# Single Frequency Networks: SynchroCast™

April 23, 2017

GatesAir Connect @ NAB Show 2017

Featuring GatesAir's

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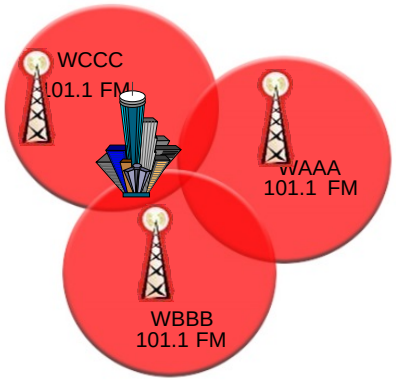
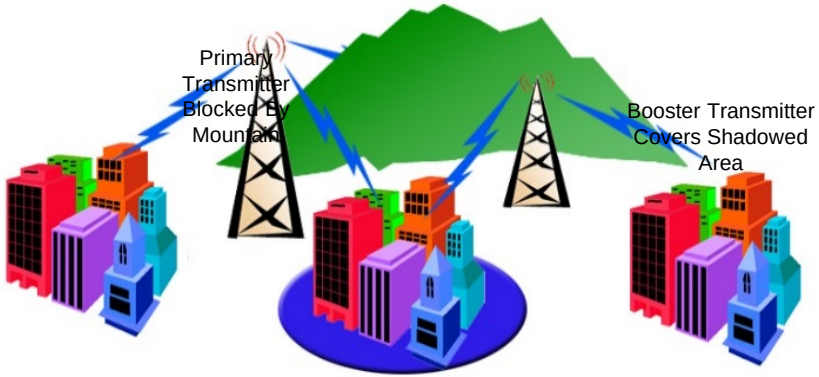
# Single Frequency Networks

## SynchroCast™

# What are Single Frequency Networks

- Single Frequency Networks are geographically dispersed RF transmitters operating on the same carrier frequency, modulating the same program material



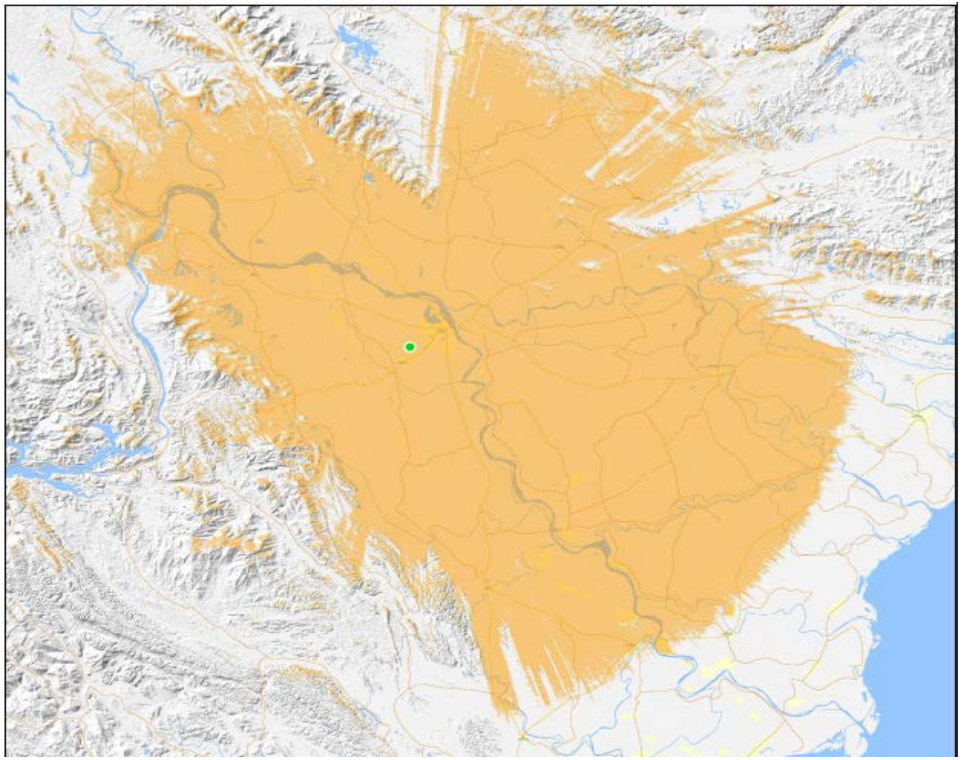




# SFN Broadcast Applications

- Improve FM or HD coverage area
- Extend coverage area
- Fill coverage gaps
  - Terrain shielding
  - Fill in “holes” within the a licensed geographical contour that is not being served by the main signal
- Cover a major highway from one end to the other on a single frequency

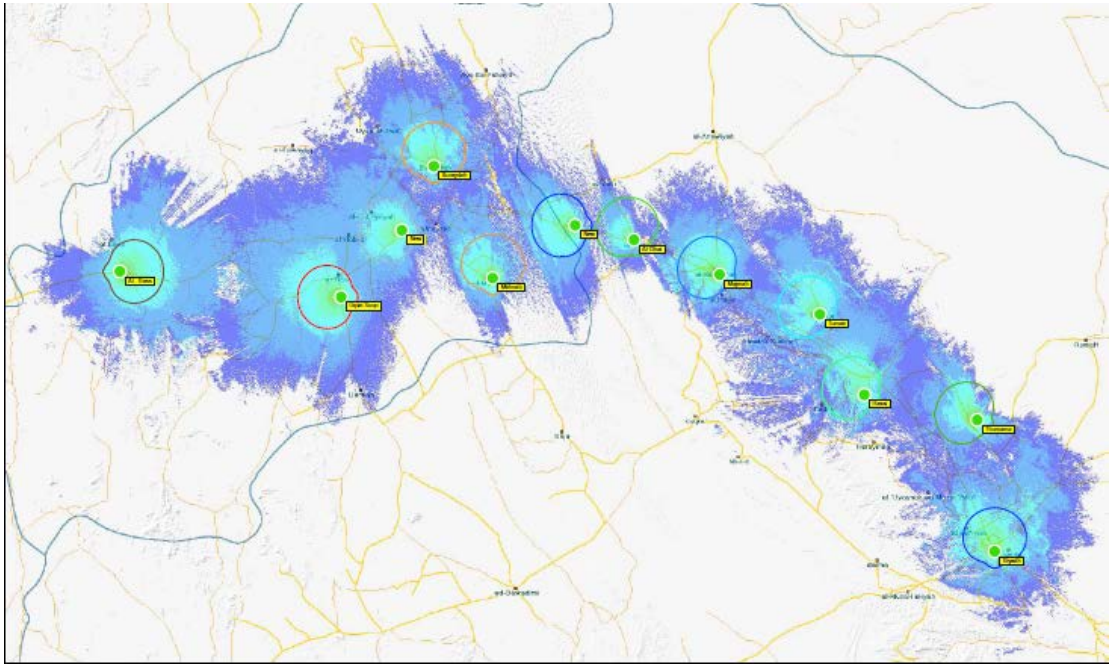
# Single Frequency Network

- Filling coverage gaps
  - Coverage gaps are created by terrain shielding – where there isn't a reasonable line of site.
  - A low power, on frequency booster may be located within the shadowed area to improve coverage.



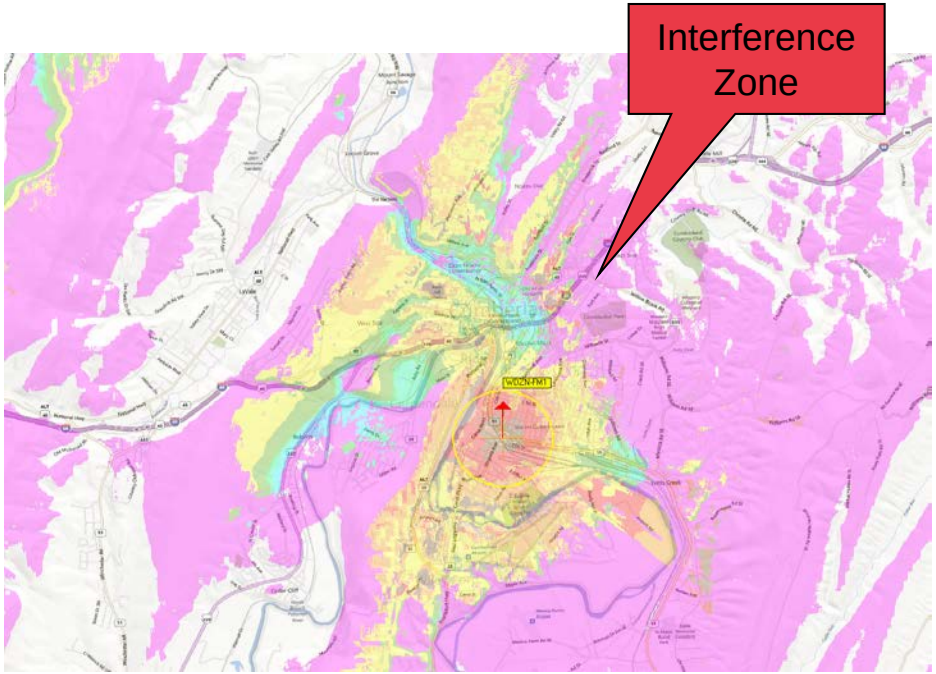
# Single Frequency Network

- Long, important highways are good targets for a radio station you can listen to without changing the station dial.
- Many small transmitters are synchronized to provide uninterrupted service.



# Single Frequency Networks

- **The SFN Challenge – Interference Zones**
  - Where the coverage areas overlap, and the ratios of the signal strengths approach unity the signal quality is affected

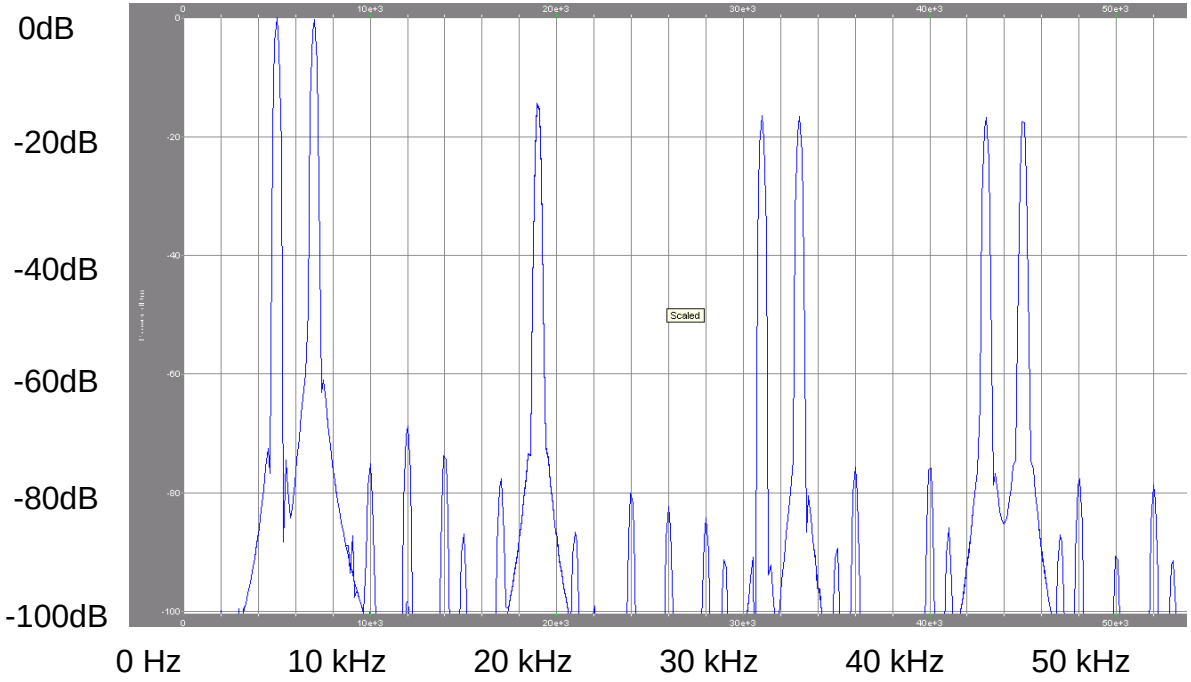


# Single Frequency Network

- **Interference Zones Issues**
  - If the RF carriers are not frequency synchronized, distortion and noise will result.
  - If the audio levels are not exactly matched, the noise floor increases, this noise varies with the level of the audio.
  - If the pilots are not synchronized, the pilot detector in the receiver will switch back and forth and this will be audible in the stereo signal.
  - If the audio phase is not synchronized, distortion results
- With audio, pilot & carrier all synchronized, the signal will sound like a multipath condition

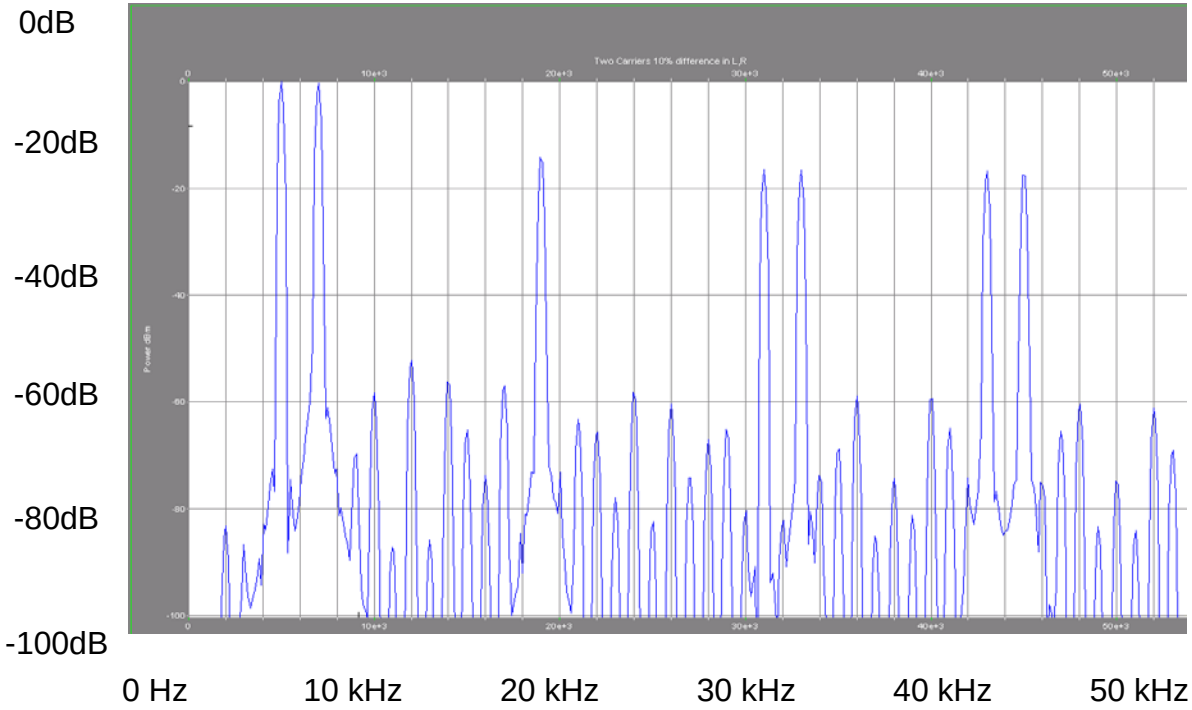
# Inference Zone - Modulation Levels

- Two carriers with ¼ dB deviation difference
- Noise floor is increased from -90dB to -70dB



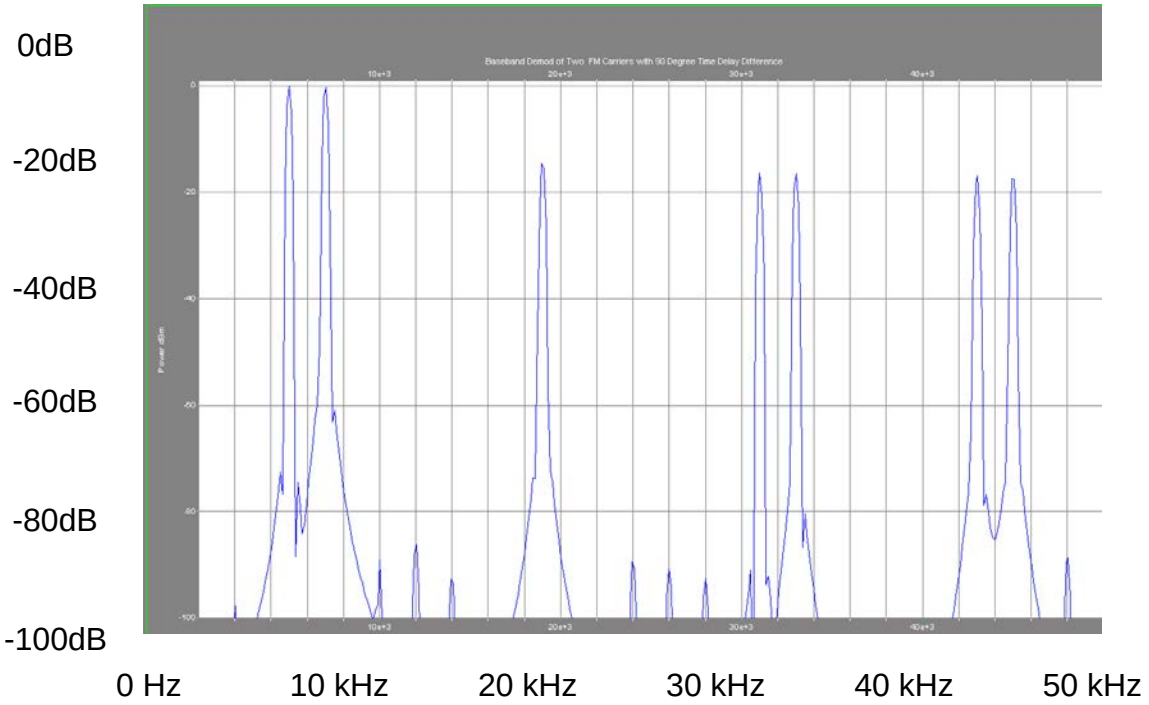
# Inference Zone - Modulation Levels

- Two carriers with ½ dB deviation difference
- Noise floor is increased from -90dB to -50dB



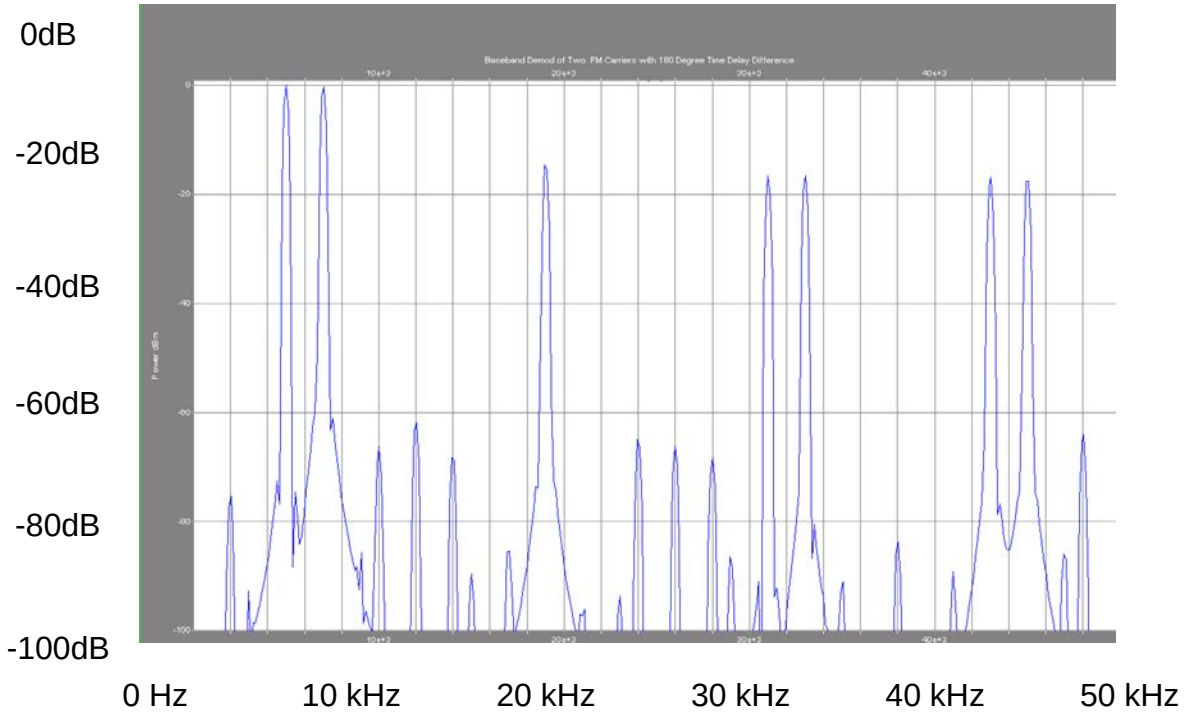
# Interference Zone – Signal Travel Time

- Two signals with travel time of one delayed by 90 degrees, resulting with introduction of noise.



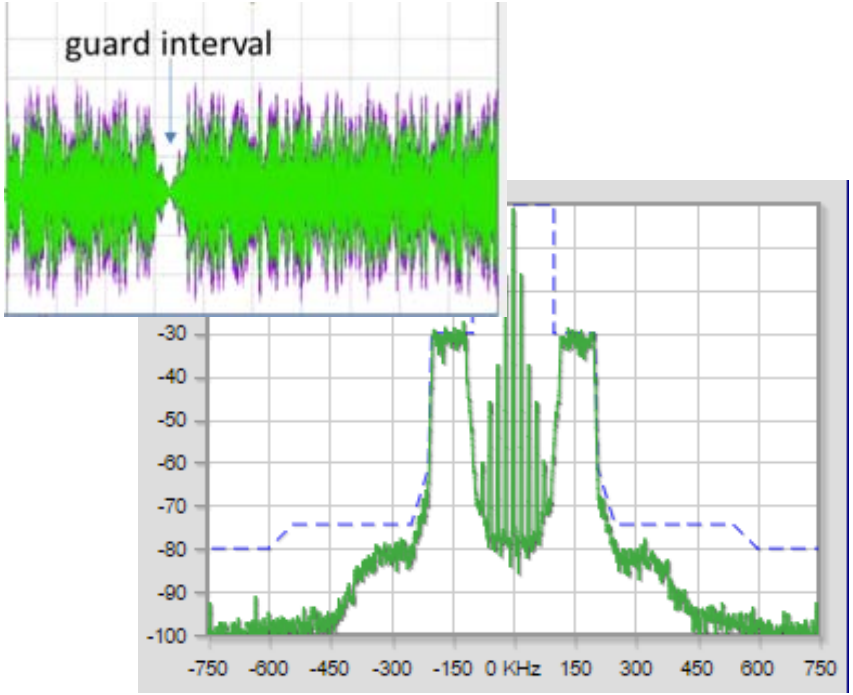
# Interference Zone – Signal Travel Time

- Two signals with travel time of one delayed by 180 degrees, with increased noise levels.



# Single Frequency Networks - HD

- Offers some distinct advantages
  - Two signals timing correlation is more favorable
  - Timing differentials of 40usec to 75usec are fine for the receiver
- Desired / Undesired ratios greater
  - HD works with 4-5dB on channel DU
  - FM begins at ratios near 20dB

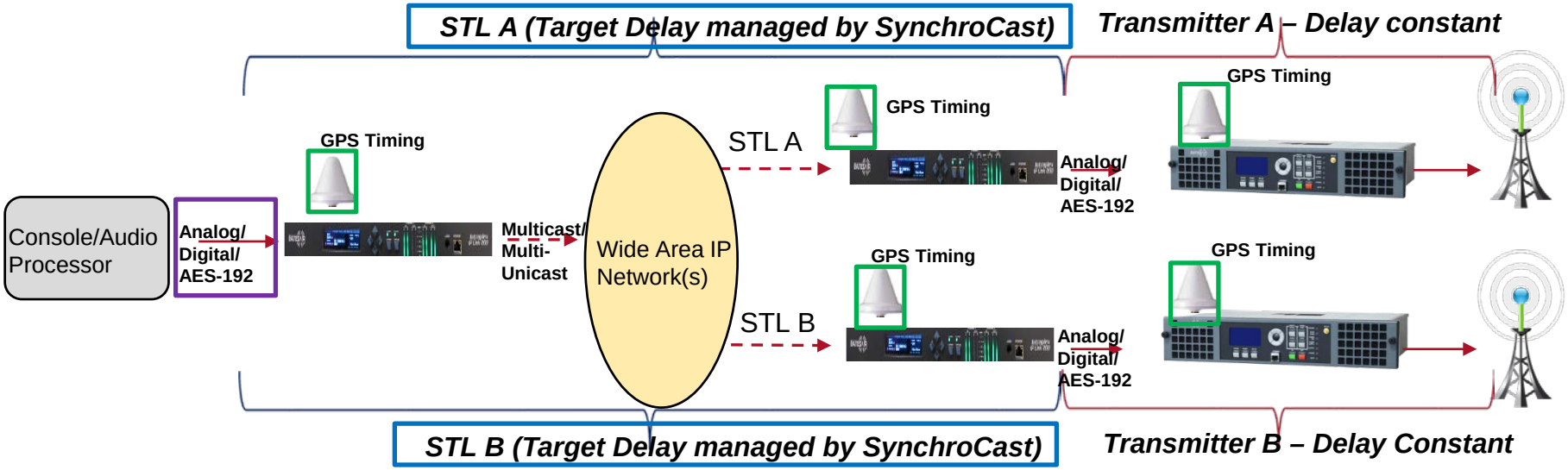


# Requirements to Achieve Signal Alignment

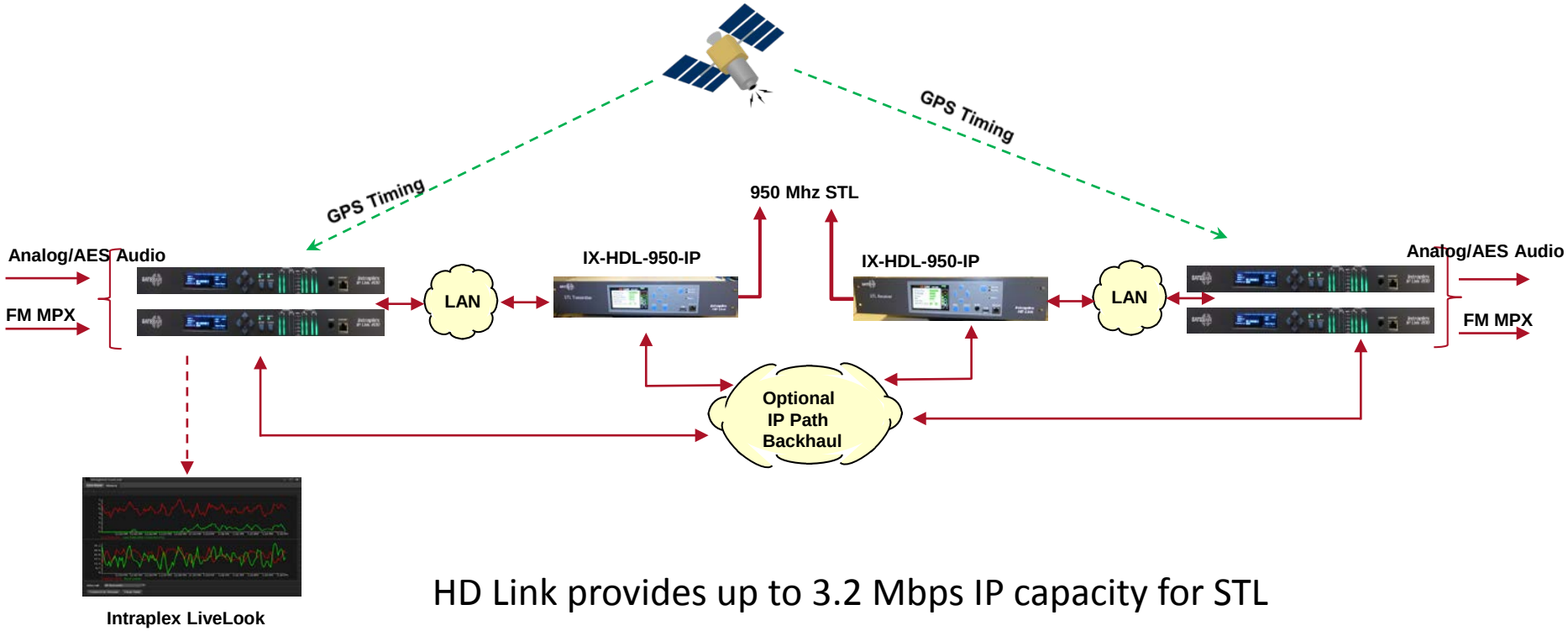
- Delay of the signal leaving the studio to the receiver in the overlap region must be precisely aligned between sites
- The signal leaving the studio experiences both uncontrolled STL network delay as well as several constant delays
- Constant delays includes processing, additional elements in the signal chain and the RF “flight” time in the air
- RF “flight” time is calculated based on speed of light ~300,000 km/sec
  - 1 mile is equal to 5.37usec
  - 1 km is equal to 3.35usec
- The exciters must produce predictable delay and have the ability to lock the carrier and pilot to a GPS reference
- System Engineering activity to perform path study and delay measurements

# SynchroCast

- To keep audio alignment from the studio ingest to output at each transmitter site
- Managing the delay across an IP STL is the most challenging aspect of signal alignment
- Use of GPS timing reference is key element for precision delay
- SynchroCast applied to the Analog, AES, digital MPX or HD E2X HD stream



# SynchroCast over 950 MHz STL



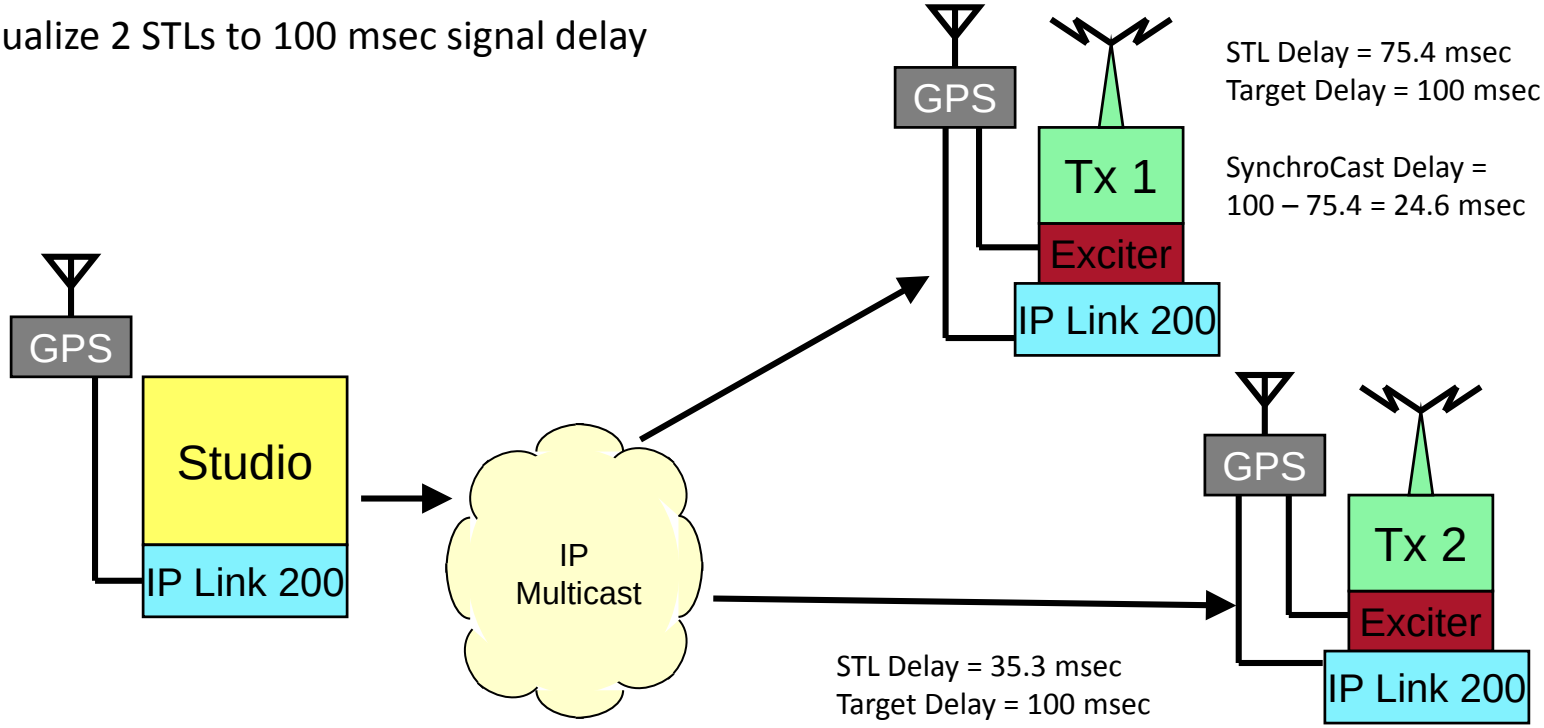

HD Link provides up to 3.2 Mbps IP capacity for STL

# SynchroCast Target Delay

- User sets Target Delay value on each Transmitter site, IP Link provides 1usec granularity Target Delay is the only delay in the chain that can be tweaked
- Target Delay must be greater than sum of IP Link delay + STL network delay
- SynchroCast supports maximum Target Delay of 1 second to allow wide range of IP Network types
- Delay sources within IP Link
  - Audio Packetization + Audio Coding/Decoding
  - Packet loss mitigation techniques (FEC, Stream Splicing)
- Once the Target Delay is set, SynchroCast maintains the delay within 1uSec, which allows for approximately 300 meters of accuracy
- SynchroCast automatically compensates for any changes in the network or IP Link delay

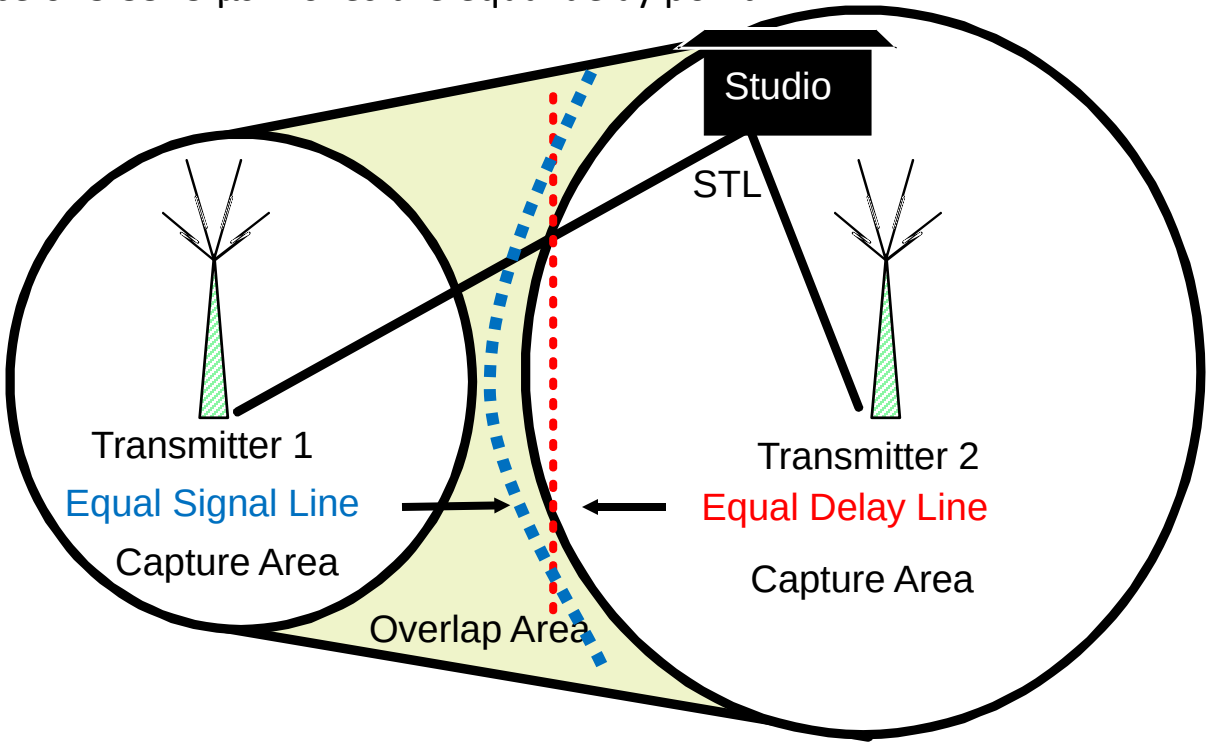
# SynchroCast Target Delay Adjustment - Example

Example: Equalize 2 STLs to 100 msec signal delay



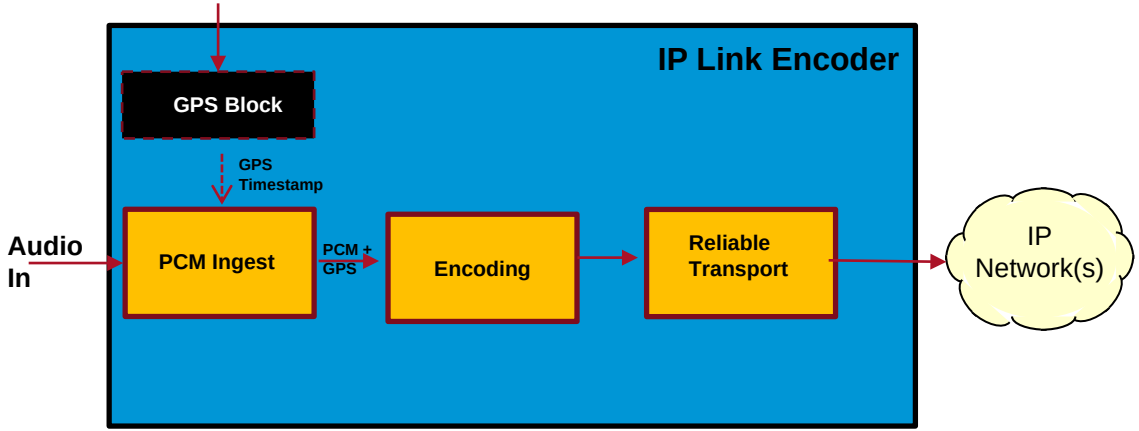
# SynchroCast Target Delay Adjustment - Example

- Adjust Target Delay to move the signal delay to the overlap area
- Delay difference of 3.3525 µs moves the equal delay point 1 km



# SynchroCast Studio Side Architecture

GPS Reference: Internal Receiver Or User Supplied 10 MHZ and 1 PPS Signals

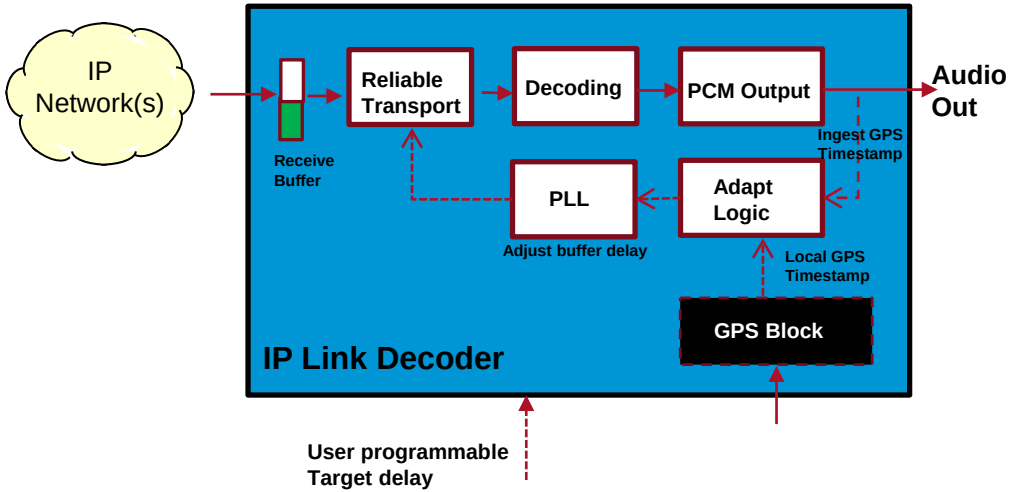



Audio Interface: AES/EBU, Analog, AES 192
Recommended Audio Encoding: Linear, AAC-LC, AAC-ELD, Opus, G722, E-aptX
Reliable Transport: RTP FEC, Stream Splicing

# Studio Side Details

- System uses either internal GPS receiver or external 10 Mhz and 1 PPS to lock its AES3 and A/D clocks
- Incoming PCM data block is time stamped using GPS reference
- Timestamp is carried through the Encoding and Reliable Transport blocks
- Outgoing RTP packets carry encoded audio and ingest GPS timestamp
- If Stream Splicing is utilized, packets along with their timestamp are duplicated
- FEC protects both audio and timestamps

# SynchroCast Receive Side Architecture

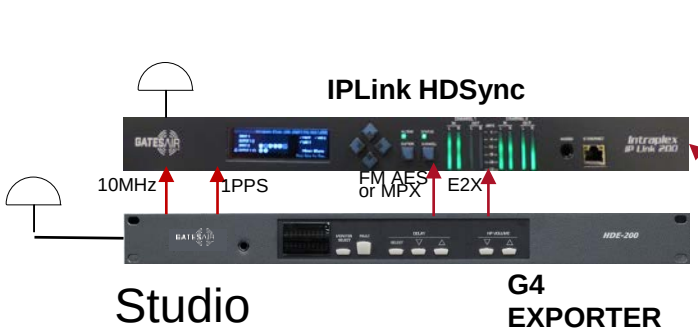



SynchroCast works independently on each IP Link output channel

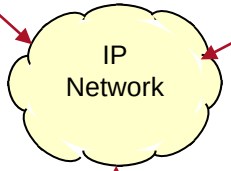
# Receive Side Details

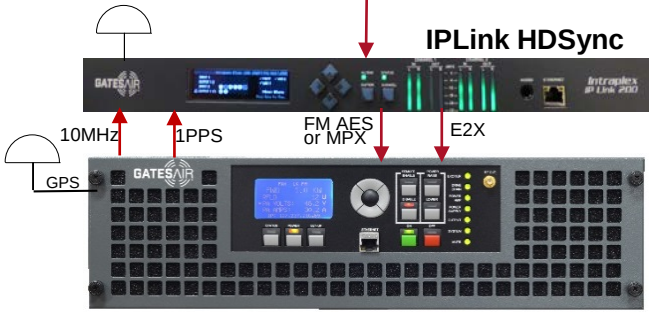
- Receive buffer (Jitter Buffer) provides controllable delay by adjusting its depth
- Adaptation logic compares local and transmit timestamps and applies an algorithm to advance or decrease PLL to change the buffer depth
- Two modes of buffer depth adjustments: Hitless and Hitfull
  - Hitless adjustment has no audible disruptions –maximum PLL deviation is 100 PPM. Takes 10 seconds to move every 1 msec
  - Hitfull or Fast Adjust mode for quick convergence at startup or anytime delay is off by more than 1 packet interval
  - Hitfull mode works by adding or removing packets in the receive buffer
- System maintains last known Target Delay in case GPS signal fails

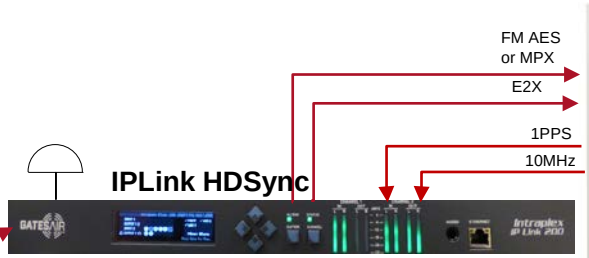
# IP Link Synchronous HD




- Uses external reference or internal GPS to lock AES3 and A/D clocks
- PCM data block is time stamped using GPS reference.
- E2X data is multiplexed with Timestamped PCM data
- Outgoing RTP packets carry encoded audio, GPS timestamp and E2X data
- If Stream Splicing is utilized, packets along with their timestamp are duplicated
- FEC protects both audio, E2X and timestamps

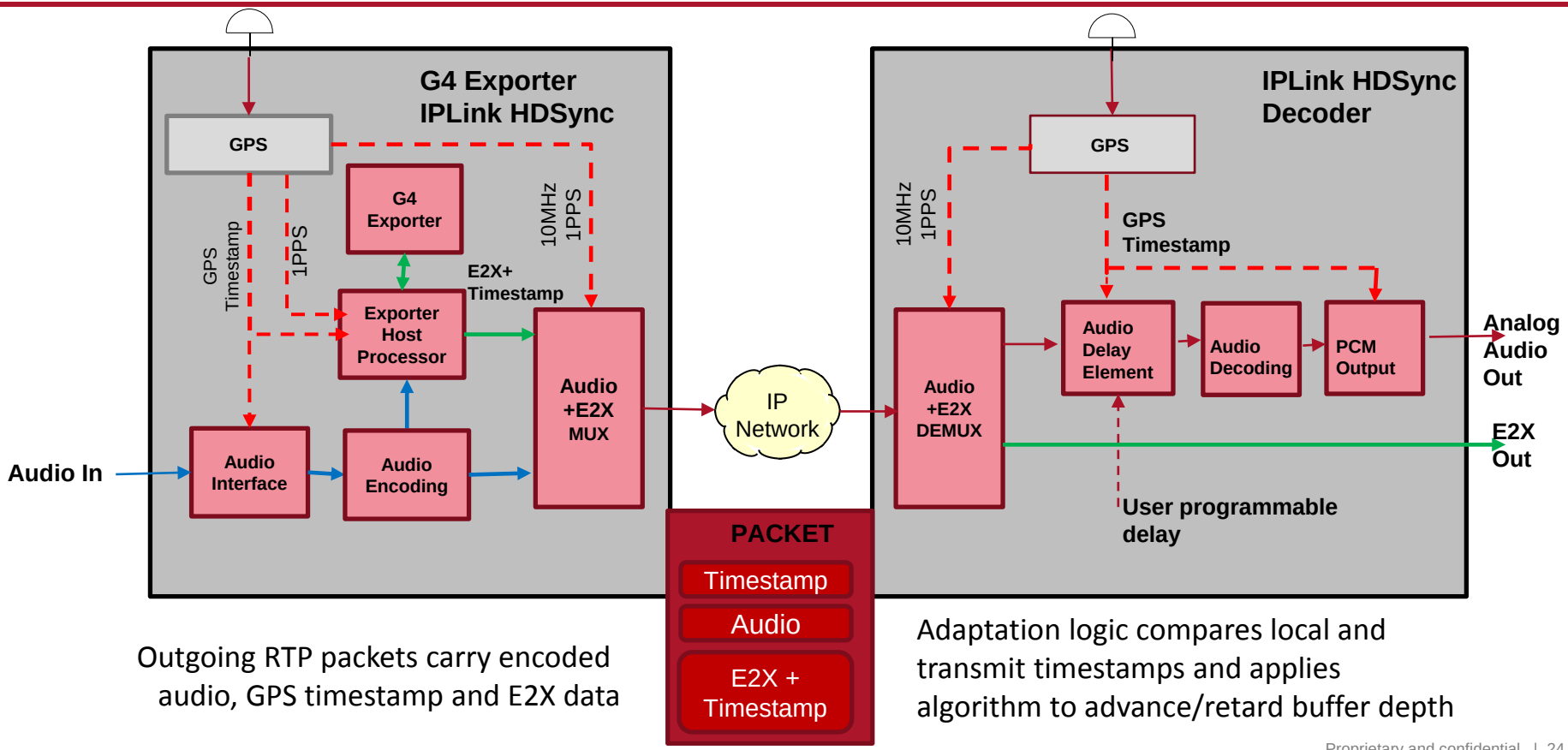



- Receive buffer provides controllable delay by adjusting its depth
- Adaptation logic compares local and transmit timestamps and applies an algorithm to advance or retard the buffer depth

# HD SynchroCast




Outgoing RTP packets carry encoded audio, GPS timestamp and E2X data

Adaptation logic compares local and transmit timestamps and applies algorithm to advance/retard buffer depth

# Summary

- FM and HD synchronous networks are possible
- Audio signal delay from different transmitters needs to be precisely aligned in the overlap region for FM analog, HD within 75usec
- Audio levels need to be within .1dB of accuracy
- RF carriers need to be synchronized
- Pilot needs to be synchronized
- Use of SynchroCast will precisely delay the audio signal at the transmitter sites by the Target Delay
- Use of synchronous networks increase reach of your station in target market
- Increase service to underserved areas

# Thank You!

Ted Lantz

Senior Manager, Radio Product Line