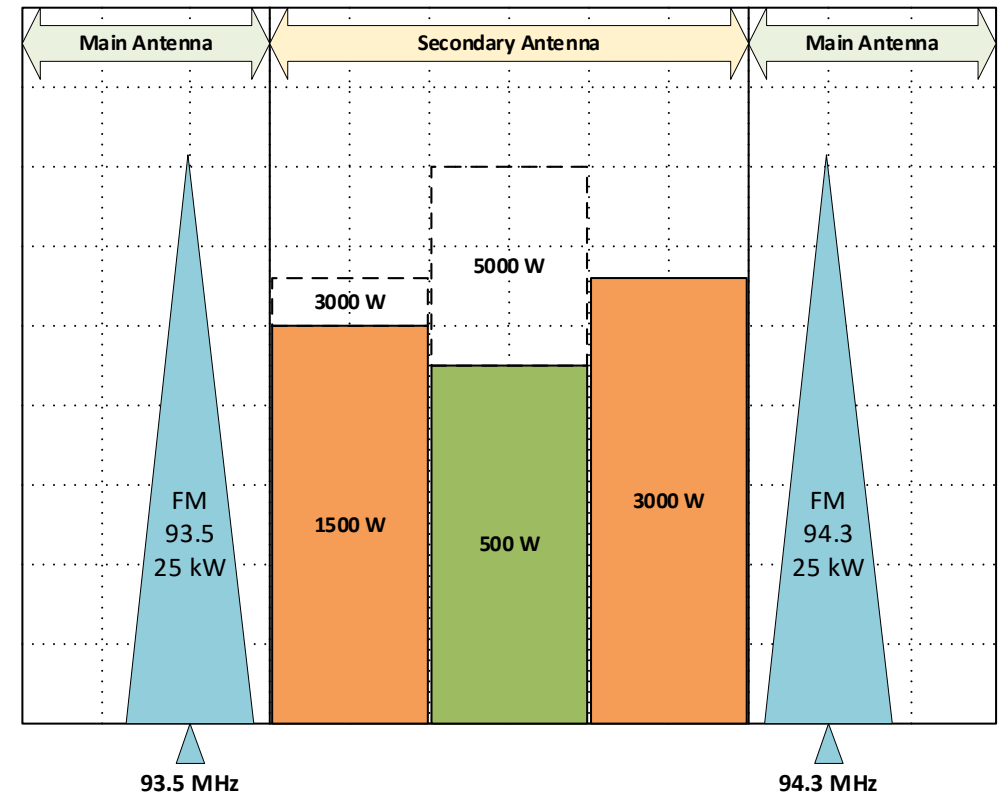
# No Interference: 400 kHz Digital



Better protection ratio:

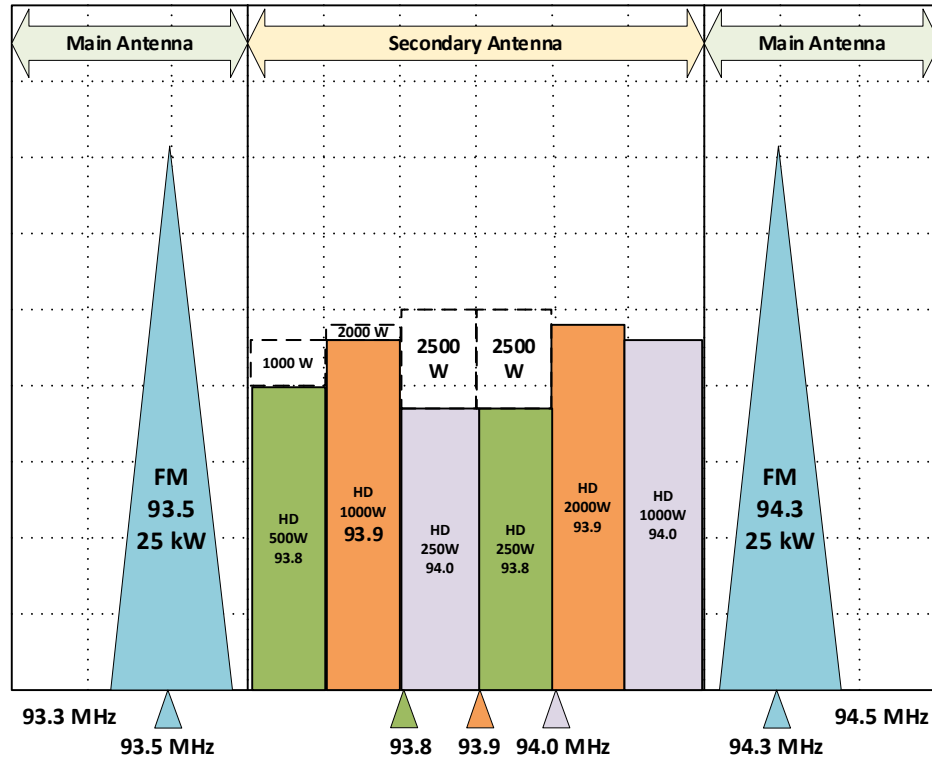
-6 dB (0.25x) to +26 dB (400x)

Option to increase digital power





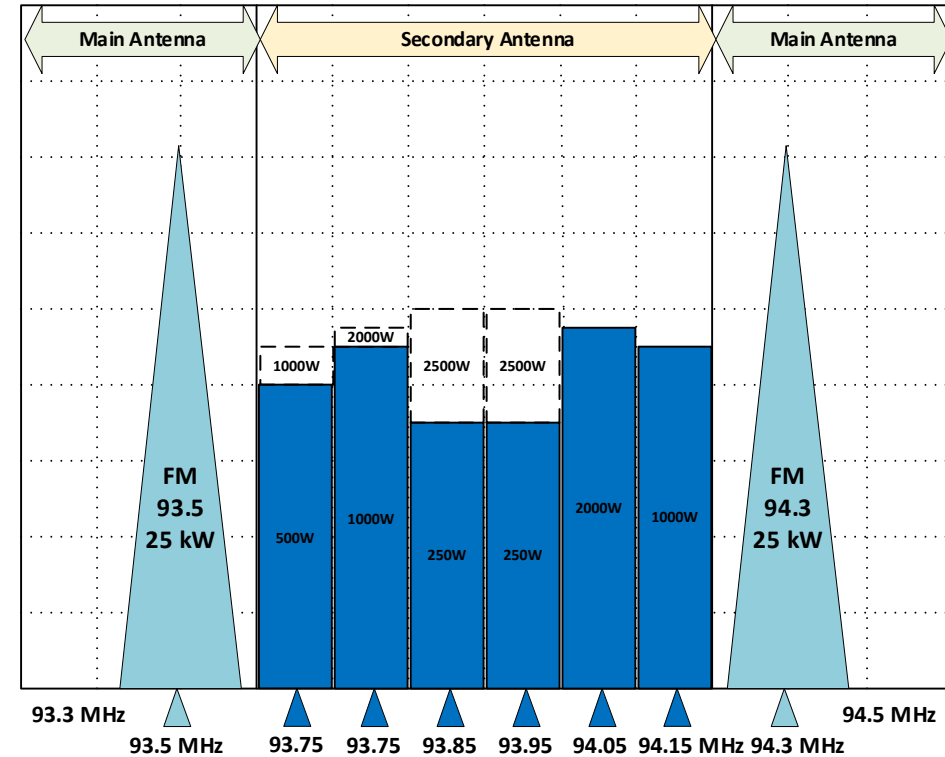
# HD Radio and DRM Application



12 audio services (5.5-12 kW)

3 spot frequencies

Power can be balanced across dual sidebands

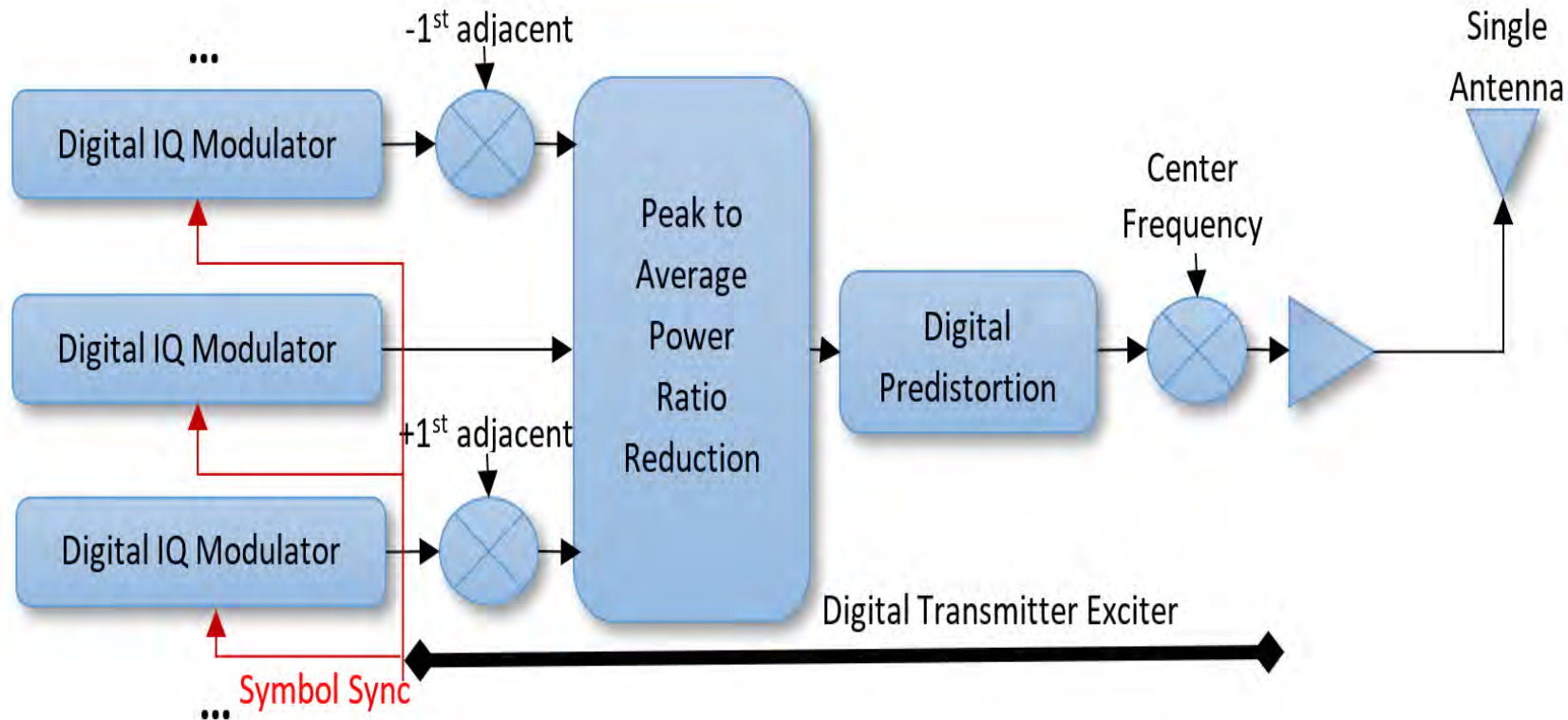


18 audio services (5.5-12 kW)

6 spot frequencies

Reduction in block reduces coverage

# New Digital Modulator / Exciter



Symbols must be

- perfectly aligned in time
- perfectly spaced in frequency

⇒ maintains orthogonality

⇒ No frequency guard band

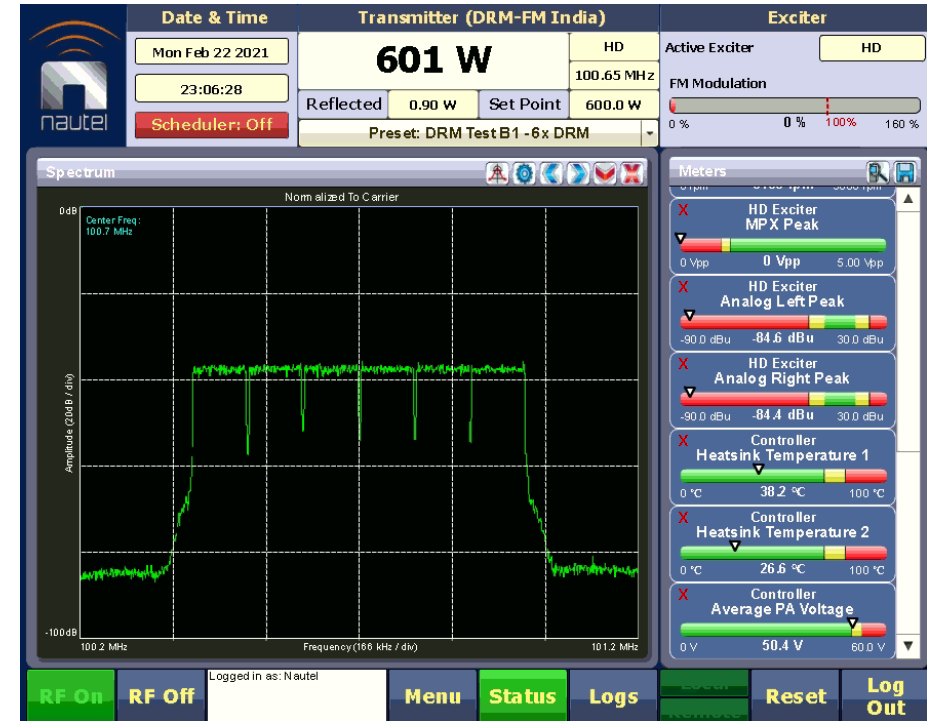
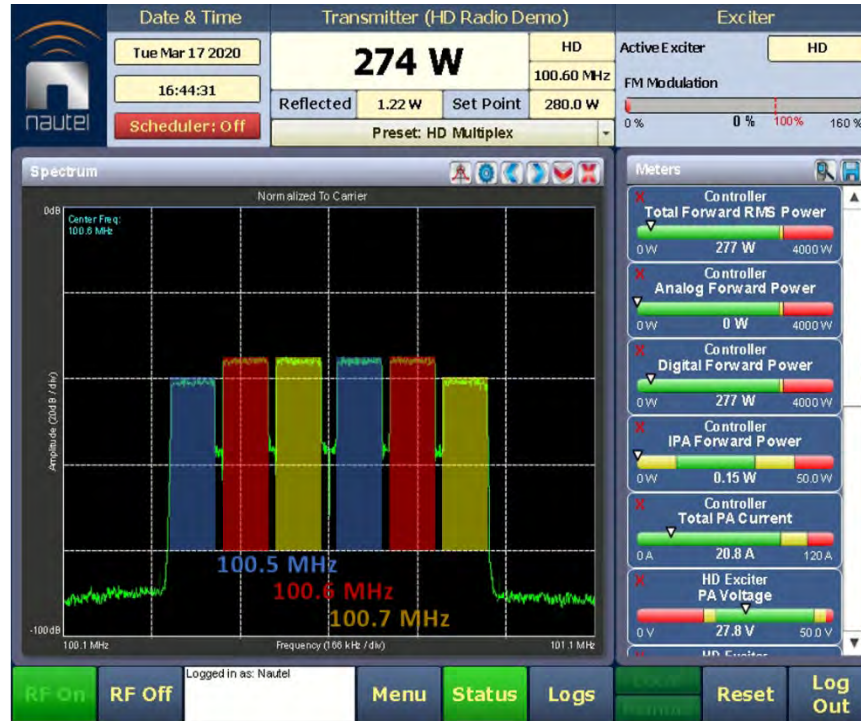
## New multi-DRM or multi-IBOC modulator exciter

- Performs Nautel proprietary peak power reduction
- Ensures best possible digital signal quality

# 600 kHz Demo in Delhi



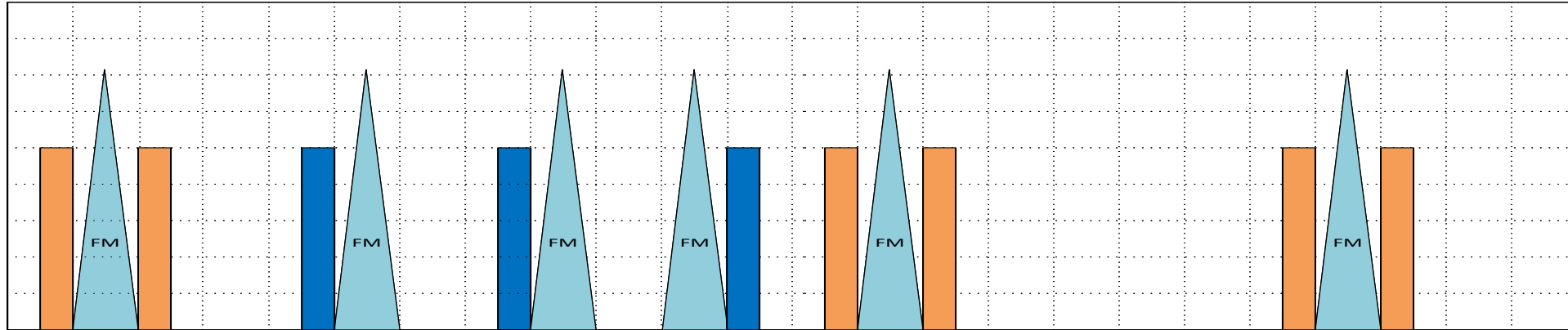
Nautel VS2.5  
Transmitter



	HD Radio	DRM-FM
Spot Frequencies	100.5/100.6/100.7 MHz	100.4/100.5/100.6/100.7/100.8/100.9 MHz
Audio Services	12 – 18 audio services	
Data capacity	223.8 kbps - 372.3 kbps	

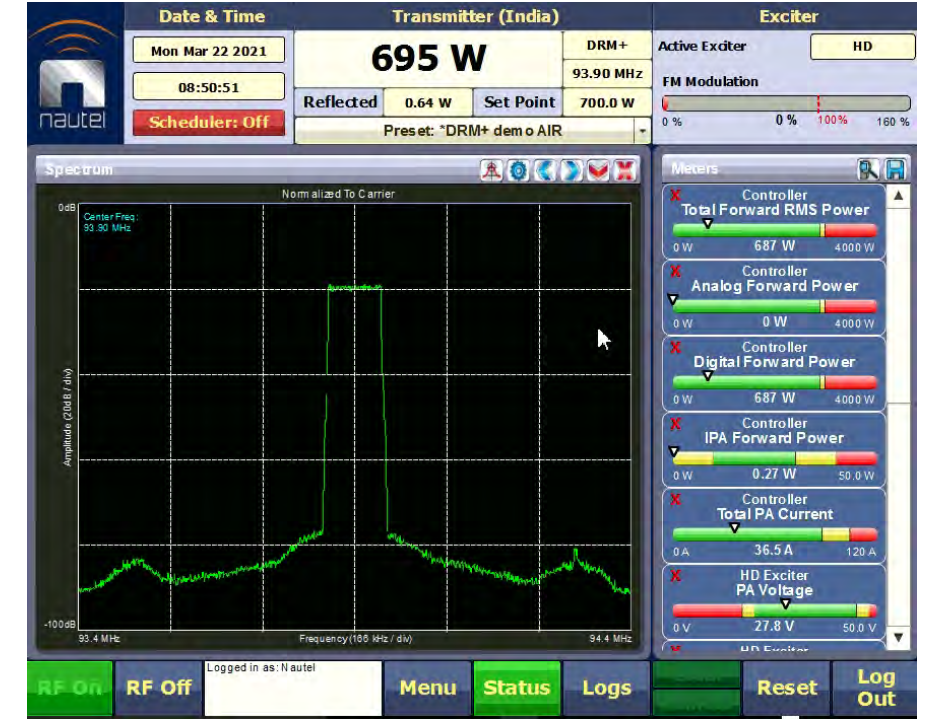
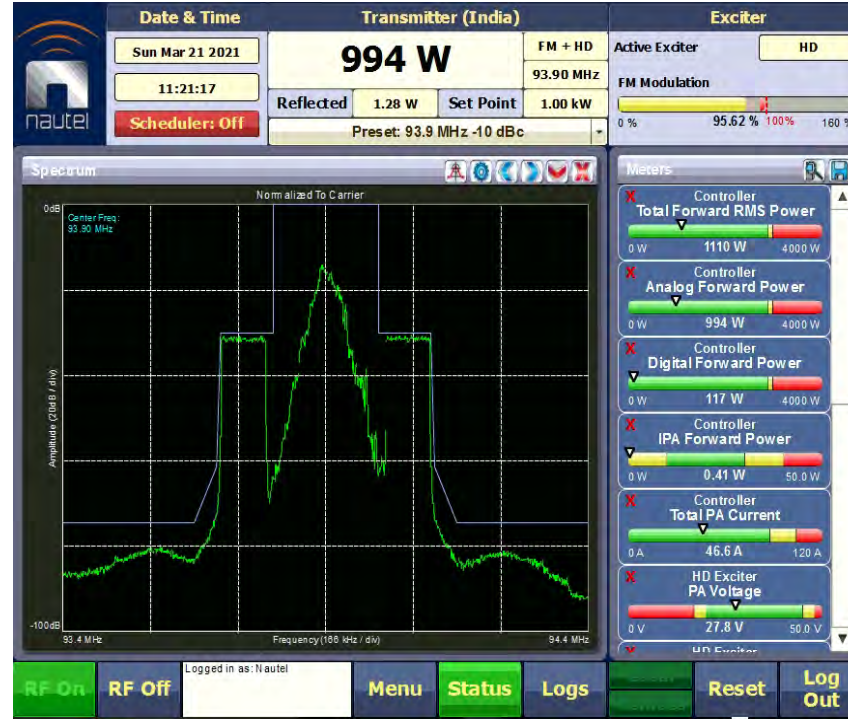
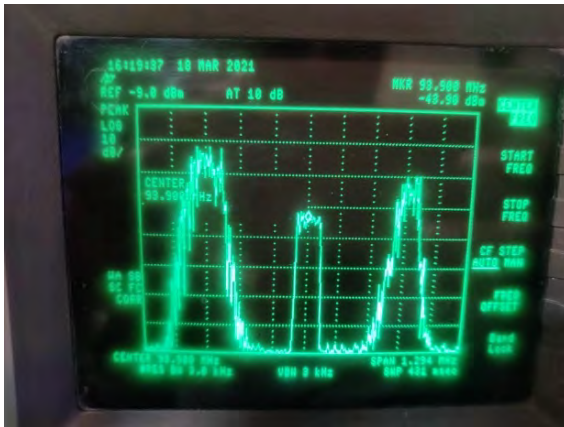


# Upgrading Common Transmission Sites



- Today: 6 x 10 kW analog FM: 60 kW average, 360 kW peak
  - Master combiner and antenna must handle combined signal
- Option 1: Upgrade all transmitters and combiner inputs
  - Requires 50% to 100% bigger transmitters (HD and DRM)
  - Widen combiner inputs to 300/400 kHz passband
  - **Peak Power triples:** Can the antenna and combiner handle that?
  - 6 x 10 kW digital + 10% digital: 66 kW average, **1200 kW peak**
  - Budget 5 dB peak-to-average power per transmitter on new sites
- Option 2: Separate antenna initially on existing sites
  - HD Radio is commonly space combined, match radiation pattern, requires antenna isolation
  - Other options exist ...

# Test at High Power Site in Jaipur



HD Radio

DRM-FM

Spot Frequencies

93.9 MHz

Audio Services

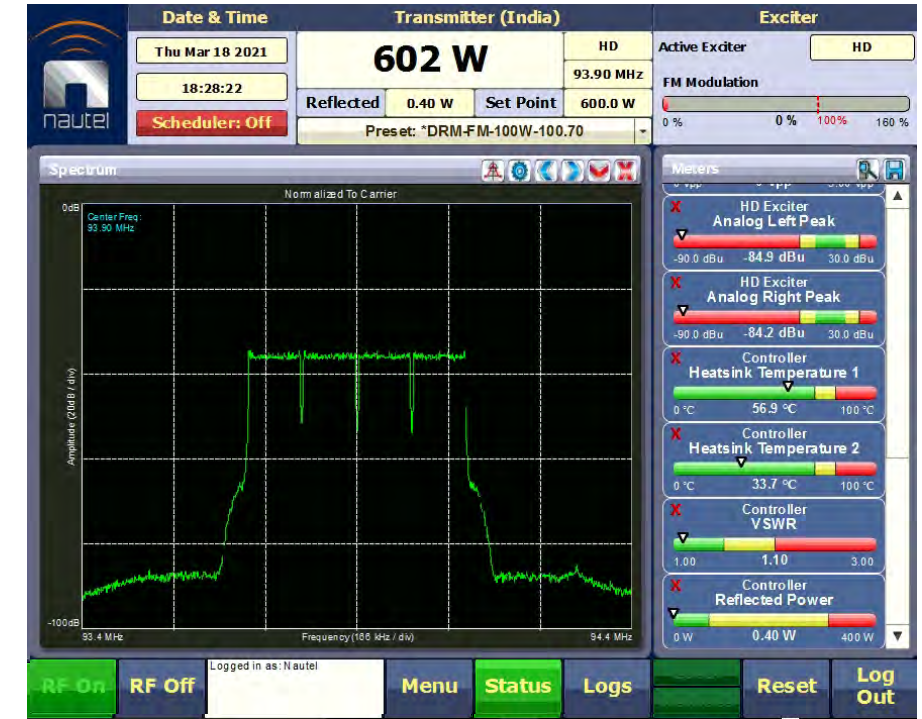
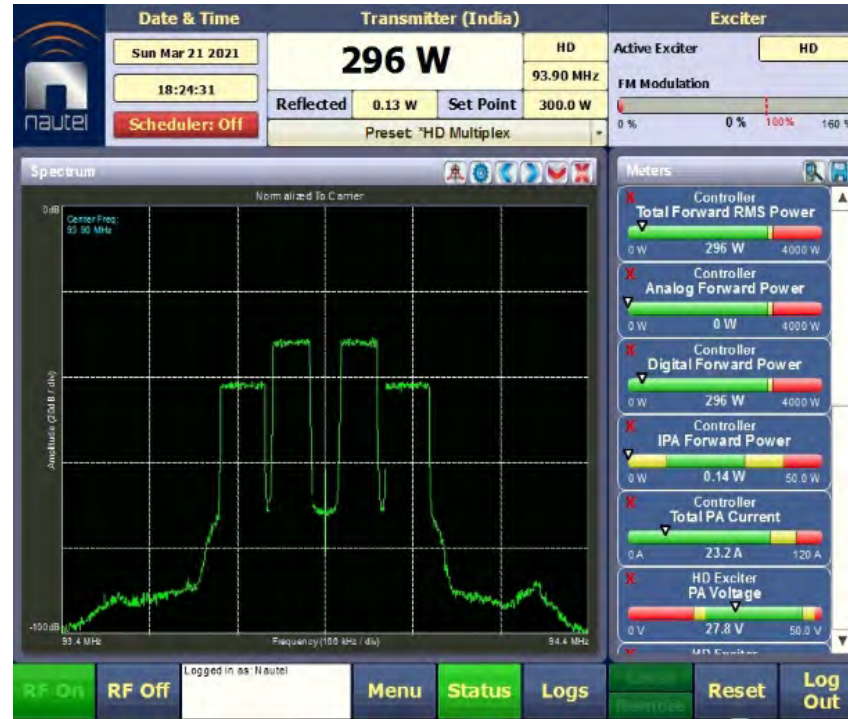
1 analog + 3-4 audio services

Data capacity

37.3 kbps - 124.1 kbps



# 400 kHz Demo in Jaipur



## HD Radio

## DRM-FM

Spot Frequencies

93.8/93.9/94.0 MHz

93.75/93.85/93.95/94.05 MHz

Audio Services

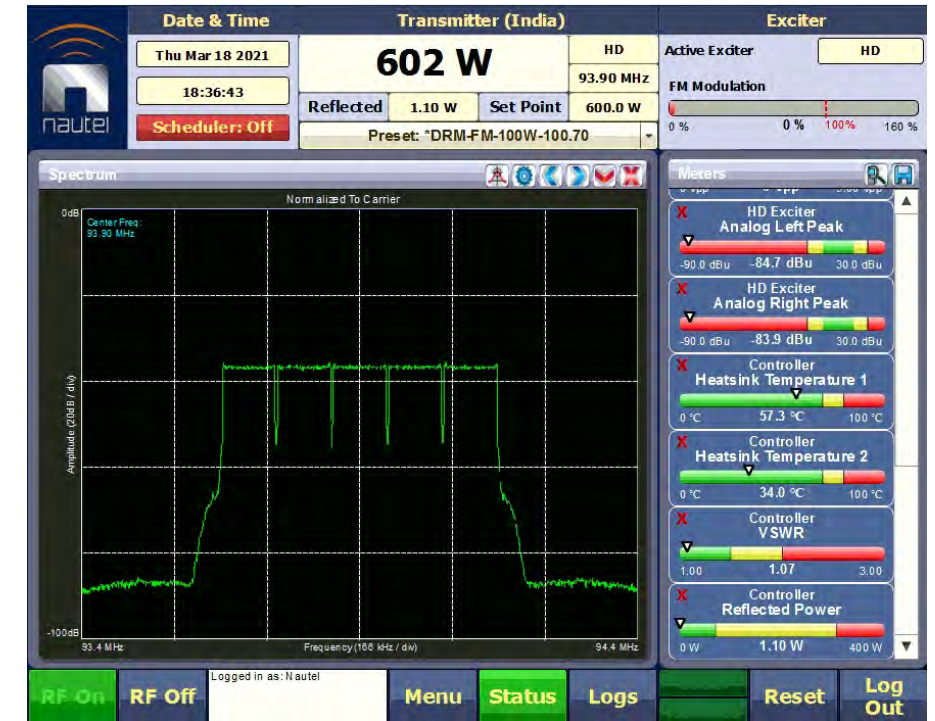
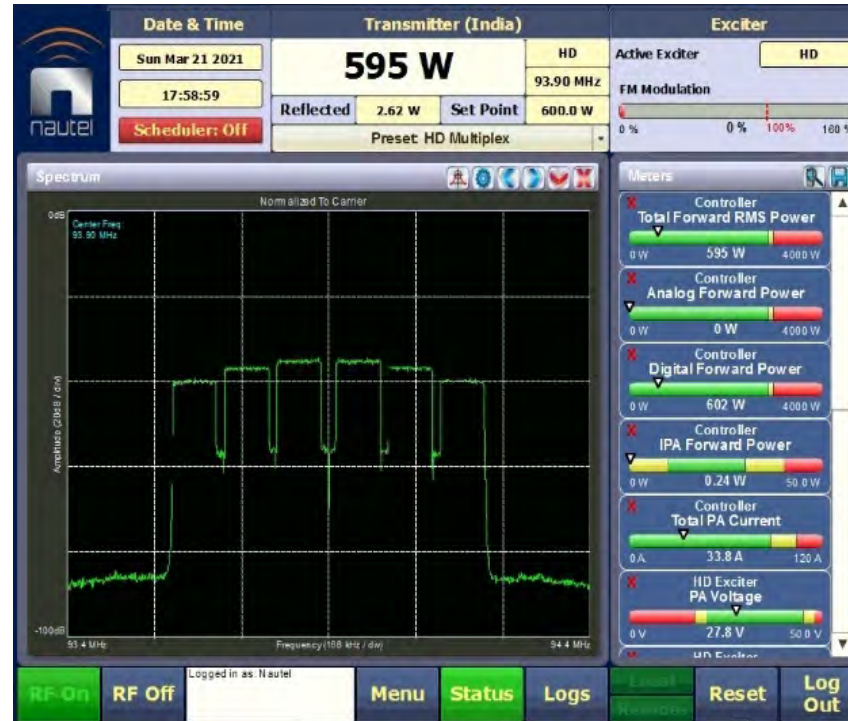
8-12 audio services

Data capacity

149.2 kbps -322.7 kbps



# 600 kHz Demo in Jaipur



## HD Radio

## DRM-FM

Spot Frequencies

93.8/93.9/94.0 MHz

93.7/93.8/93.9/94.0/94.1 MHz

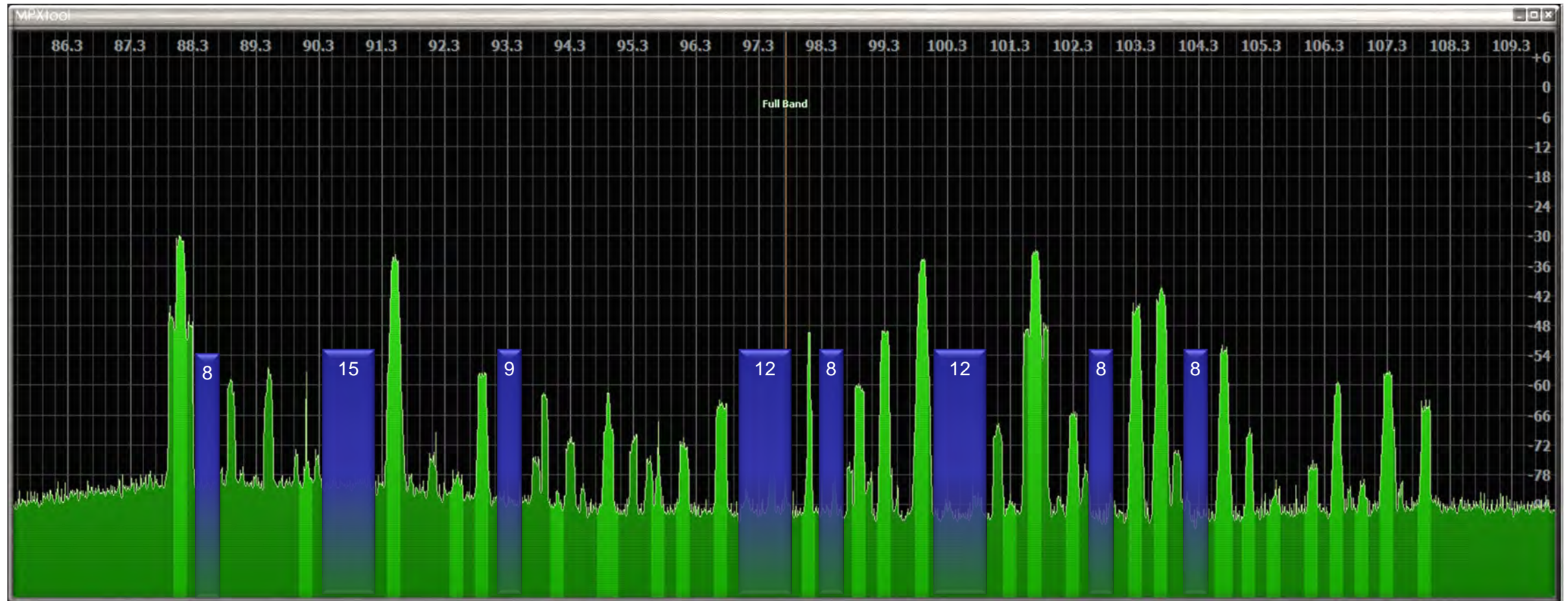
Audio Services

12-15 audio services

Data capacity

186.5 kbps - 372.3 kbps

# Add 80 New Digital Channels



# Summary

- Add new digital channels in FM whitespace
  - Both HD Radio and DRM can exploit whitespace through 10% power
  - No impact on existing analog channels, no Interference
- Single multiplexed transmitter optimally fills whitespace
  - up to 12 HD Radio channels, up to 18 DRM channels, single antenna
  - Low capital and operational costs per audio service
- Build multi-channel audio services
  - Option for spectrum or channel auction
  - Nationwide SFN on dedicated FM band portion
  - Regional, multi-lingual, educational, new stations, ...

# Resources

Digital Radio Mondiale (see downloads): [www.drm.org](http://www.drm.org)

DRM Handbook:

<https://www.drm.org/wp-content/uploads/2020/05/DRM-Handbook-Version-5.pdf>

Nautel resources and papers: <https://www.nautel.com/?s=drm>



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# Thank You