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ATSC 3.0 STATUS UPDATE

BY

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Boston SBE Chapter 11

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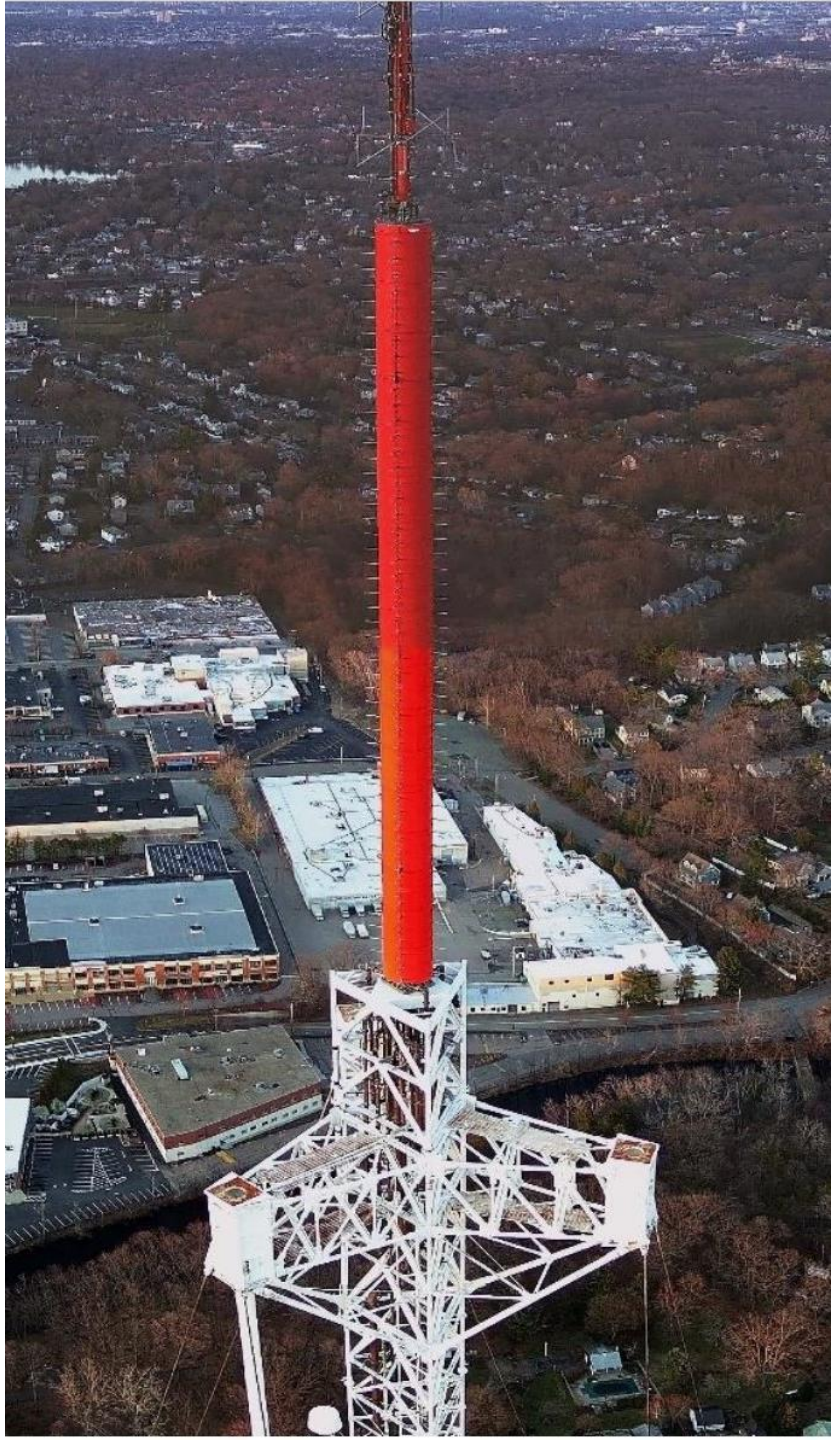

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Subjects To Discuss

- WHY 3.0?
- ON AIR
- LIGHTHOUSING
- MODCOD VARIABLES
- COVERAGE
- DATACASTING
- CONVERSION
- RECEIVERS
- DRM

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Why 3.0?

- Improved Video Codecs reduce bit rates and increase channel capacity
- Updated error correction improves receivability
- IP base files allow off the shelf hardware usage and simplified use case development
- App interface provides new multimedia experiences
- Mobile reception at high speeds possible
- Single Frequency Networks can expand coverage
- Best in the world coding and RF performance

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ATSC 3.0 Stations On-air

- 88 FULL POWERS
- 53 LPTV/CLASS A'S
- 17 CH6 LPTV FRANKEN'S

nextgenTV

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Lighthousing

- LIGHTHOUSING ON ATSC 1.0 OF PRIMARY STREAM REQUIRED
- MUST COVER 95% OF AREA COVERED
- MOST STATIONS NOW HAVE MANY PARTNERS TO ALLOW LIGHTHOUSING OF ALL STREAMS
- VERY FEW HAVE “EXCESS” 3.0 CAPACITY AVAILABLE
- LIMITED ABILITY TO EXPERIMENT

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Modcod Variables: Modulation Rate

- Number of possible symbol choices each time period
  - QPSK (4 symbols) = most robust, lowest capacity, -6 to 11 dB SNR, 1.5 to 10 MB
  - 16QAM = very robust, limited capacity, -2 to 17 dB snr, 3 to 21 mB
  - 64QAM = fairly robust, moderate capacity, 1 to 22 dB snr, 5 to 31 mB
  - 256QAM = good robustness, good capacity, 3 to 27 dB snr, 6 to 41 MB
  - 1024QAM = poor robustness, high capacity, 5 to 32 dB SNR, 8 to 52 MB
  - 4096 QUAM = very high signal needed, HUGE capacity, 7 to 37 dB snr, 9 to 62 MB
- Nu = non uniform constellations optimize performance
- 1024 and 4096 not currently recommended for OTA use

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Modcod Variables: Code Rate & Length

- Defines amount of redundant data sent to ensure delivery
- Rate defined as payload bits/total bits transmitted
  - 2/15 means 2 units of payload out of total = 13% payload, very robust
  - 13/15 means 13 units of payload out of total = 87% payload, not robust
- More coding (lower fraction) increases receivability in noise and channel variation = lower snr BUT reduces capacity = lower mb
- Code length = long for better snr performance but increased overhead, short for less power consumption, lower latency, mobile performance
- Interleaving reduces errors, through time diversity

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Modcod Variables: FFT Length

- Determines the maximum number of OFDM carriers
  - 8k FFT = △Fc = 843Hz = 6913 carriers
  - 16k FFT = △Fc = 422Hz = 13,825 carriers
  - 32k FFT = △Fc = 211Hz = 27,649 carriers
- Influences capacity, delay, and mobility tolerance
  - Smaller FFT = better mobile performance, lower efficiency
  - Larger FFT = better fixed reception, efficiency and delay tolerance

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Modcod Variables: PILOT PATTERNS

- Pilots estimate OTA channel performance
  - More pilots increase performance but decrease capacity
  - Less pilots decrease performance but increase capacity
  - Pilot spacing defines mobile speed tolerance
- Numbers relate to how many data cells are skipped in two directions
  - D_x = pilot separation
    - Values = 2, 3, 4,6,8,12,16,32
    - Higher # = less of them and therefore lower overhead
  - D_y = # of symbols in sequence
    - Values = 2 or 4
    - Selection has a big effect on capacity
- SP3_2 = 16.7% overhead, sp32_4 = 0.8% overhead

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Modcod Variables: GUARD INTERVAL

- Prevents intersymbol interference from reflections/multipath/other TX's
- Significant benefit of OFDM modulation
- Longer intervals prevent interference over long echo distances
- Waves travel at 5.4 u_s/mile
- Interval measured in samples from 192 to 4864, some examples
  - 192 = shortest = 28 u_s = approx. 5 miles, least pilots, least overhead 0.6 - 2.3%
  - 512 = short = 74 u_s = approx. 14 miles, less pilots, low overhead 1.5 – 5.9%
  - 768 = short = 111 u_s = approx. 21 miles, moderate pilots, moderate overhead 2.3 – 8.6%
  - 2048 = long = 296 u_s = approx. 55 miles, many pilots, higher overhead 5.9 – 20.0%

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Many Choices For Similar Bit Rates

- For 19 MB (ATSC 1.0 Bit Rate) these are possible:
  - SNR = 11.5dB, Mod = 256QAM, Code = 9/15 long, FFT = 32k, SP = 8_2, G/I = 1536, 222us A good fixed service replacement ready for SFN's
  - SNR = 11.8dB, Mod = 64QAM, Code = 9/15 short, FFT = 16k, SP = 12_2, G/I = 512, 74us Better mobile performance
  - SNR = 12.1dB, Mod = 256QAM, Code = 7/15 long, FFT = 32k, SP = 16_2, G/I = 768, 111us Another replacement, good error correction
- We used to spend $$$$$ to increase ERP a few tenths of a dB and now we have a way to optimize and increase coverage quickly.
- ATSC 1.0 to 3.0 conversion at same bit rate is like doubling TX power
- 1.0 dB difference = 23% power difference
- 0.6 dB difference = 15% power difference
- 0.3 dB difference = 7% power difference

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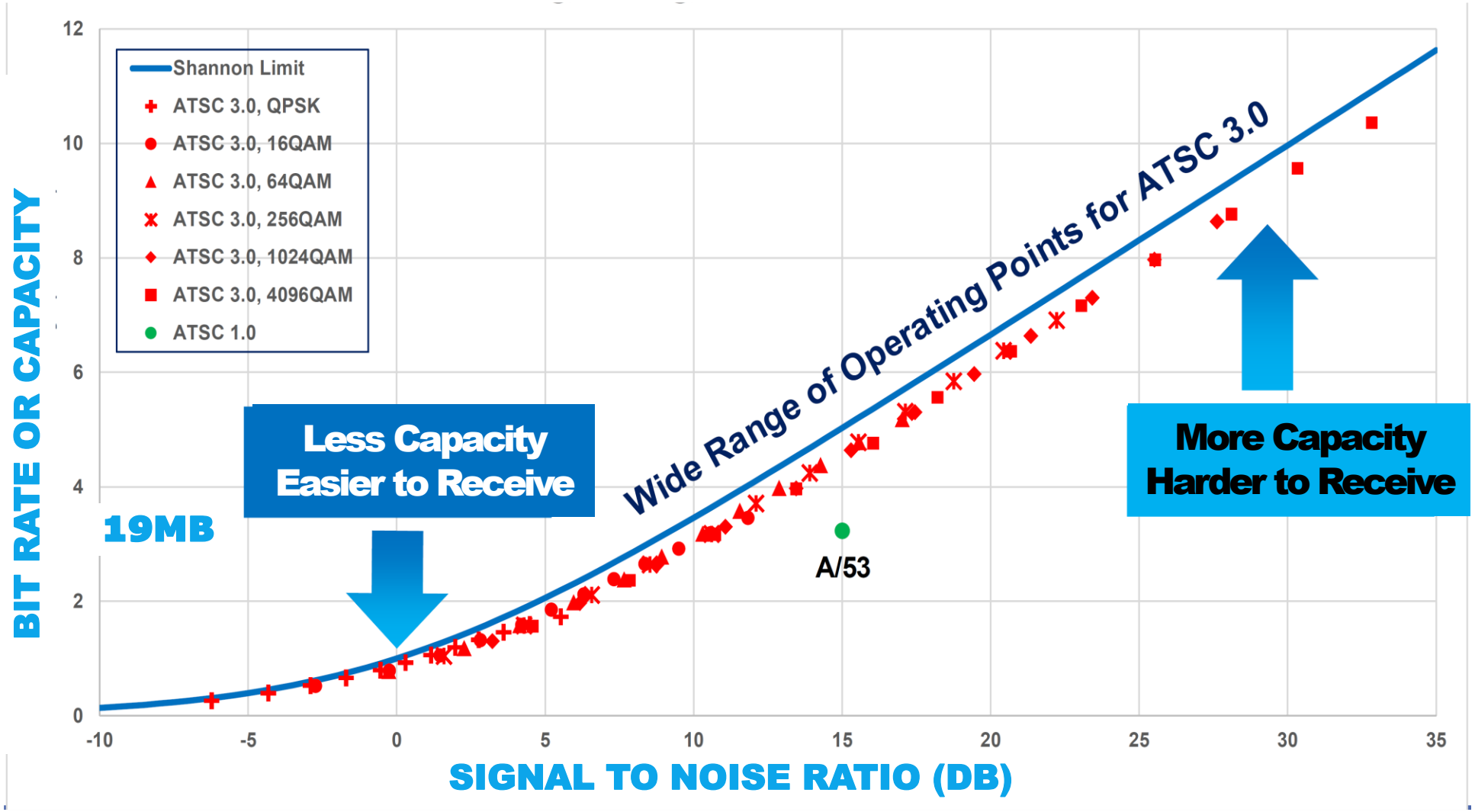
Signal To Noise Ratio Versus Capacity

- Higher order modulation yields more capacity
- Higher capacity takes more signal strength



the shannon limit describes the, can't get something for nothing tradeoff

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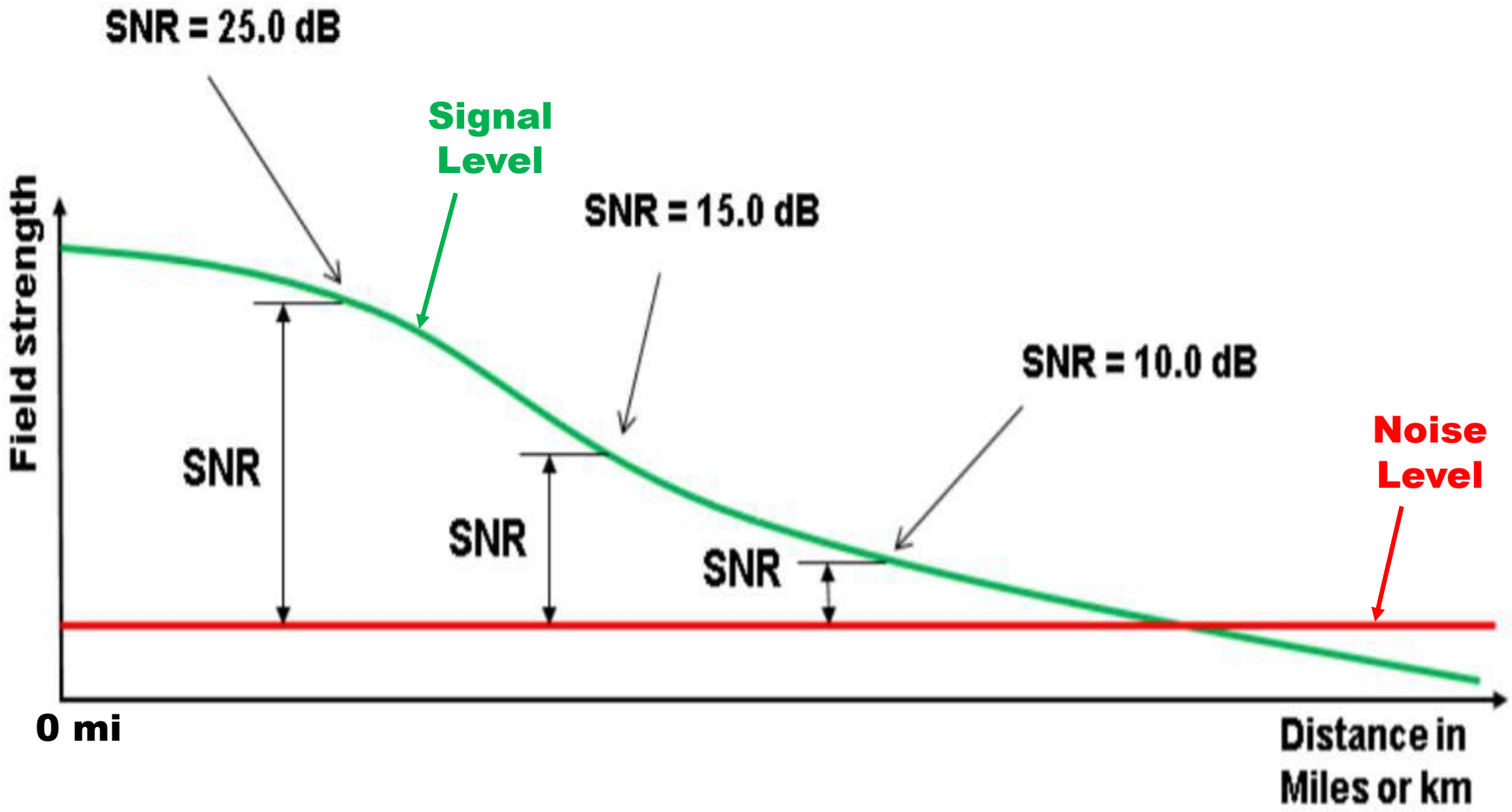
Signal To Noise Ratio Versus Coverage

- Signal levels decrease by distance squared from the transmitter
- For digital signals, reception occurs only above a given S/N ratio (SNR)



this graph is the fundamental relationship to keep in mind

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Coverage

We don't know signal levels (dBu) needed for particular combination of receiver/antenna/location

- **Outdoor/Car w/ short antenna**
- **Outdoor handheld w/ integrated antenna**
- **Indoor w/ external antenna**
- **Deep Indoor w/ integrated antenna**

We need GASSERs = Generally Accepted Signal Strength Requirements

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Coverage

GASSERs = Generally Accepted Signal Strength Requirements

- Industry guidelines for predicting real world coverage to different devices and locations
- Assume certain real world environmental losses, receive antenna gains, and noise conditions
- More testing with real receivers is needed to agree on them
- Not established for 1.0
- More important for 3.0 and predicting receivability

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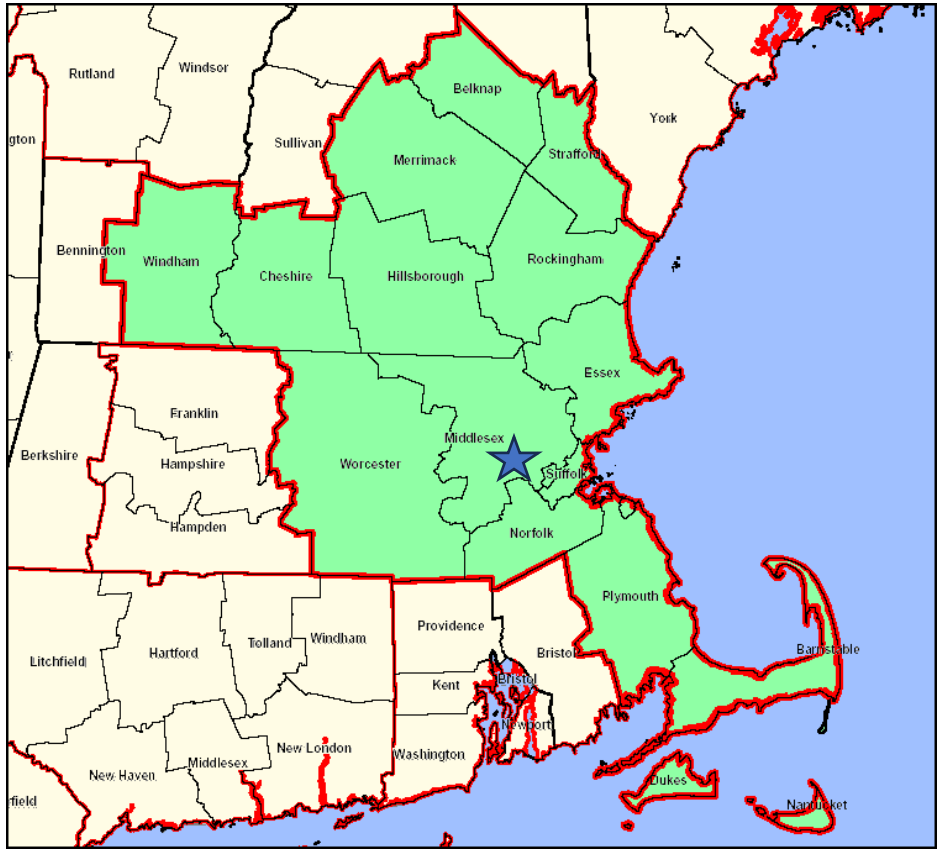
Reference Station: Wuni Dt 27 Univision

Some information:



BOSTON TV DMA = #9

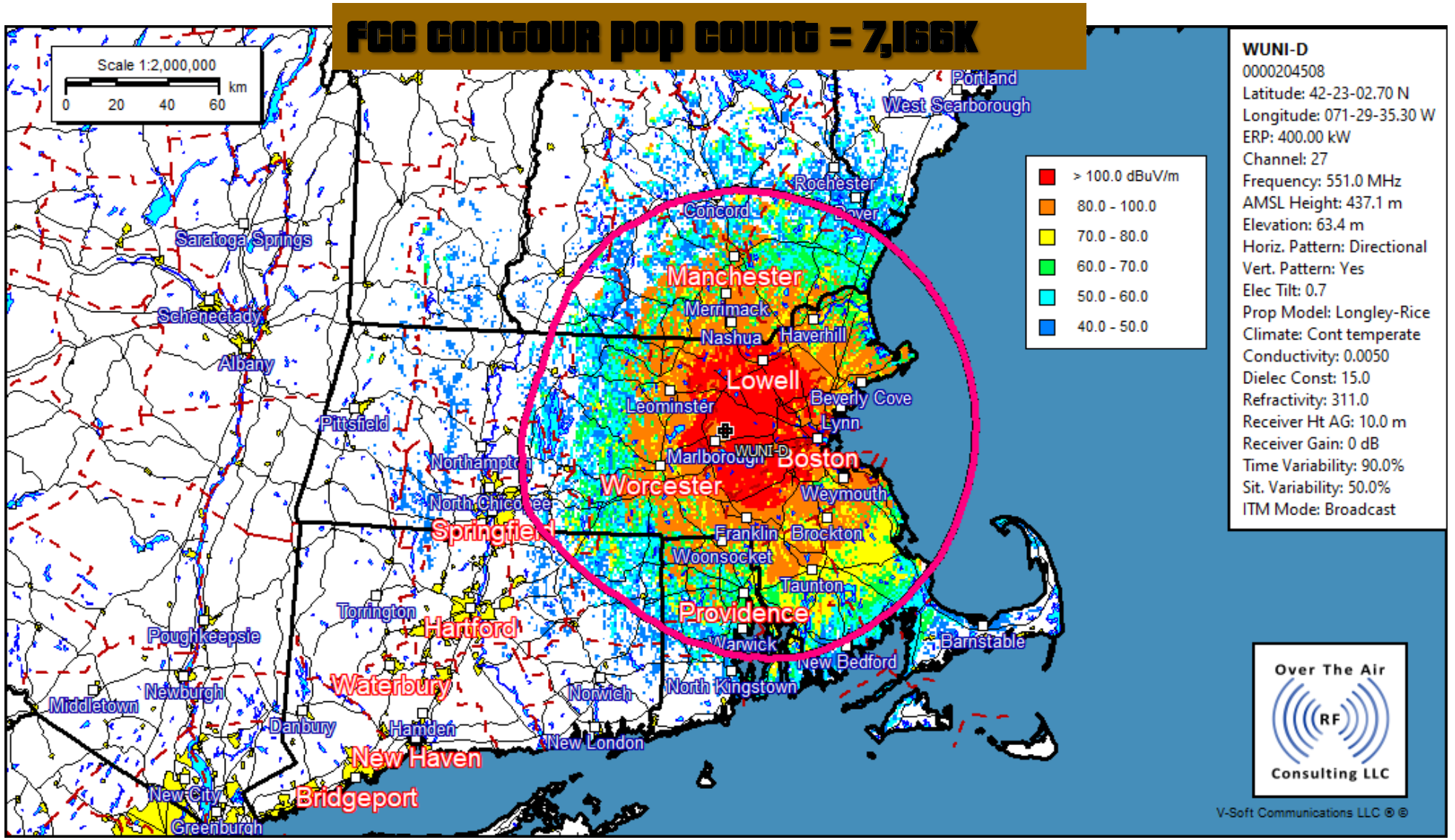
- 3.0 host for wgbh, wbz, wcvb, wbts, wfxt, wwje, and wuni
- RF Channel = 27
- ERP = 400kw
- AMSL = 1434 ft
- Haat = 1168 ft
- Cardioid azimuth pattern facing Northeast

UNIVISION BOSTON

Reference Station: WUNI Signal Strength

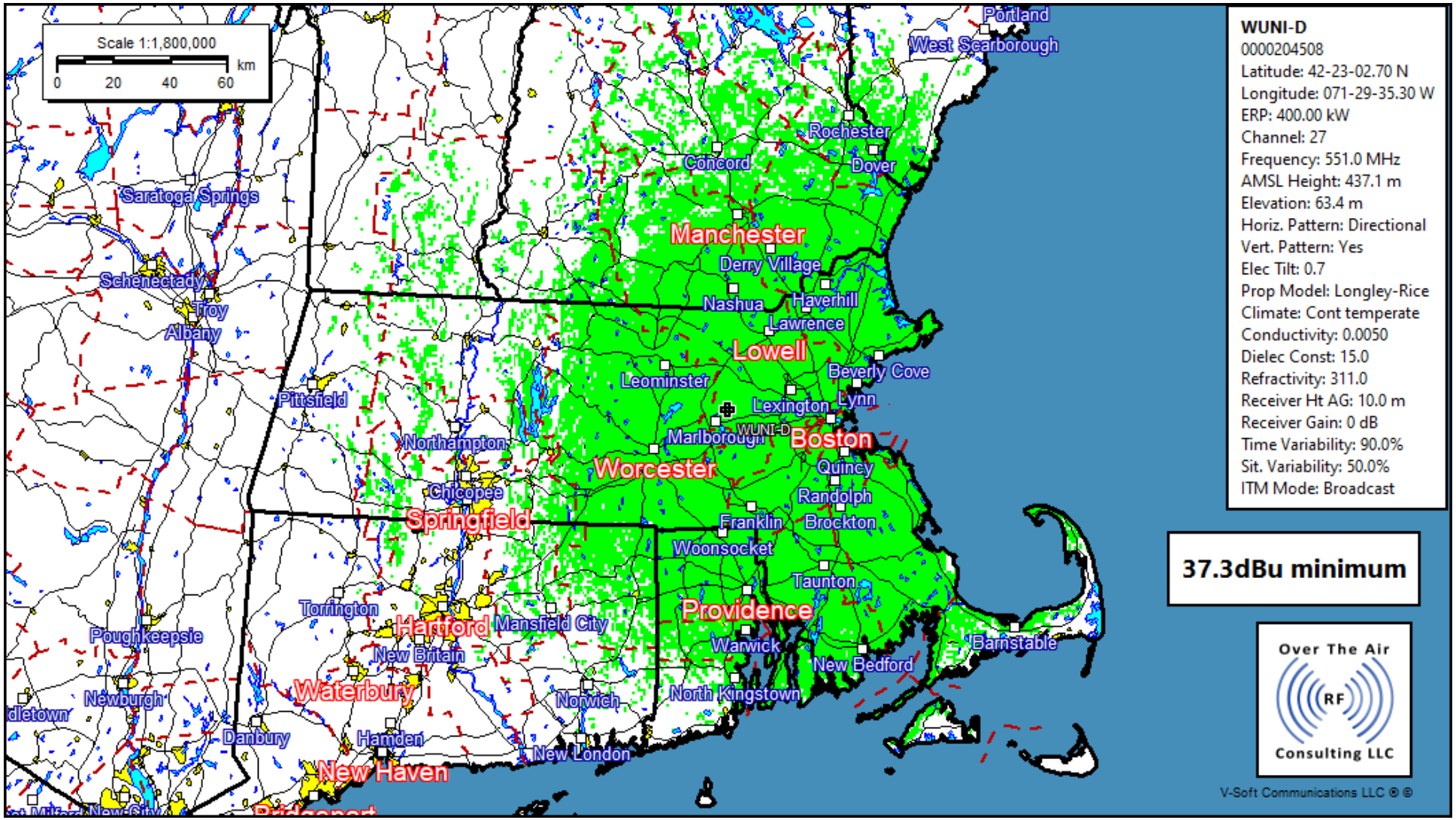
ATSC 1.0

- Designed to deliver
  - 19.2 Mb
  - @ 15.2 dB SNR
  - @ 41 dBu minimum signal strength
  - to fixed antennas @ 10m



3.0 Replication of 1.0 Bit Rate @WUNI

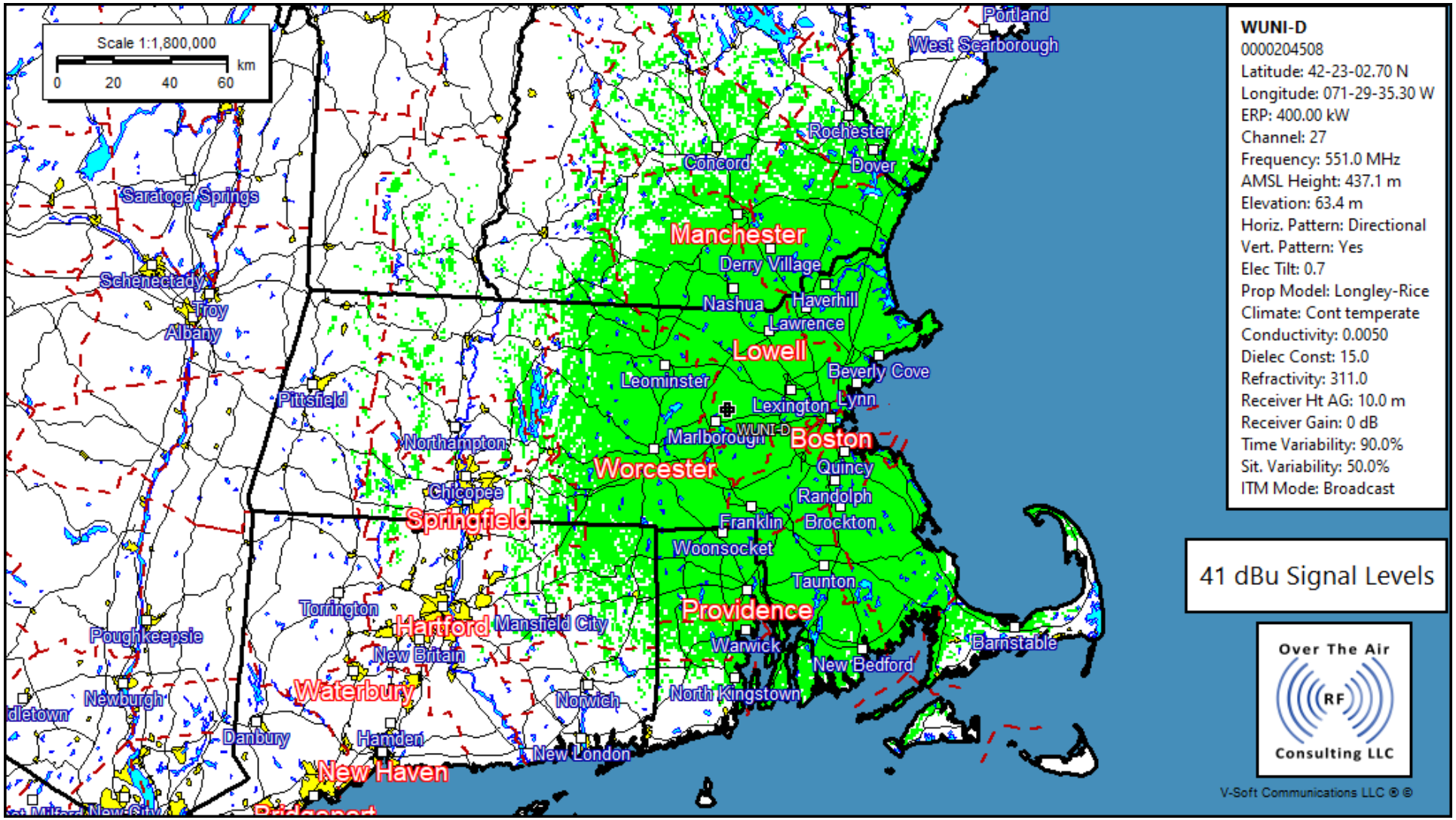
- Data Rate = 19 Mb
- SNR = 11.5 dB awgn
- Mod = 64QAM
- Code = 9/15 long
- FFT = 32k
- SP = 8_2
- G/I = 1536, 222us



Longley-Rice predicted 37.3dBu pop count = 8,114k

3.0 Replication of 1.0 SNR @WUNI

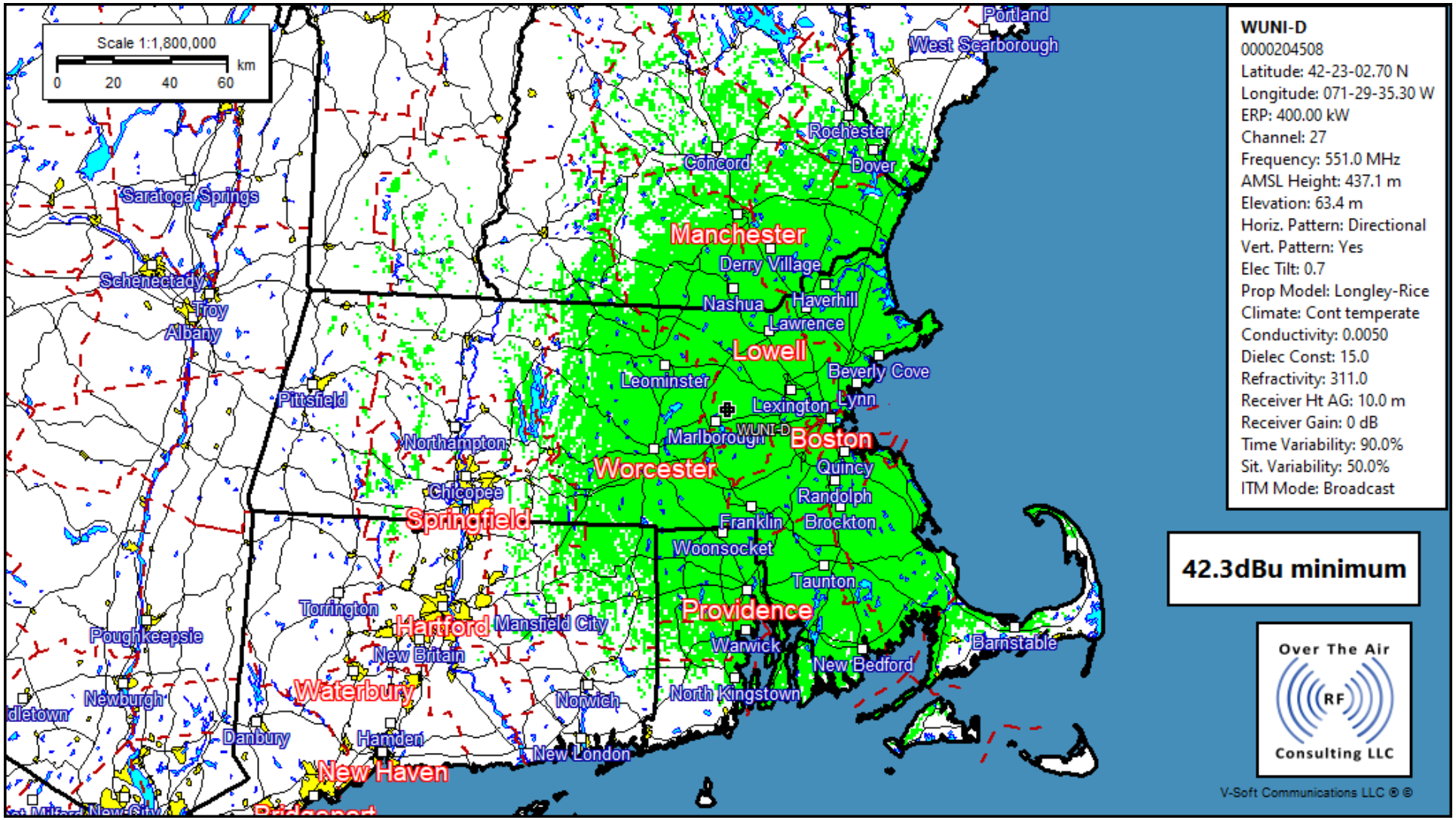
- Data Rate = 25 Mb
- SNR = 15.5 dB awgn
- Mod = 256QAM
- Code = 9/15 long
- FFT = 16k
- SP = 12_4
- G/I = 1024, 148us



Longley-Rice predicted 41 dBu pop count = 7,943K

Actual WUNI Configuration For 6 HD + 1 SD

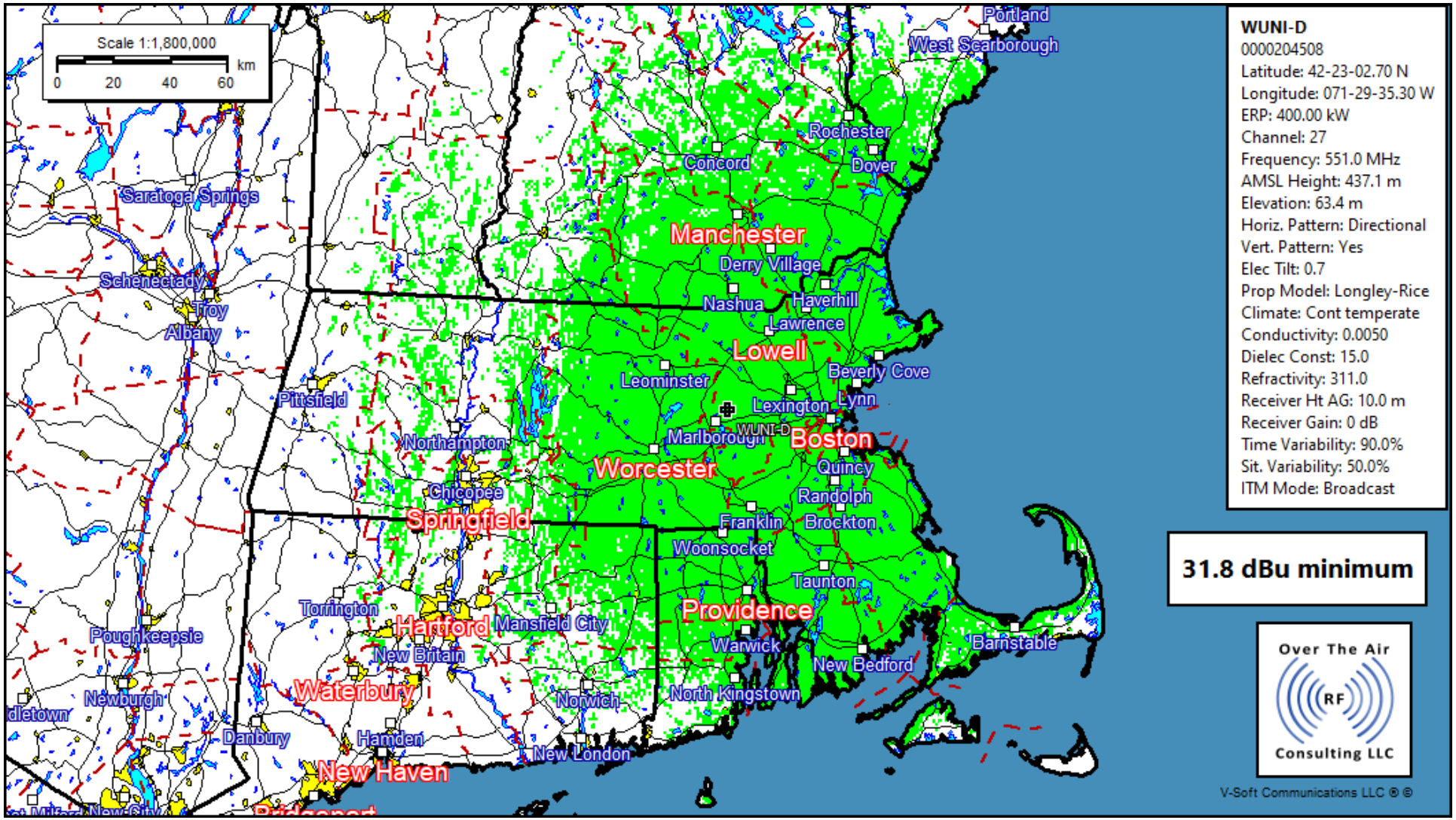
- Data Rate = 28.6 Mb
- SNR = 17.1 dB awgn
- Mod = 256QAM
- Code = 10/15 long
- FFT = 32k
- SP = 24_2
- G/I = 1024, 148us



Longley-Rice predicted 42.3 dBu pop count = 7,888K

Potential 2 HD + 1 SD CONFIGURATION

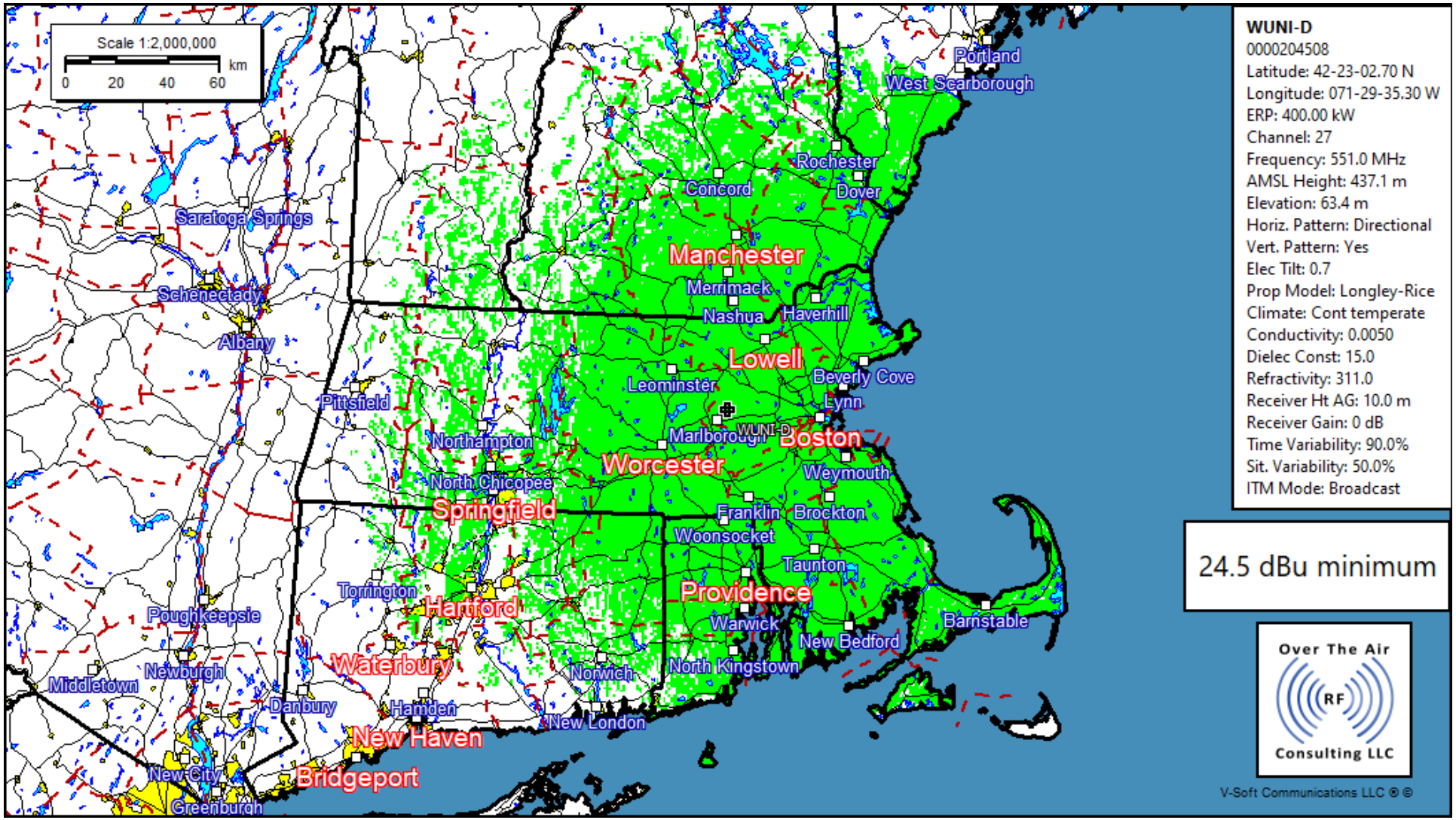
- Data Rate = 10.7 Mb
- SNR = 6.0 dB awgn
- Mod = 64QAM
- Code = 5/15 long
- FFT = 16k
- SP = 16_2
- G/I = 384, 56us



Longley-Rice predicted 31.8 dBu pop count = 8,414K

Potential Datacasting PLP Example

- Data Rate = 3.1 Mb
- SNR = -1.3 dB awgn
- Mod = QPSK
- Code = 5/15 short
- FFT = 8k
- SP = 6_2
- G/I = 512, 74us



Longley-Rice predicted 24.5 dBu pop count = 9,152K

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Datacasting

- Uses excess 3.0 capacity for other business cases
  - Public safety
  - BPS Broadcast Positioning System
  - Car firmware/software updates
  - Road sign updates

Conversion

- Encoding update
- Gateway
- Scheduler
- Exciter
- Transmitter Issues
- Filter Issues
- Antenna Issues

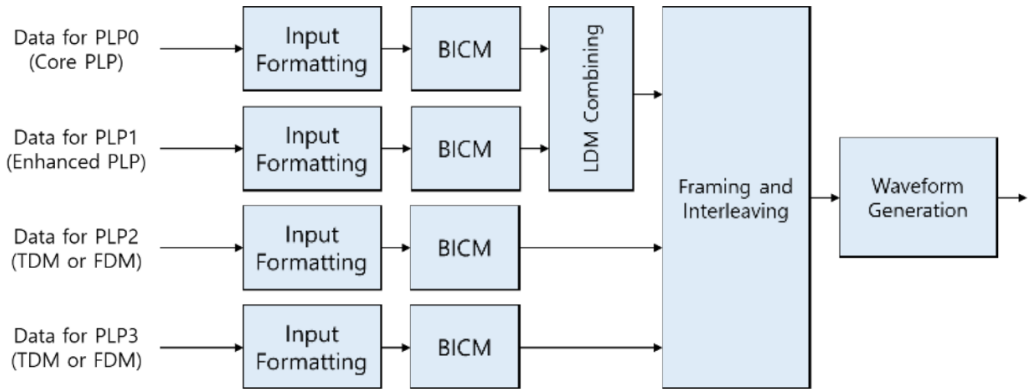
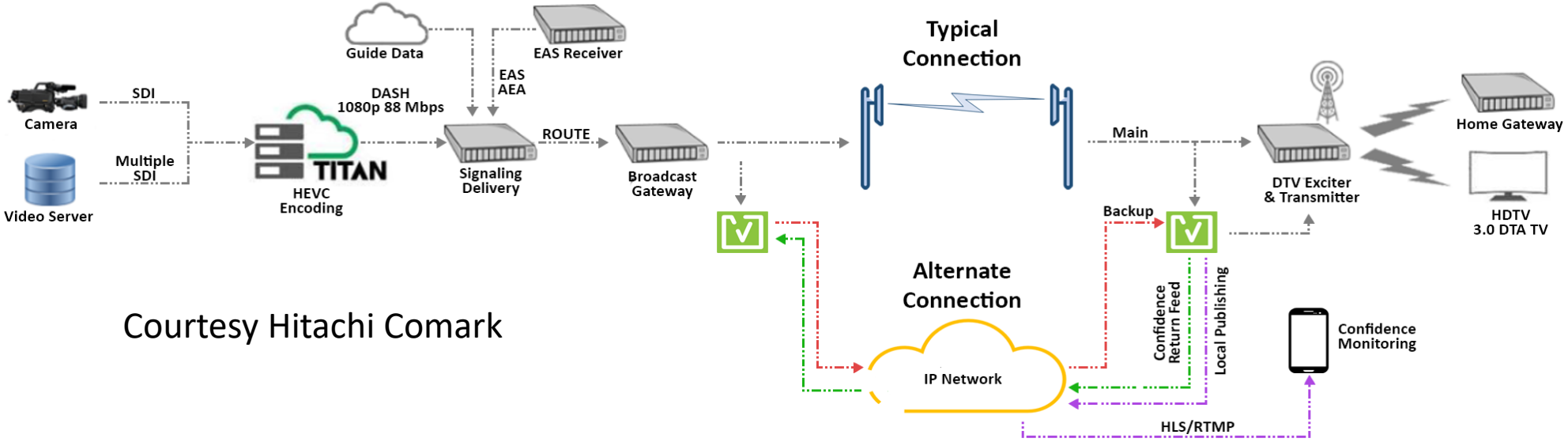


Figure 4.1 High level ATSC 3.0 physical layer protocol diagram enabling an example of multiple-PLP architecture.

Courtesy ATSC A/327 Recommended Practice



Courtesy Hitachi Comark

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Receivers

- More than 100 models now available
- Reported that more than 10,000 sold per day
- Total installed now more than 10 million
- Many different types
  - “TV Sets”
  - Dongles
  - HDMI Receivers
  - Wifi Gateways
  - Mobile and Portable

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DRM

- Digital rights management
- Meant to primarily protect content from spoofing and interruption
- Requires a key to unlock similar to most websites
- Not implemented in original receivers
- Has caused serious delays in receiver roll-outs

THANK YOU FOR ATTENDING!

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