



Wireless Transmission A Fundamental Guide . . .

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Agenda

- RF Spectrum
- Digital Audio Transmission

Spectrum Crunch

Changes In Spectrum Policy The Impact On Wireless Mic Operations

Joe Ciaudelli

Frequencies for Wireless Mic's

30 - 45 MHz (8-m HF)

Antenna length ;
RF-interference from (electric) appliances

174 - 250 MHz (VHF)

Good wave propagation; TV-transmitters;
RF-distortions from digital equipment

450 - 960 MHz (UHF)

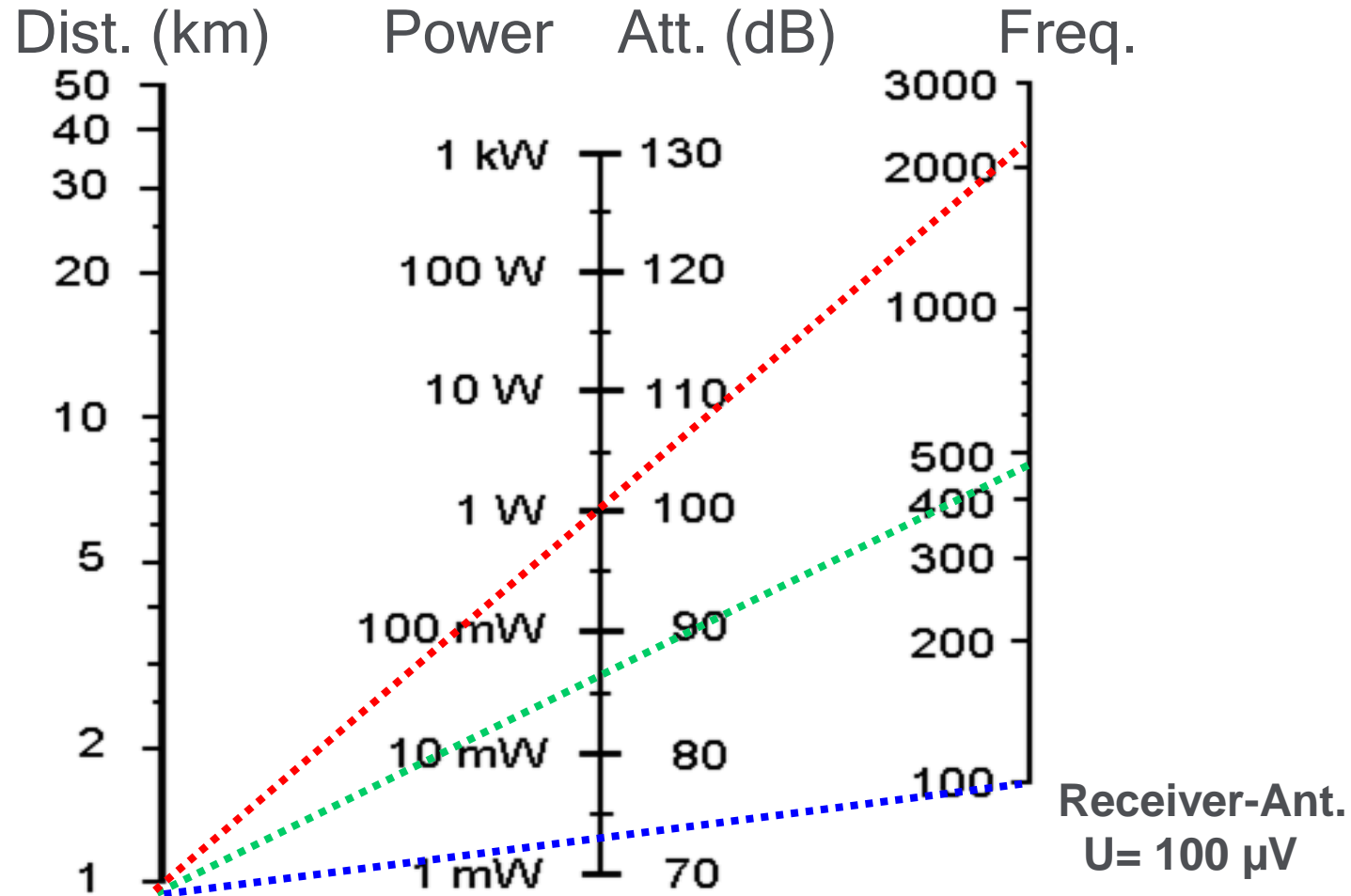
wide frequency range
good wave propagation

2400 - 2485 MHz (ISM)

IndustrialScientificMedical

poor wave propagation ;
no exclusive frequencies
(license free devices);
interference from microwave-ovens

Range / Power / Frequency



UHF has greater range compared to higher frequencies

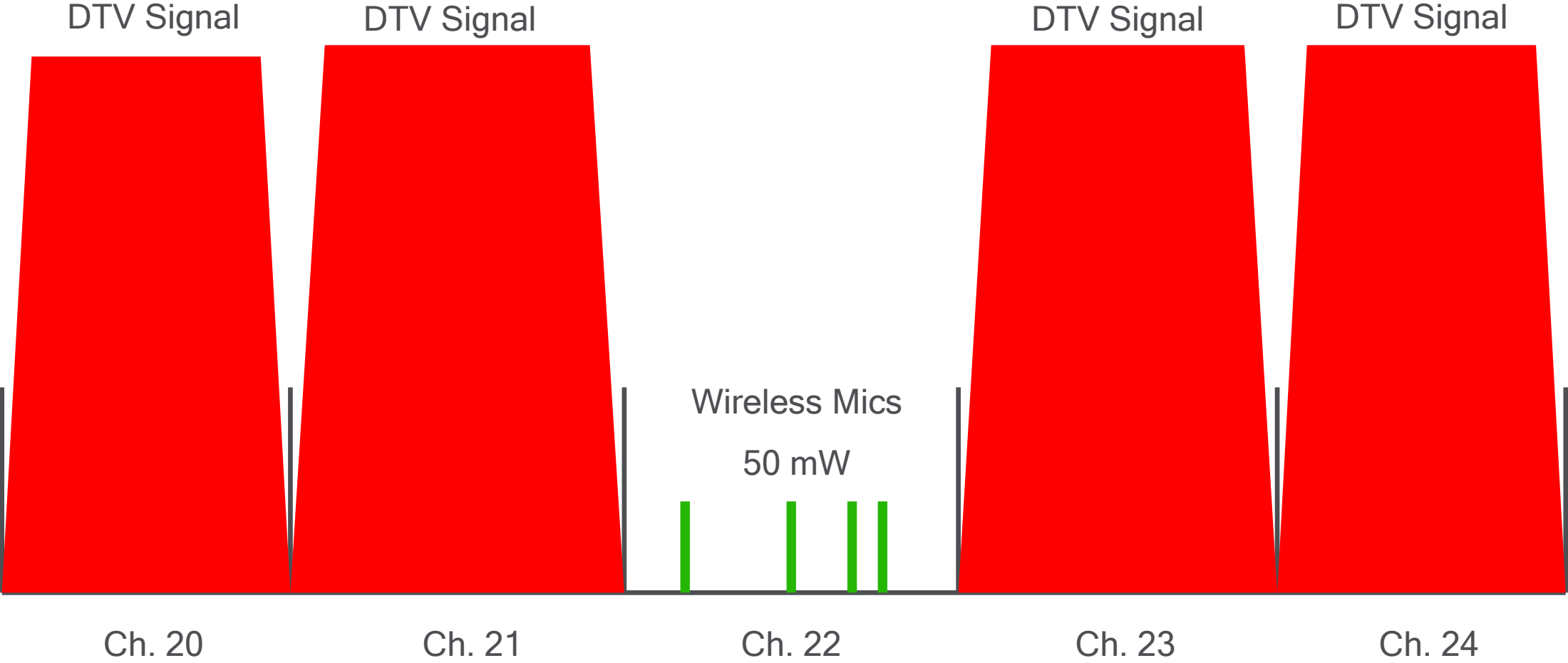
500 MHz UHF frequency (green line) requires only about 75 mW to transmit 1 kilometer (about ½ mile) - line of sight.

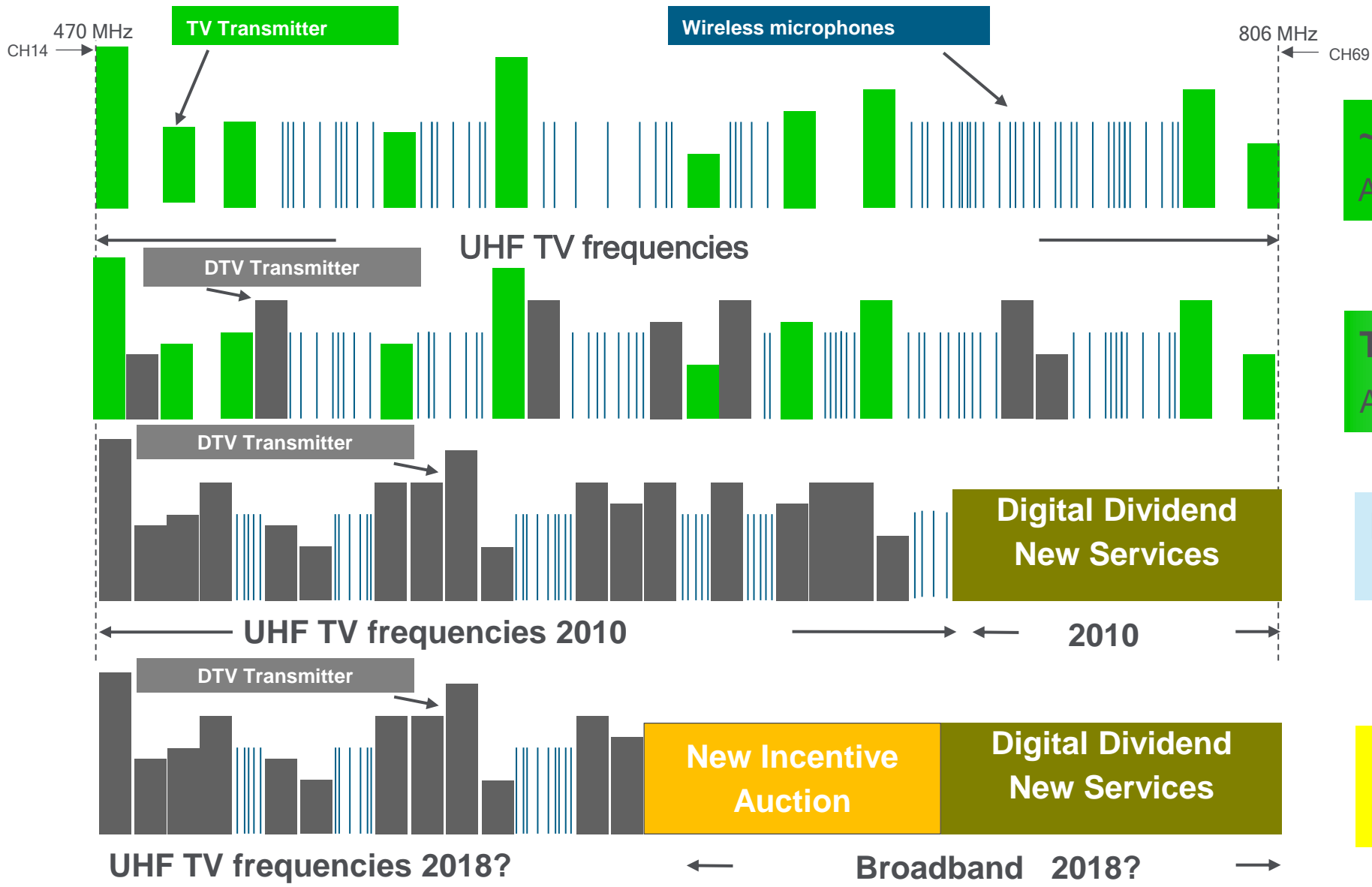
2.4 GHz (red line) requires about 1000 mW (much greater power) to travel the same distance

UHF is the beach front property in the spectrum

- Provides exceptional wave propagation characteristics
 - Travels through foliage, walls, furniture, etc
- Operates with compact antennas and filter components
 - Important for small mobile transmitters like mics
- Less susceptible to noise from electronic devices
- Long transmission range using moderate power output

Operating in vacant (“white space”) TV channels





~20 years ago:
Analog TV only

Transition:
Analog & DTV

Now:
Full Digital Scenario

Future:
More Broadband services

What You Should Know

- A large portion of the upper UHF spectrum, specifically the 600 MHz band will be repurposed and become unavailable to mics in about three (3) years in the United States.
- There will be small pockets in the repurposed spectrum where mics will still be allowed to operate, under different rules, after the spectrum repacking is completed.
- License eligibility has been expanded, providing valuable rights to additional categories of wireless mic professionals.
- Rules regarding co-channel operation with TV broadcast have been revised, opening some channels to mics at locations that were formerly prohibited.
- Additional frequency bands outside of UHF are likely to become available to wireless mics in the future.
- Spectrum sharing with other devices and services will be “the new norm”

Licensed vs Unlicensed Mic Operation

■ Licensed

- Priority over unlicensed operation
- Operate up to 250mW in UHF band.

■ Unlicensed

- Limited to 50mW
- No recourse if interference is experienced.
- Consumer alert at point-of-sale or packaging

License Eligibility

- Previously only broadcasters, cable TV operators, film and content providers were eligible to obtain a license.
- Now sound companies and venues who routinely use 50 mics are too.

White Space Devices (WSD)

a.k.a. TV White Space (TVWS) or TV Band Devices (TVBD)

- “White Space” channels 2 - 51 are open to unlicensed devices:
 - Rural broadband internet
 - Metropolitan broadband internet
 - Multimedia services
 - Home networking systems
 - Consumer electronics: PDA’s and cell phones w/ advanced features
 - Future products

A new class of consumer electronics operating in the TV spectrum on locally vacant channels. They are categorized as:

- **Fixed**
 - Moderate power: up to 4W
 - A few are currently active - mostly on school campuses
- **Personal/Portable**
 - Low power: 40 - 100 mW (like wireless mics)
 - Not in the market yet

Safeguards For Wireless Mics

- FCC rules governing WSD include safeguards to avoid interference to wireless microphones:
 - Reserved channels: 2 channels in each market are reserved for wireless mics - *but the FCC plans to eliminate them !*
 - WSD must use Geolocation/Database system to find channels that are not reserved for TV or by wireless mic operators

Database System

[Company](#)[Products & Services](#)[Markets We Serve](#)[Partners](#)[Contact Us](#)[Login](#)[White Space Overview](#)[White Space Plus](#)[Register for Protection](#)[Knowledge Center](#)

White Space Plus for Operators & Users

Spectrum Bridge's vision is to empower the wireless Internet by improving the availability, access and allocation of wireless spectrum. In this pursuit, Spectrum Bridge has developed an FCC certified spectrum management platform to manage the White Space ecosystem. Spectrum Bridge offers two tiers of service designed to help you optimize the performance of your network:

White Space Plus: Spectrum Bridge's White Space Plus service provides advanced features designed to help you optimize the performance of your unlicensed network. This service includes planning tools to facilitate better network design and ensures the best performance in daily operation.

White Space Basic: This service provides radio devices with direct access to the database and channel lists, ensures FCC compliant operations and is offered for the lifetime of the device.

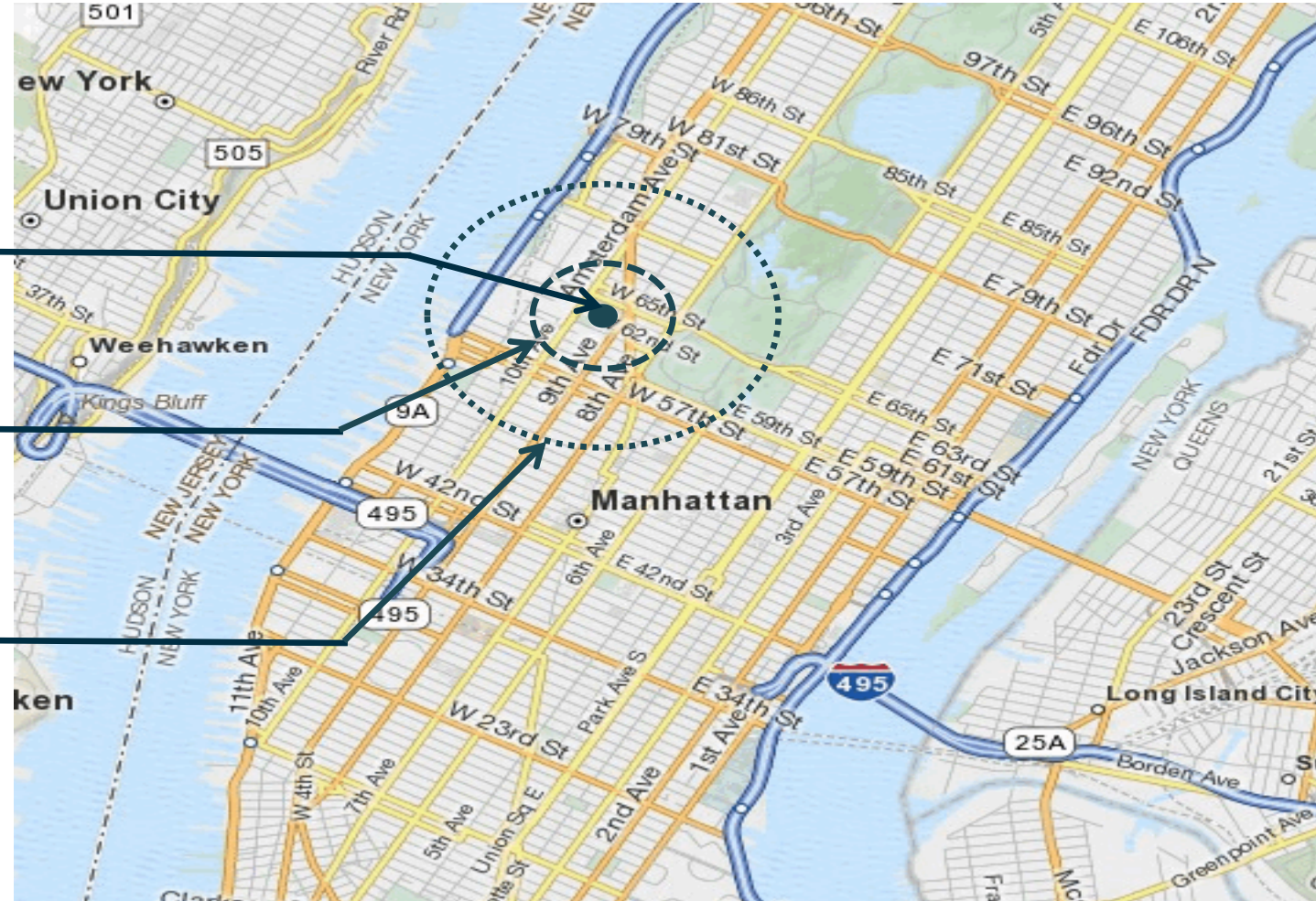
Wireless Microphone Protection Area

Microphone operating around a geographic point

400m protection from mobile WSDs

1 km protection from fixed WSDs

May specify up to 25 geographic points per registration



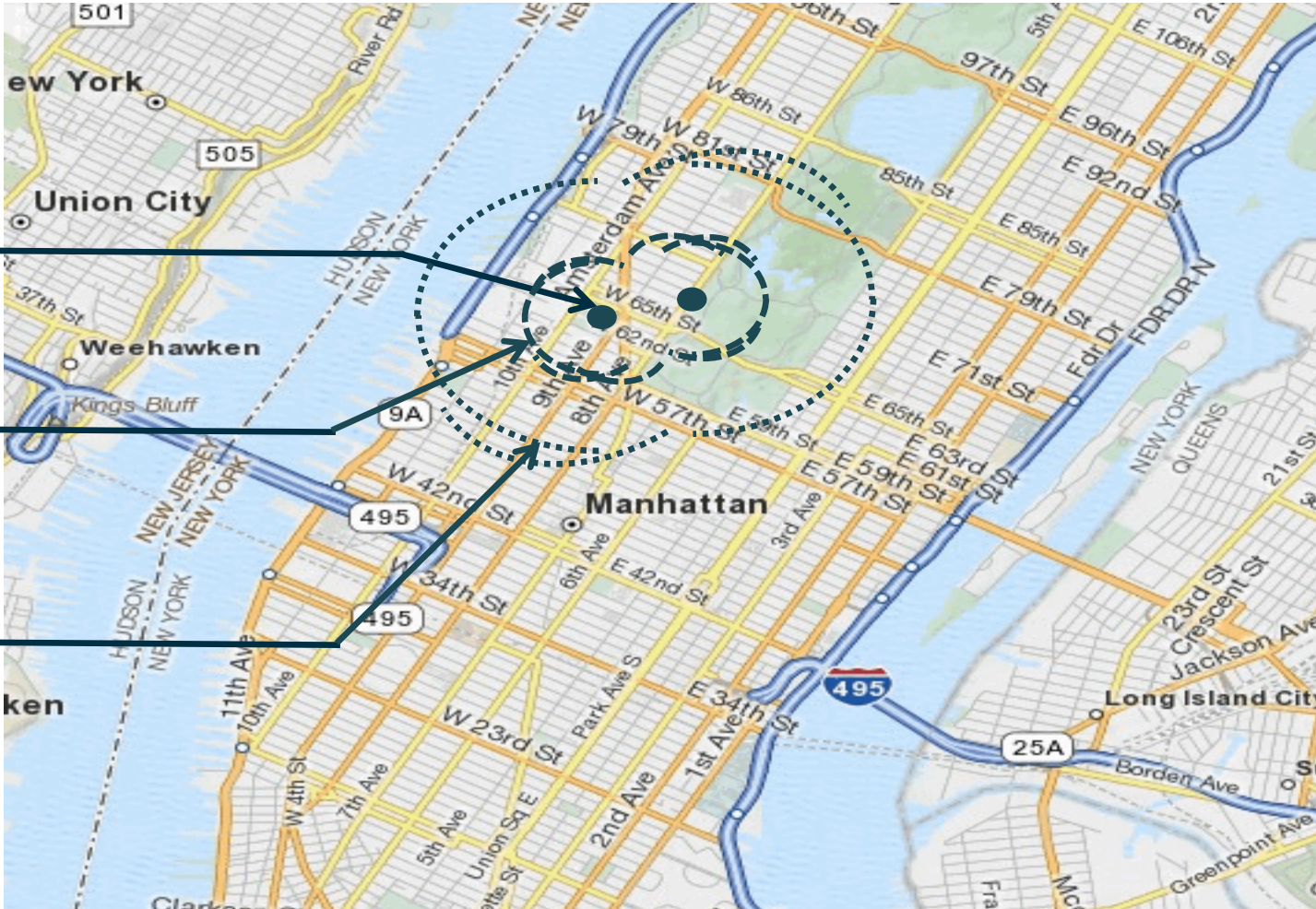
Wireless Microphone Protection Area, cont'd.

Microphone operating around a geographic point

400m protection from mobile WSDs

1 km protection from fixed WSDs

May specify up to 25 geographic points per registration



Protection of composite area

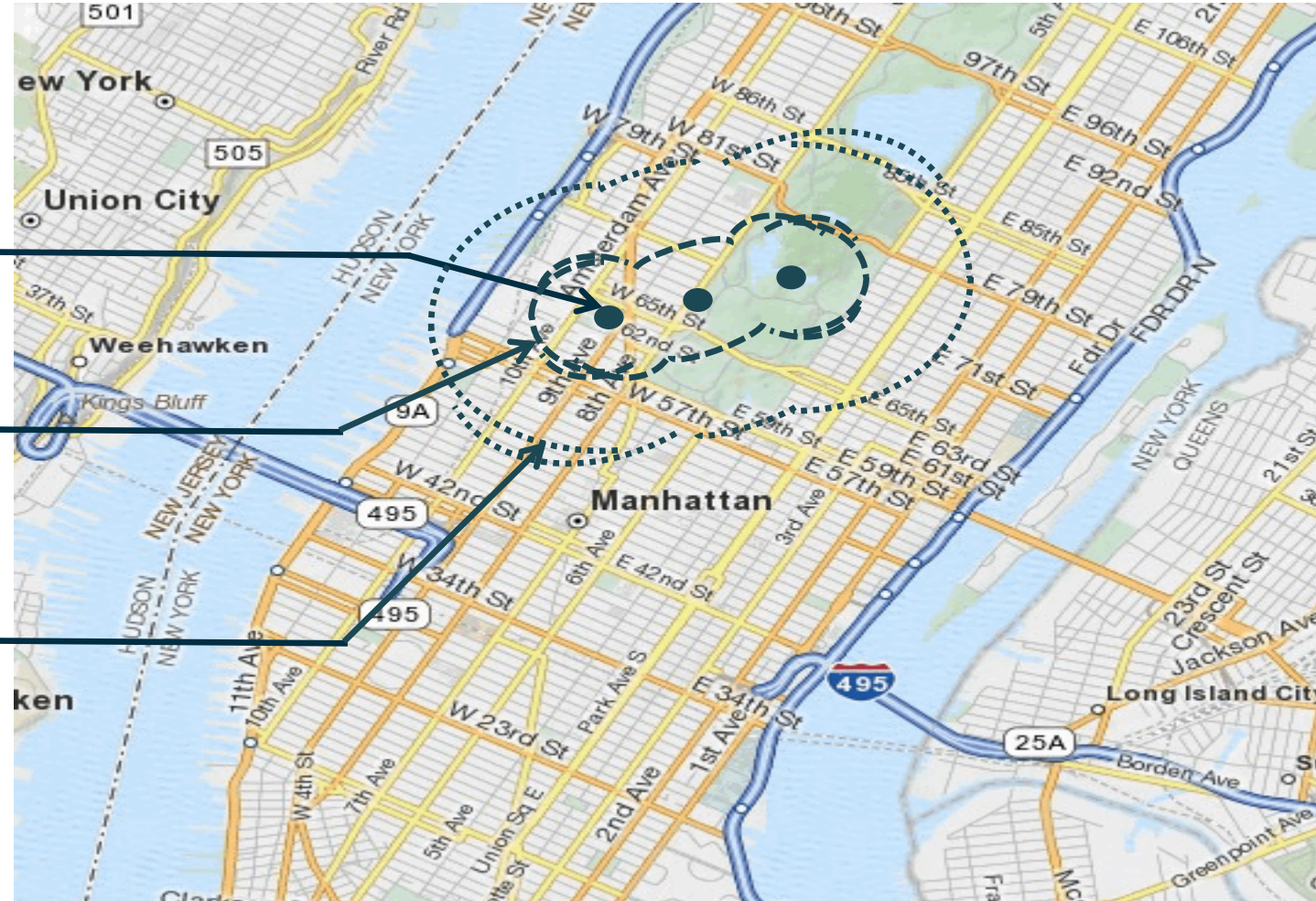
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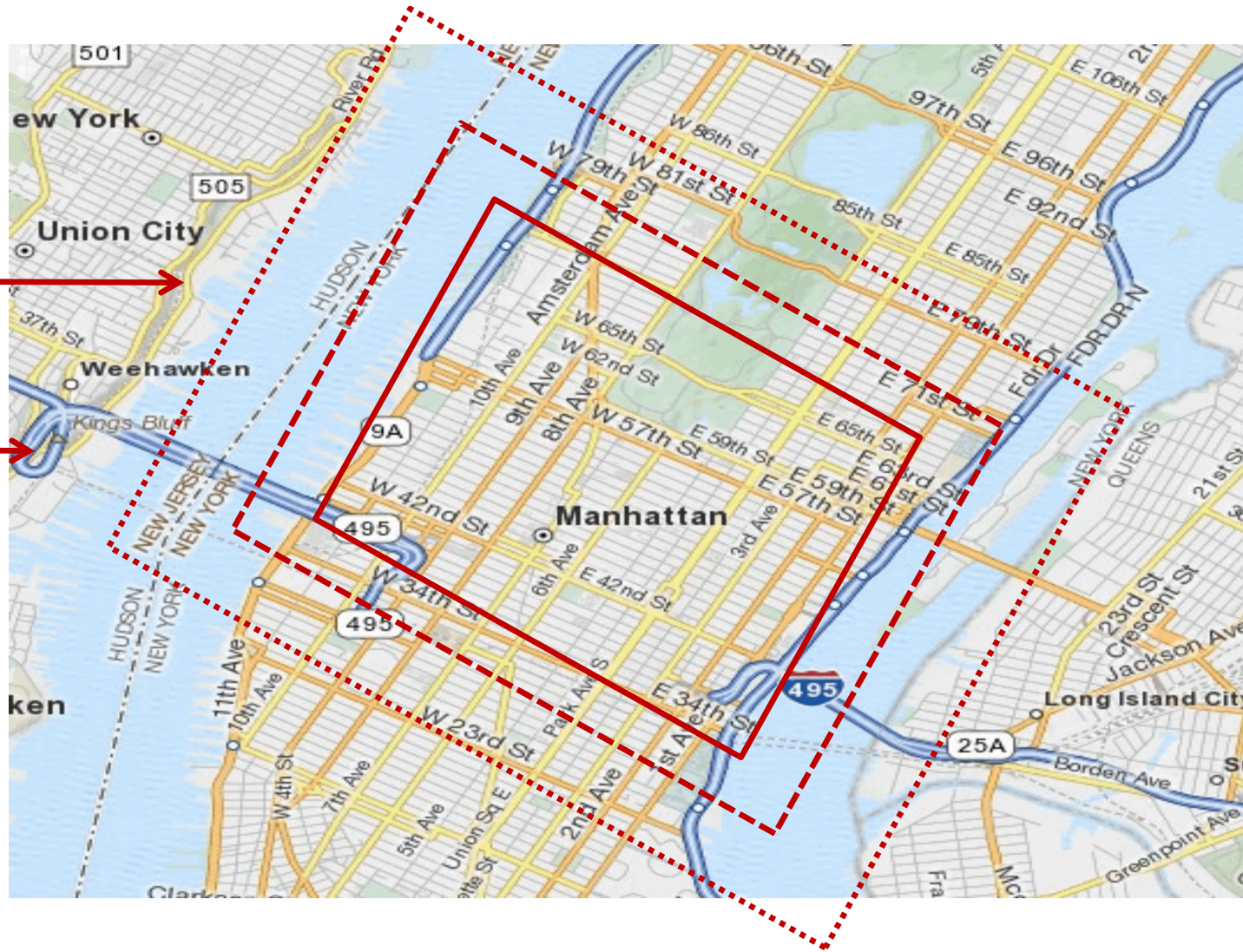
Polygon – limited to 4 vertices & 3 km sides

Microphone operating area - 3 km square

400m protection from mobile WSDs

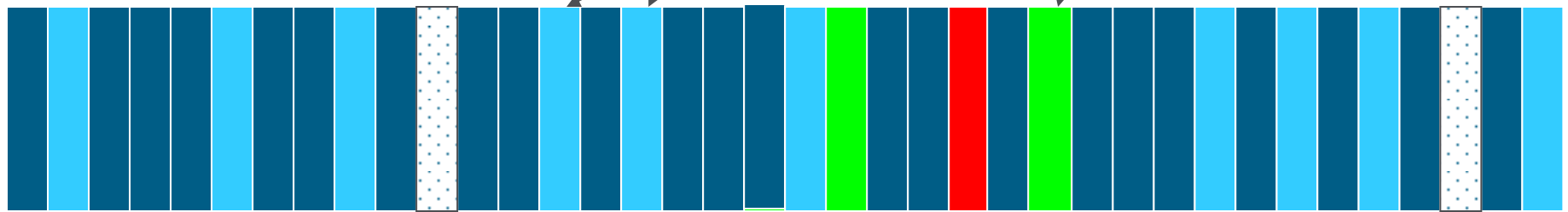
1 km protection from fixed WSDs

May specify up to 4 polygons per registration



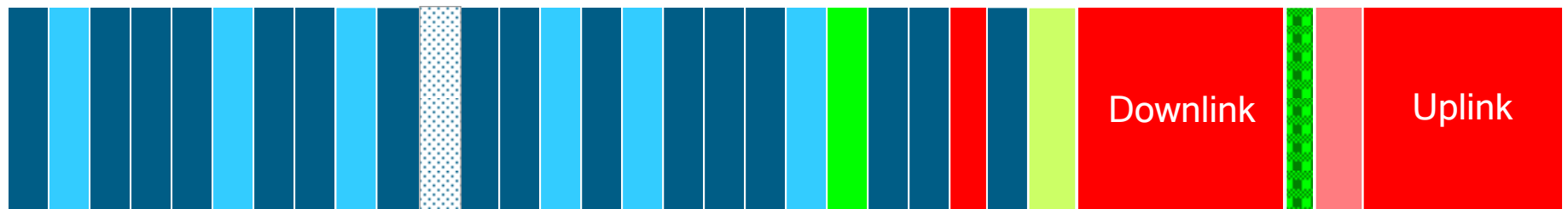
Incentive Auction

- Two Parts:
 - Reverse Auction
 - TV stations can voluntarily participate in return for a portion of the auction revenues. They can opt to:
 - Go off the air
 - Share a channel with another station
 - They privately indicate their minimum price to the FCC. Their spectrum then becomes available in the:
 - Forward Auction
 - Wireless broadband providers can then bid on the spectrum available in the various markets.



Ch 14 Ch 37 Ch 51

Current TV band
TVWS devices are presently few and far between



Naturally occurring White Space channel. Higher activity as more TVWS devices enter the market

Guard band: unlicensed operation of mics & WSD

Duplex Gap for licensed mic use. High noise floor possible

Duplex Gap unlicensed operation of mics & WSD

Repacking scenario (simplified)
7 station off air
4 stations relocated

Long Term Future

- The FCC has stated its commitment "...to accommodate the longer-term needs of wireless microphone users through use of additional frequency bands to meet their varying needs."
- In discussion:
 - 941-960 MHz (licensed only)
 - 1435-1525 MHz (licensed only)
 - 2020-2025 MHz



It is a bit freaky with this wireless technology

Ready . . . Steady . . . Digital



Digital Audio Transmission

Why everyone wants “Digital Audio ?”

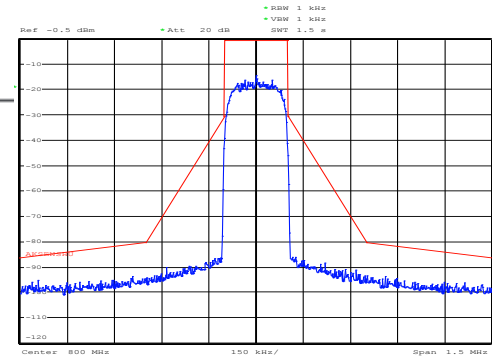
Advantages of Digital Audio Transmission

- No/ less compromises in audio quality
(→ without audio codec)
 - Even with audio codec usually better audio quality compared to compander systems
- Encryption of the transmission link
- Spectral efficiency can be further increased
 - If you are doing it the right way!

Challenges of Digital Audio Transmission

- Latency
- Operating time, size
- Higher cost
- Missing experience (at this point in time)

Digital Audio Transmission



Improved sound quality
Less artifacts

High Power Dissipation
Less battery life time

No data compression

Linear RF Amplifier

High data rate

Less Robust RF Transmission
Due to Higher Carrier/ Noise Ratio

High RF bandwidth

Complex Digital Modulation Scheme

Modulation



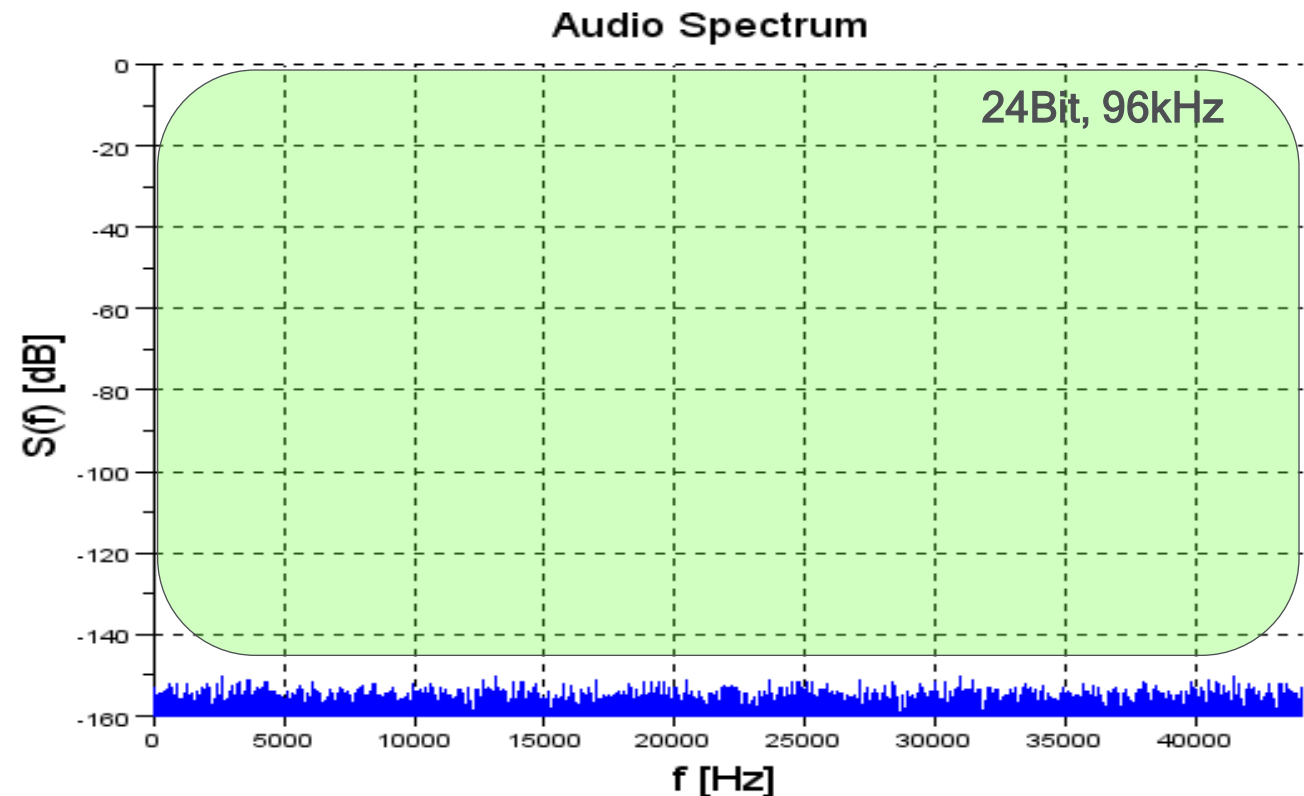
Difference in Modulation

There are three characteristics of a carrier

- Amplitude
- Phase/ Frequency
- Digital Modulation is a misnomer and refers to an analog carrier modulated with digital data

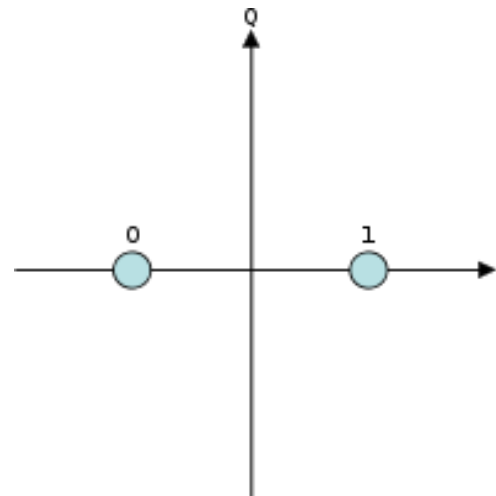
How much Data Rate is Required?

- No Audio Data Compression results in high data rate
 - $24\text{Bit} * 96\text{kHz} \approx 2.3\text{MBit/s}$
 - Additional Data for Framing and Channel Coding (usually x1,5)
→ **3.4MBit/s**

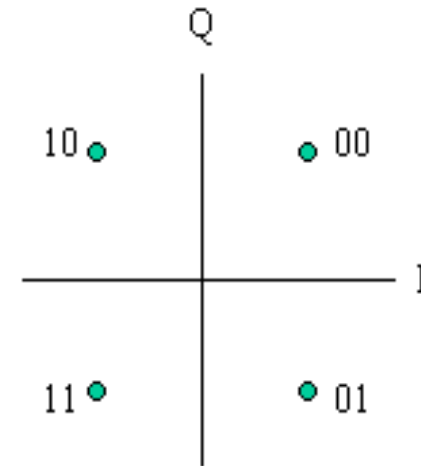


Constellation Diagrams

- Low complexity Modulation Schemes (FSK, PSK, ASK) provide only a fraction of the needed Data Rate (within 200kHz RF Bandwidth → typ. 150kBit/s...300kBit/s)



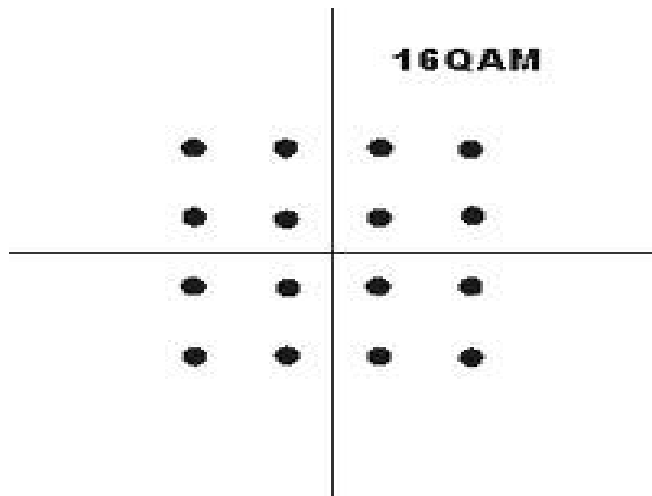
FSK
1 bit / symbol



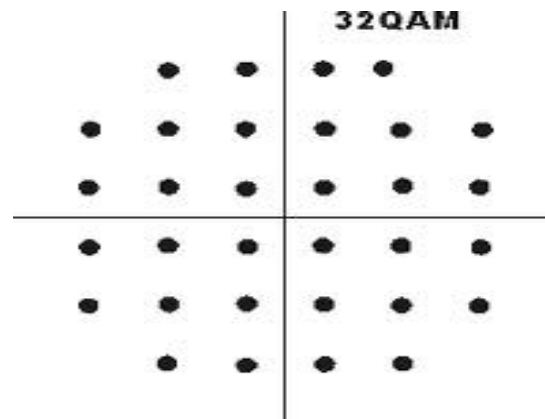
QAM
2 bits / symbol

Constellation Diagrams

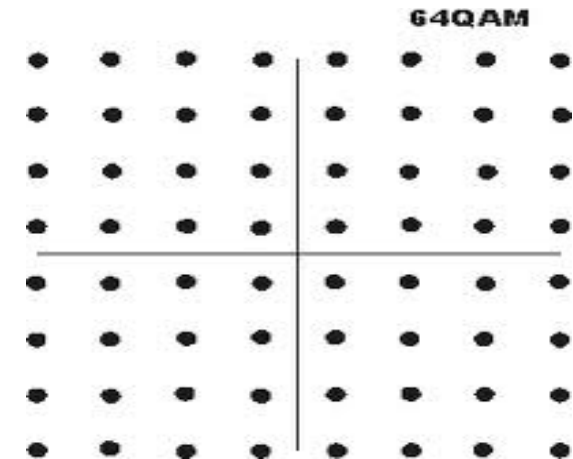
- Order of modulation increases, the number of constellation points increases



4 bits/symbol (2^4 CPs)



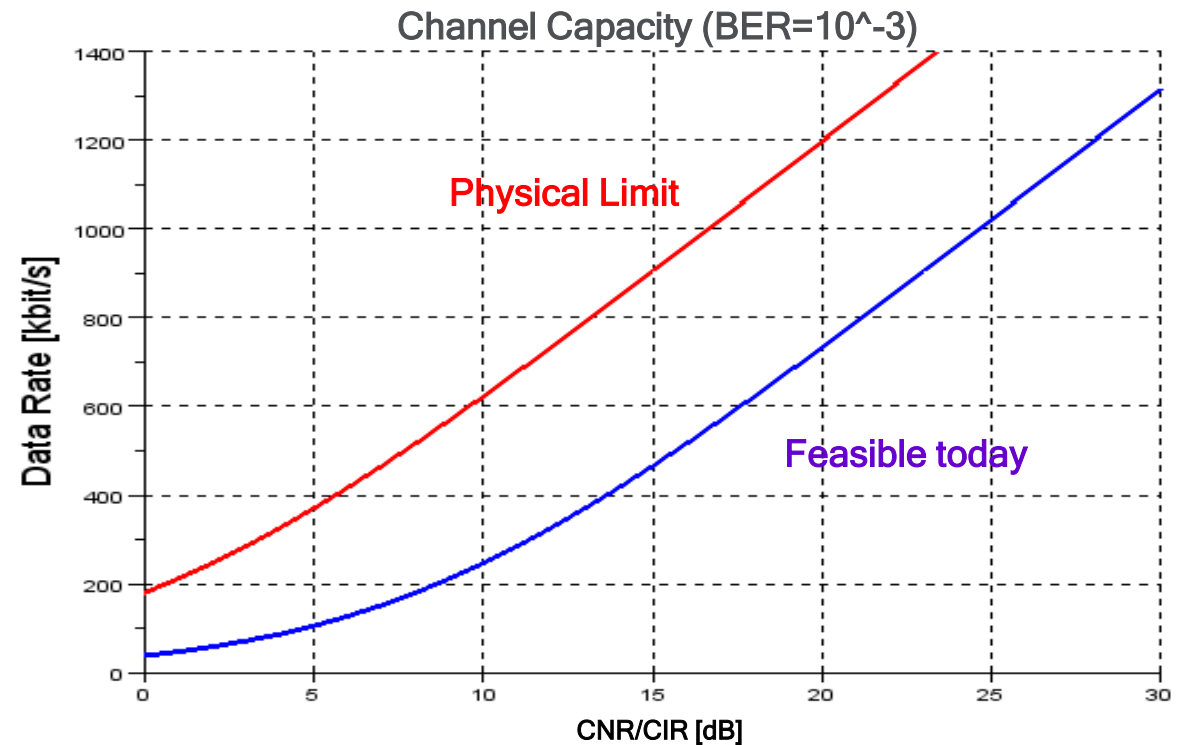
5 bits/symbol (2^5 CPs)



6 bits/symbol (2^6 CPs)

How does it Work - Digital Transmission?

- Narrow RF channel bandwidth of 200kHz (ETSI EN300422)
 - Higher Data Rate requires
 - High CNR/CIR

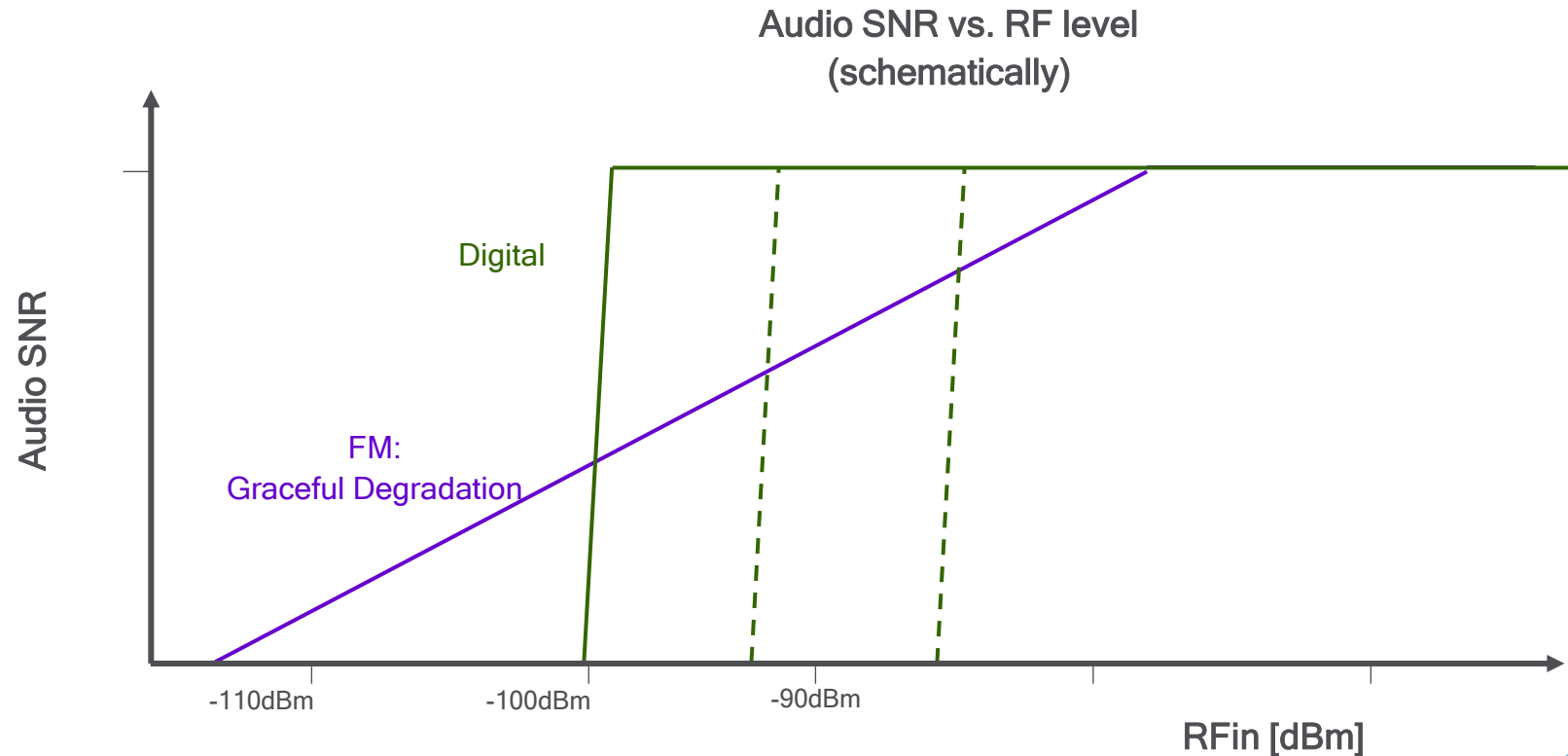


Difference between Analogue and Digital Transmission



Digital Links behave different to FM Links

- FM: Audio SNR depending on receiving field strength
- Digital: Direct changeover from Muting to superior audio



THANK
YOU

Q&A

