



Ensuring Public Safety Emergency Communications:

What Impairs Radio Communications?

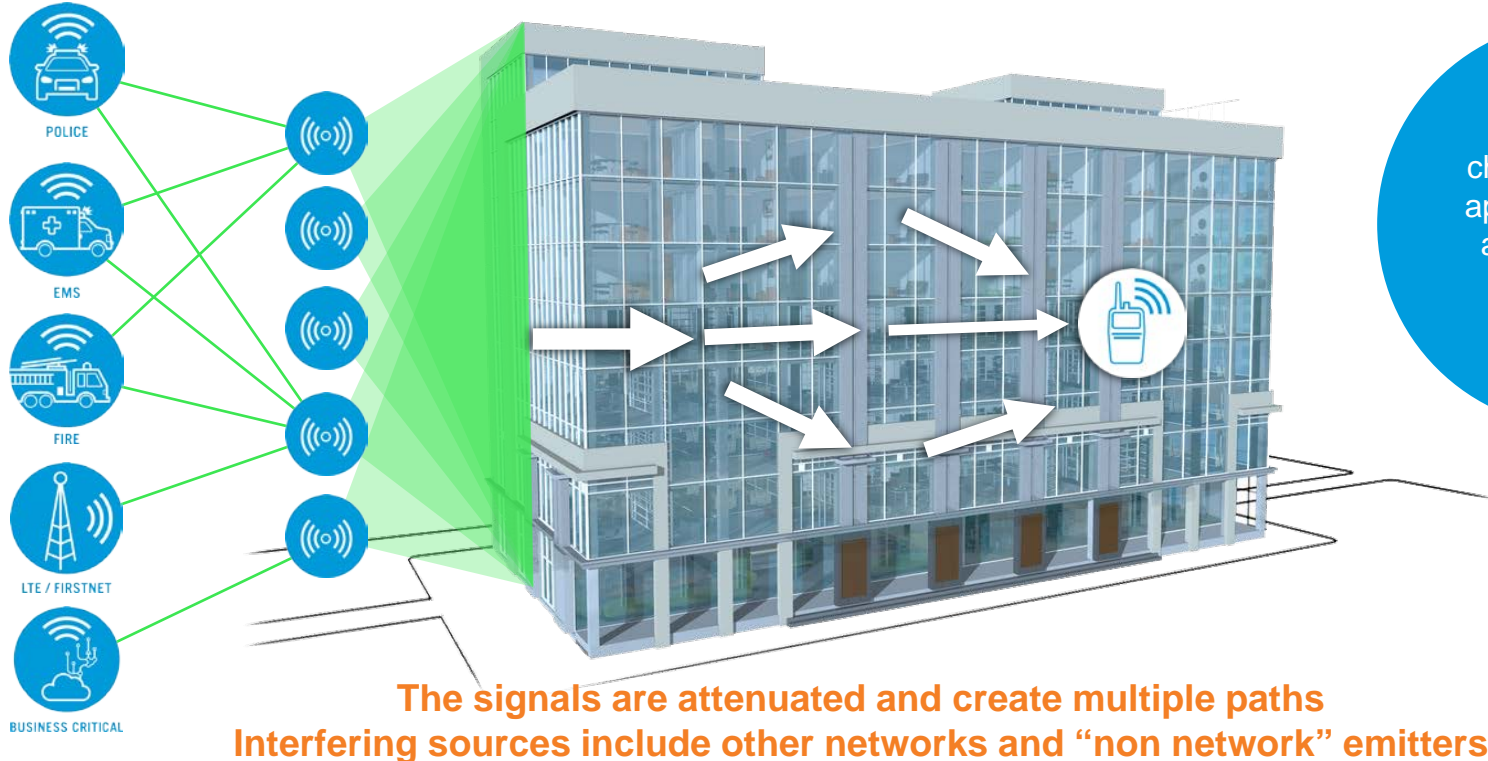


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Indoor Signal Coverage: Challenges

The jurisdictions are responsible for “outdoor” networks used by Public Safety agencies...but the radio signals penetrate “in building” poorly – the radio signal degrades



These challenges also apply to **cellular** and **business critical** radio networks

The signals are attenuated and create multiple paths
Interfering sources include other networks and “non network” emitters

Metrics to Measure

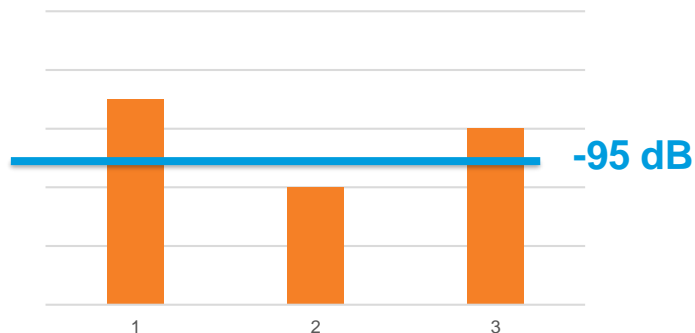
Typical AHJ Requirements

Minimum **signal strength level sufficient for DAQ 3.0**, or **SINR** both in and out

510.4.1.1 Minimum signal strength into the building...provide usable voice...provide not less than a Delivered Audio Quality (DAQ) of 3.0 or an equivalent Signal-to-Interference-Plus-Noise Ratio (SINR)...

510.4.1.2 Minimum signal strength out of the building.
Similar **IFC 510 2018**

510.4.1.1 Minimum of -95dBm...DAQ of 3.0 or an equivalent SINR...(outbound the same) **IFC 510 2021 Proposed**



- **RSSI (signal power):** most common historically (being restored in next version)
- **Accurate “Averaging” and Test Method** (antenna usage, movement, etc.) are important
- **Voice Quality test:** graded based on DAQ
- **“Signal Quality”:** some local AHJs adding SINR/BER; under consideration for national
- **In Practice?** Power at a minimum with radio or SA; some require 2-way voice; starting to add/substitute with signal quality; a few require power/SINR/BER at the radio site

How to Measure “Good” Radio Coverage

The priority is to ensure voice communication throughout the building for first responder in emergency situations

Two individuals speak to each other over radios (Harvard sentences) and assess the “delivered audio quality”

Delivered Audio Quality Metrics (DAQ):

DAQ 1 Unusable. Speech present but not understandable.

DAQ 2 Speech understandable with considerable effort. Requires frequent repetition due to noise/distortion.

DAQ 3 Speech understandable with slight effort. Requires occasional repetition due to noise/distortion.

DAQ 3.4 Speech understandable without repetition. Some noise/distortion present.

DAQ 4 Speech easily understood. Occasional noise/distortion present.

DAQ 5 Speech easily understood.

Reliable equipment measures the radio power (signal strength, RSSI) and quality (signal relative to the radio noise)

Radio	DAQ 3.0	DAQ 3.0	DAQ 3.4	DAQ 3.4
	BER %	SINR	BER %	SINR
P25 C4FM	2.6	17.4	2	19
P25 CQPSK	2.6	15.7	2	17

Source: TIA TSB-88.1E Annex A Table A1 11/2018

*Real speech assessment up and down
Subjective, individual opinion, expensive*

*Focus on the radio signal
Objective, uniform, repeatable, accurate
Ideally up link measurements as well*

Sources of RF Signal Degradation

THERE ARE MANY FACTORS THAT AFFECT VOICE AND DATA SERVICE BY DEGRADING RF SIGNAL QUALITY – OCCURS ON BOTH DOWNLINK AND UPLINK

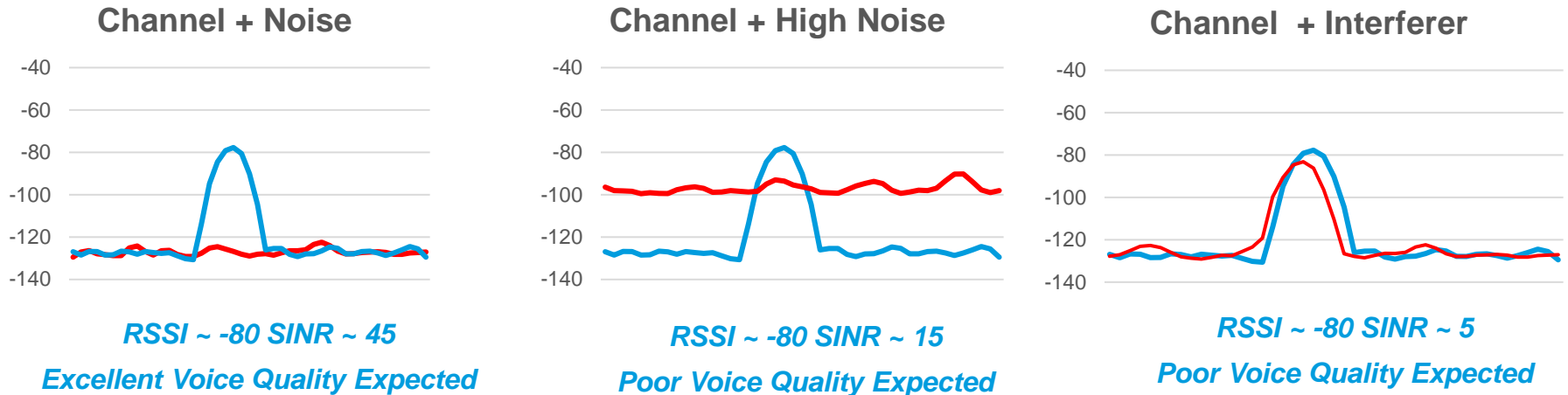
- High noise floor
- Interference from “non-network” sources
- Adjacent channel interference
- Co-channel interference
- Fading
- Time Delay Interference (TDI, or Delay Spread) in Simulcast systems
- TDI from multi-path (outside and inside a building)
- TDI from insufficient isolation between the in-building system and the Donor
- TDI from leakage to the user on the outside of a building
- TDI from BDA Congestion

Measuring Signal Quality has been the main approach to optimizing networks

Power (RSSI) Measurements Will Not Reveal These

RF Degradation: Noise and Interferers

RF Noise and Interference is the Primary Contributor to Poor Voice Quality

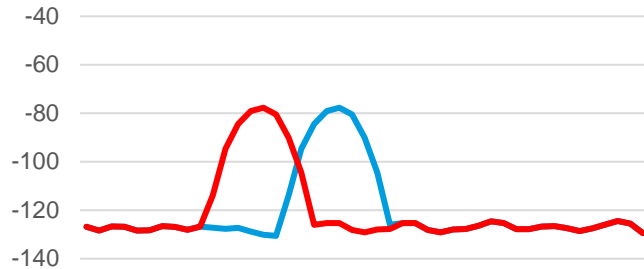


NOTE: while the **noise is shown in red** separately, it is really combined with channel power and not visible without a SINR measurements

RF Degradation: Network Channels

Channels in other networks or the same network can cause problems

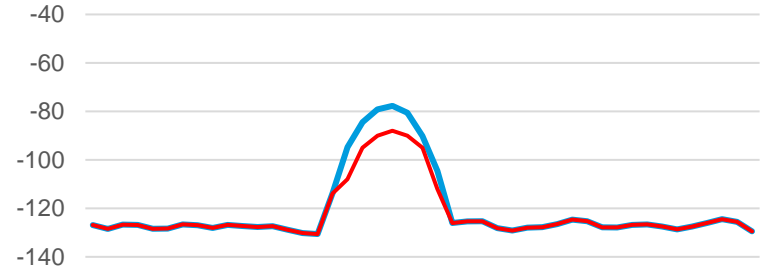
Channel + Adjacent Channel



RSSI ~ -80 SINR ~ 15

Poor Voice Quality Expected

Channel + Co-Channel



RSSI ~ -80 SINR ~ 5

Poor Voice Quality Expected

Another network is using channels without the proper spacing

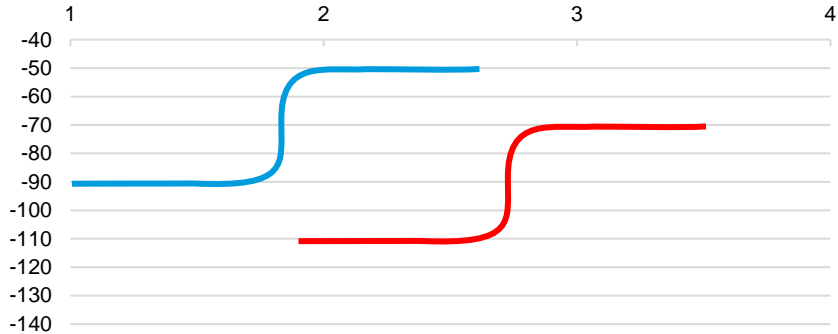
*Another networks in adjacent jurisdiction
Simulcast system*

NOTE: while the channels are shown in red separately, it is really combined with main channel power and not visible without a SINR measurements

RF Degradation: Time Delay Interference (TDI)

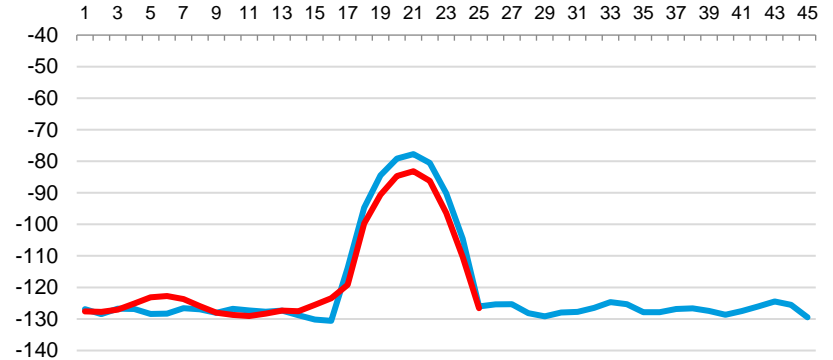
WHEN THE SIGNALS COME FROM DIFFERENT DISTANCES.... SIMULCAST OR MULTI-PATH

**Main Channel Source +
2nd Source Delayed in Time**



... the 2 signals can arrive at
different times...

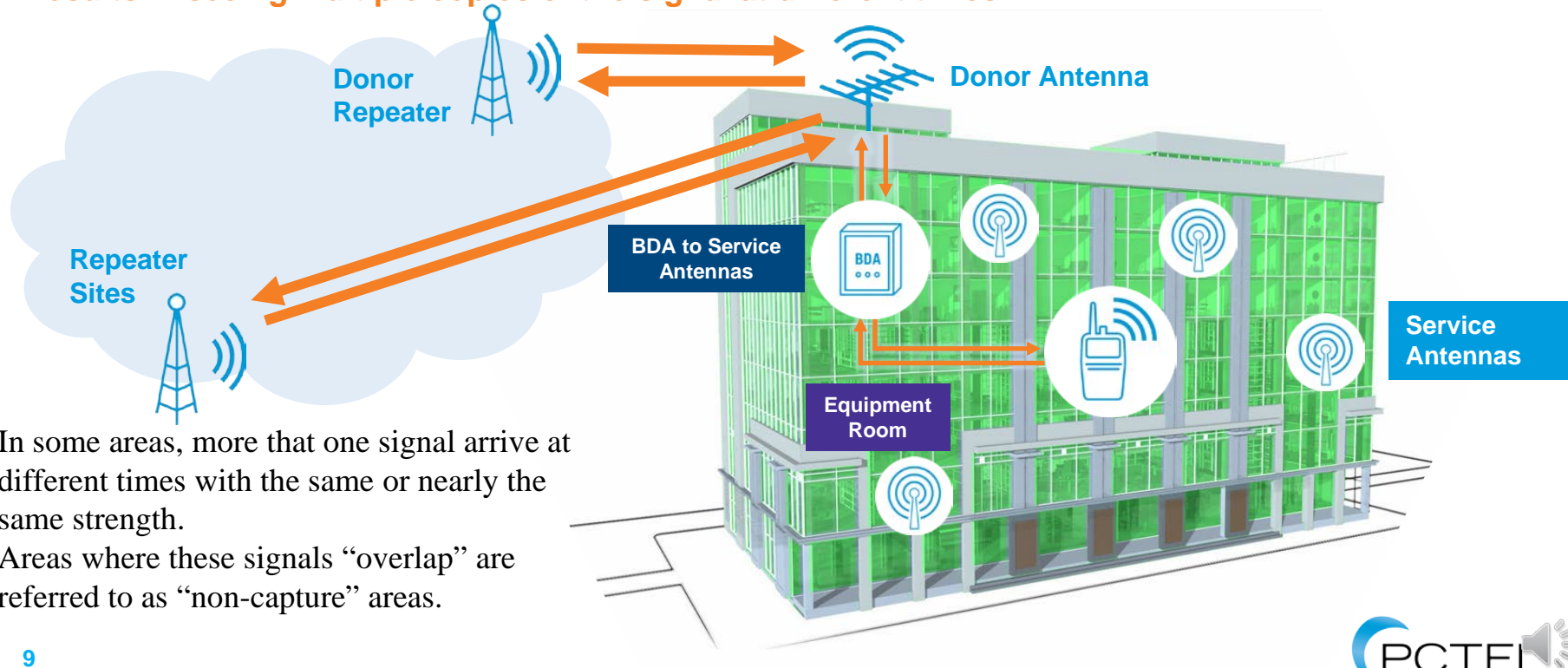
**Main Channel Source + 2nd Source
With Similar Power Levels**



... and can arrive at
different power levels

TDI Source: Simulcast

SIMULCAST: All repeater sites send the same signal from different distances
Results in seeing multiple copies of the signal at different times

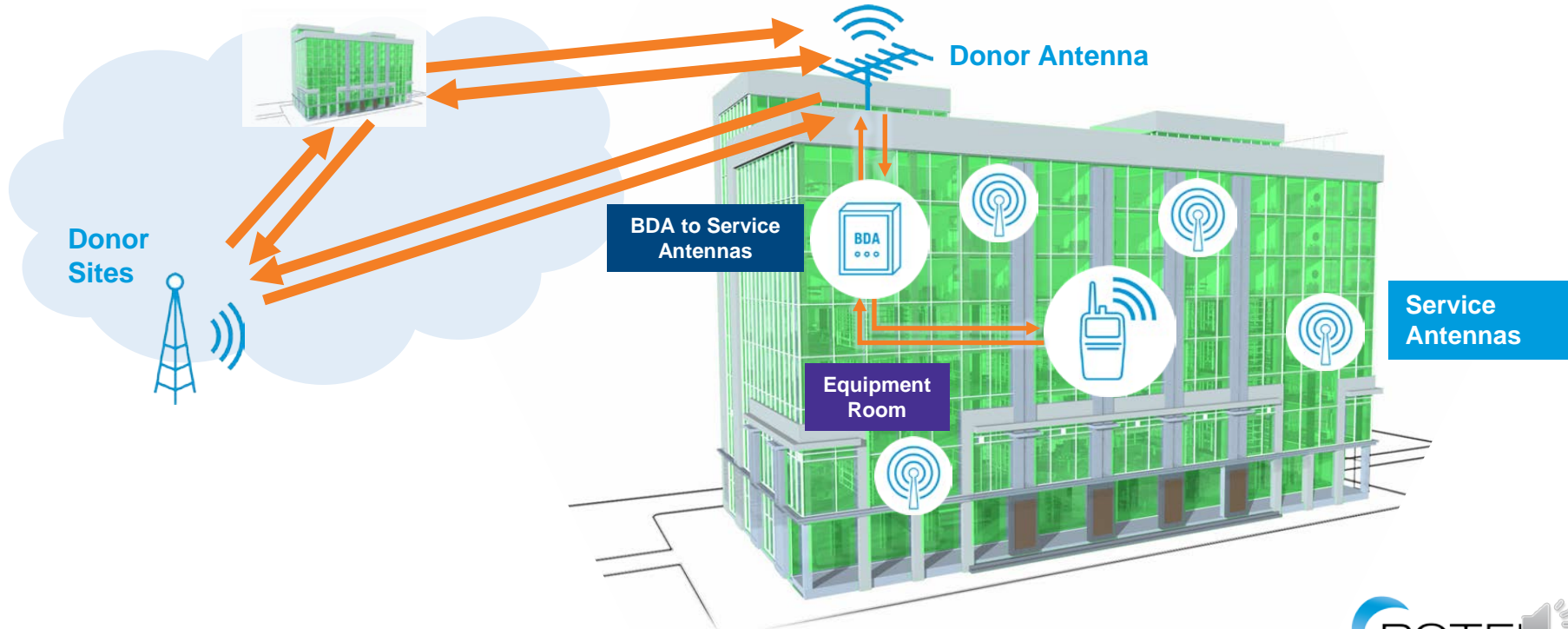


In some areas, more than one signal arrive at different times with the same or nearly the same strength.

Areas where these signals “overlap” are referred to as “non-capture” areas.

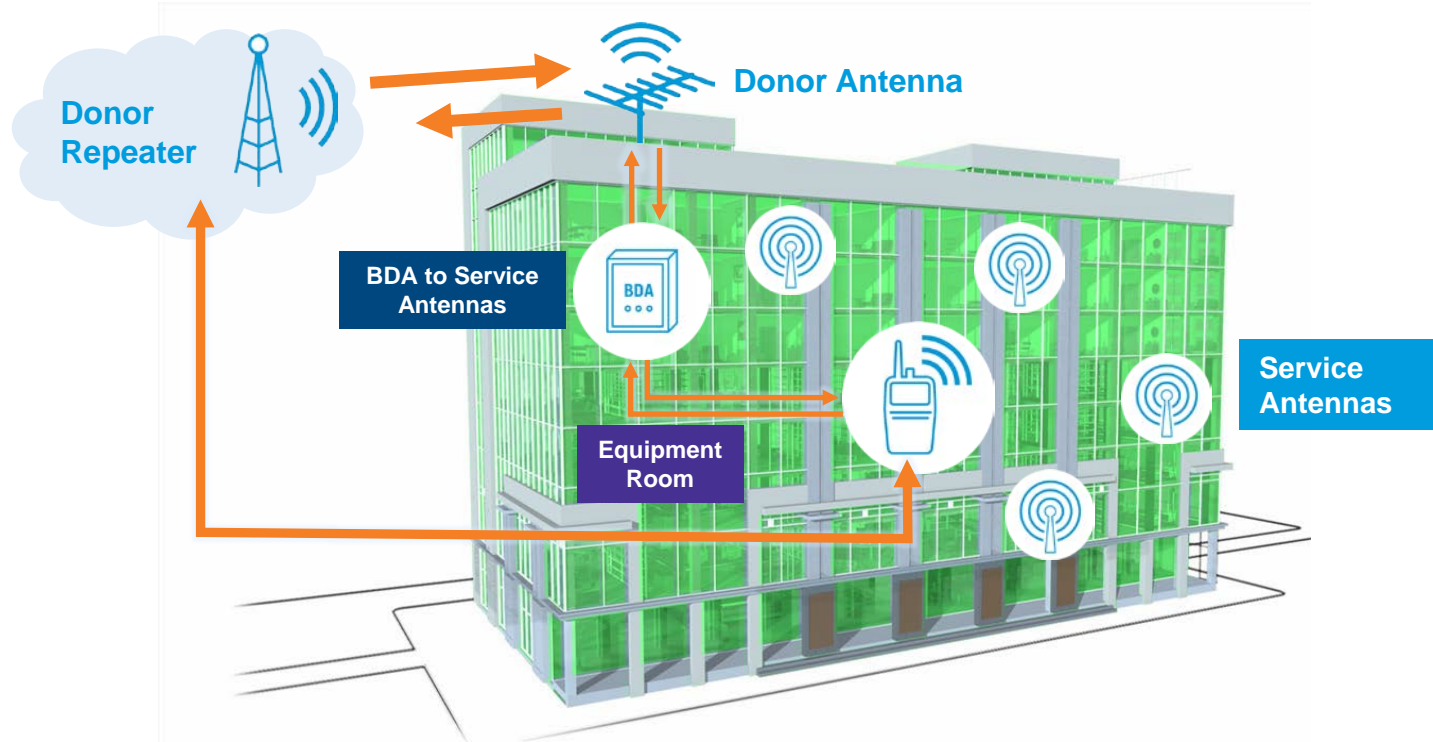
TDI Source: Multi-Path Outside

MULTI-PATH: a similar effect occurs when a single signal “bounces” and multiple copies are seen by the radio



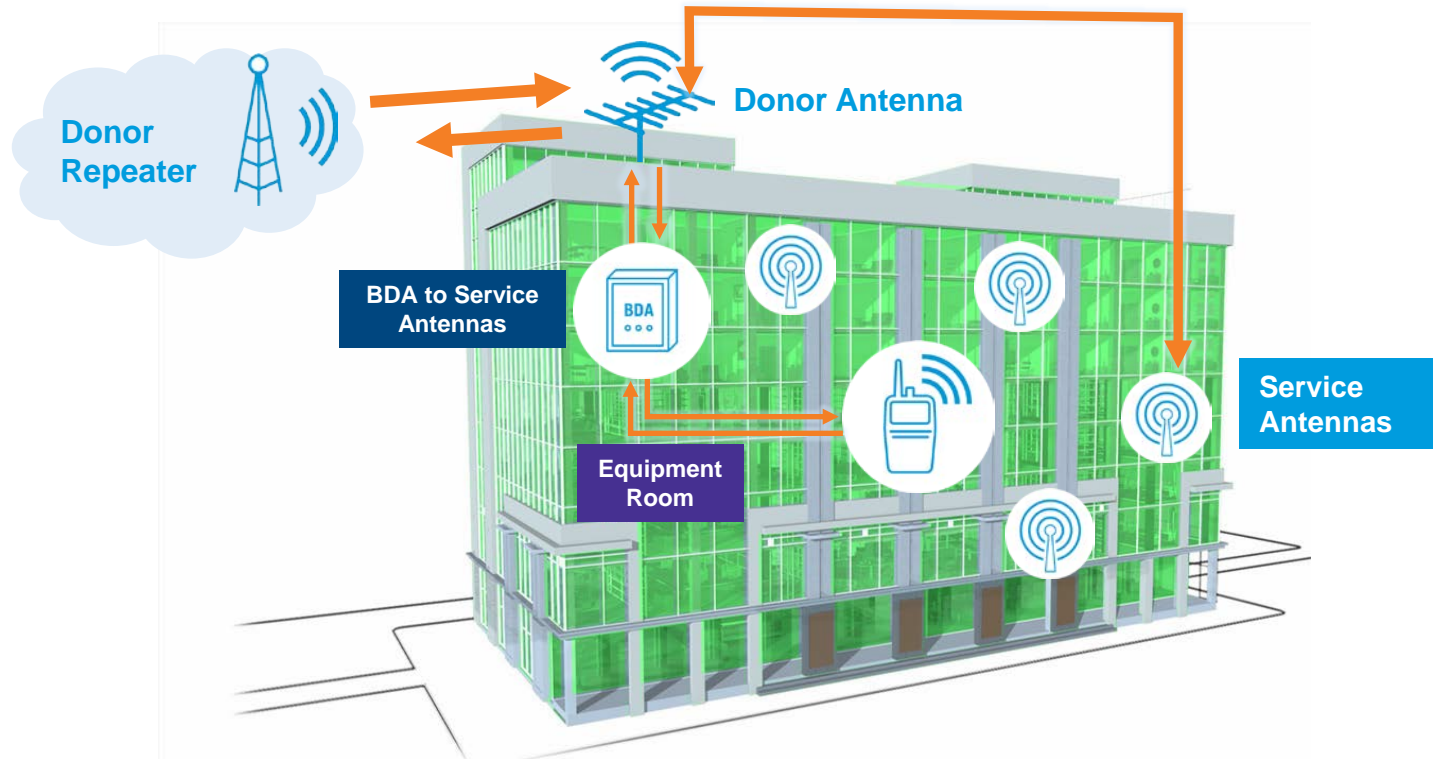
TDI Source: Multi-Path Inside (Dominance)

AMPLIFIED SIGNAL VS. OUTSIDE SIGNAL: The signal through the BDA is delayed vs. The signal that “leaks in” from the outside



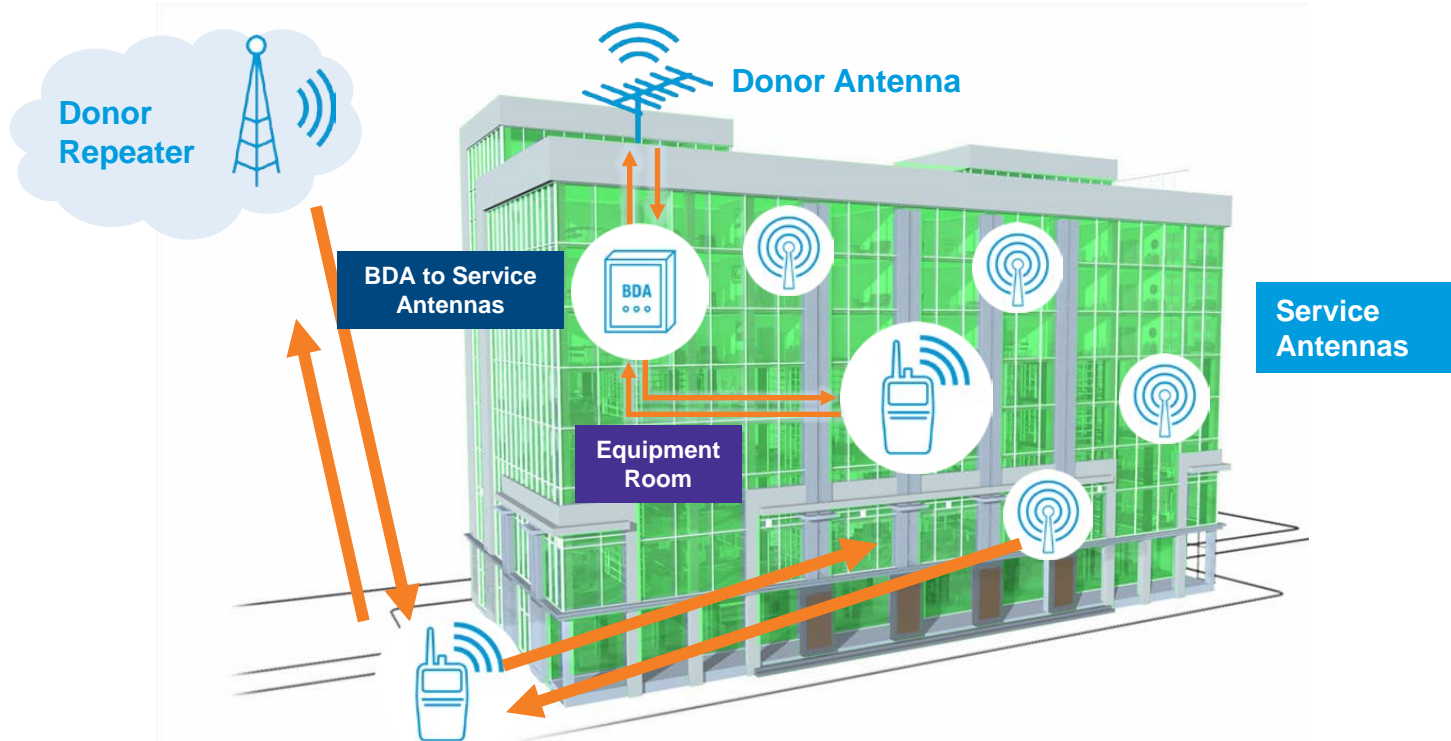
TDI Source: Insufficient Isolation

“LEAKED” SIGNAL VS. OUTSIDE SIGNAL: The signal through the BDA is “leaks out” and comes back through the Donor Antenna with too much strength – similar on the uplink



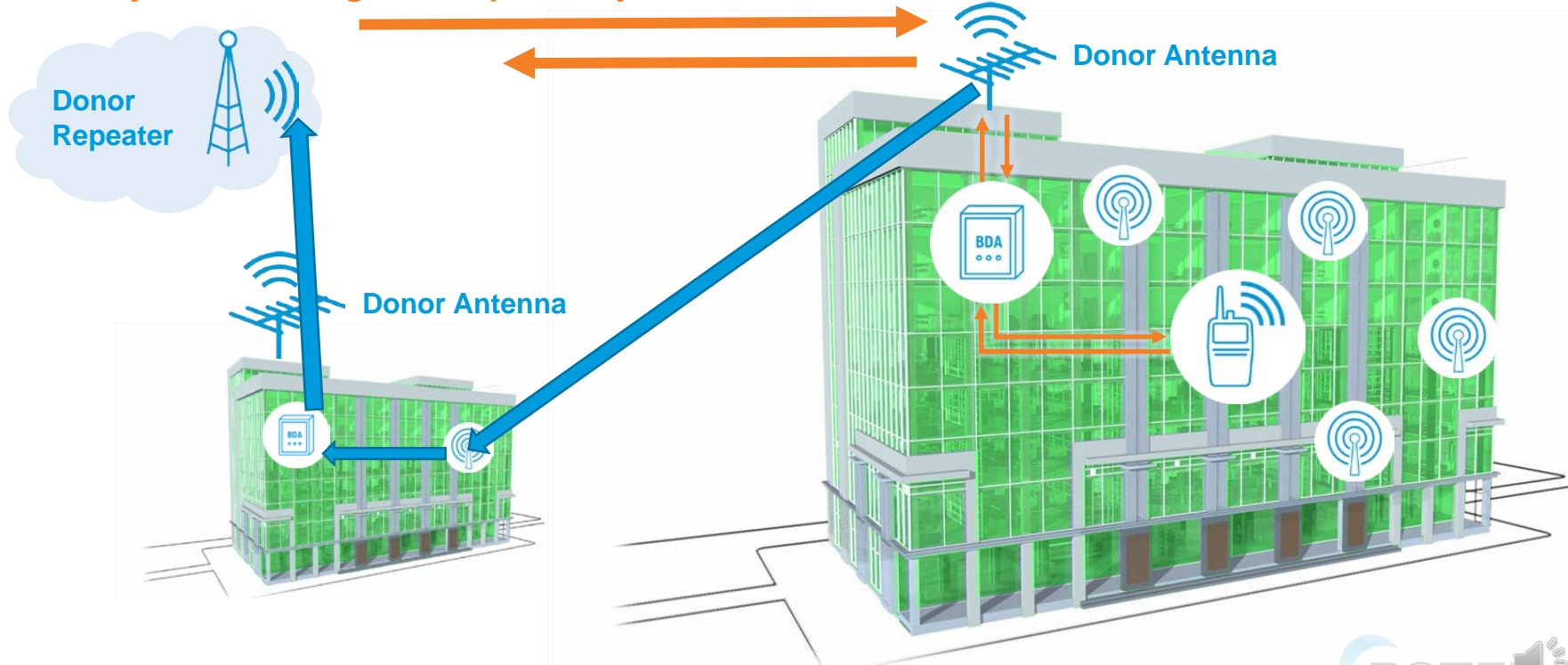
TDI Source: Leakage

AMPLIFIED SIGNAL VS. OUTSIDE SIGNAL ON THE OUTSIDE OF THE BUILDING: The signal through the BDA is “leaks out” with too much strength for the outside user



Time Delay Interference: BDA Congestion

AMPLIFIED SIGNAL REPEATED BY ADJACENT BDA: The signal from the Donor Antenna “leaks” into an adjacent building and amplified by the second BDA



Advantages of RF Signal Quality Testing

MEASURING RF SIGNAL QUALITY ADDRESSES THE CHALLENGES OF DAQ TESTING

- RF signal quality testing is widely accepted as an accurate measure of voice quality
 - Endorsed by major standards bodies,
 - Shown to correlate well with DAQ metrics
 - In use for 25+ years in numerous communication networks.
- Two basic types: SINR and BER measurements
- Reflects the RF phenomena that degrade performance in digital radio systems
- Accurate, repeatable, objective, uniform
- Easily automated with significant time and cost savings

THIS METHOD HAS KEY ADVANTAGES WHEN PERFORMED BY QUALITY EQUIPMENT AND PROCEDURES

REPLACES OR REDUCES THE AMOUNT OF MANUAL DAQ TESTING

Thank You. Questions?

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Resources:

pctel.com/public-safety-testing-solution/



> pctel.com

