Welcome to today's University Business web seminar

Campus-Wide RF: Solutions for our Changing World

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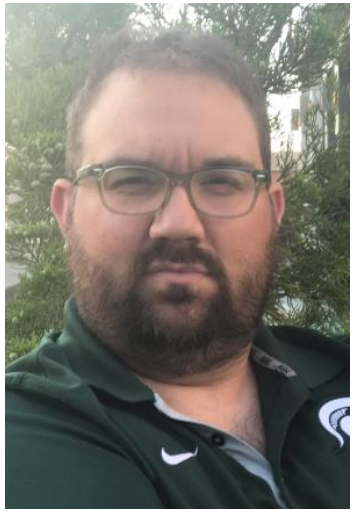
Web Seminar Editor
University Business

David Missall
Customer Development & Application Engineering
Sennheiser

Chris Phillips
Customer Development & Application Engineering
Sennheiser



Greg Koerner
Manager of Digital Classroom Services
Michigan State University Information Technology

Kenneth Fountain
Audio/Visual Engineer
Michigan State University

Thank you for joining us! The web seminar will start promptly at 2:00 ET.

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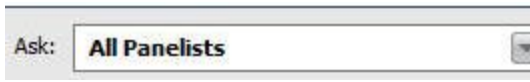

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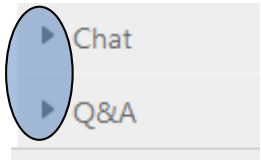

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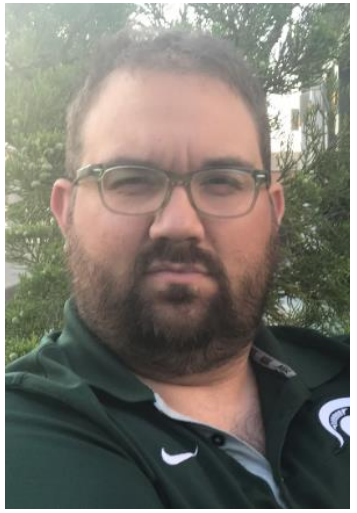

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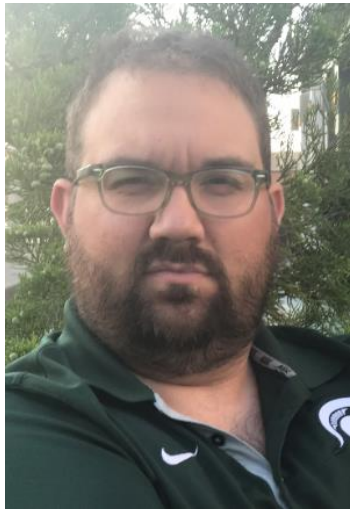

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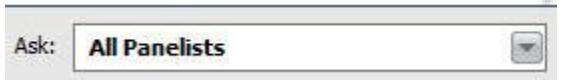

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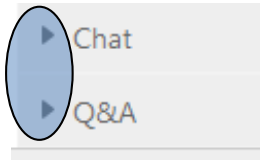

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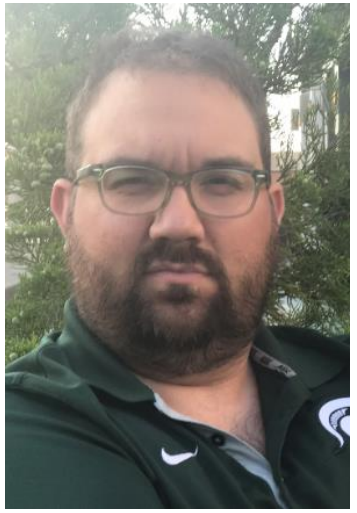

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CUSTOMER DEVELOPMENT & APPLICATIONS ENGINEERING/MICHIGAN STATE UNIVERSITY

Wireless Microphones in the Campus Environment

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Agenda

Wireless Microphone Basics

Wireless Microphone Components
RF Theory
Frequencies for Wireless Microphones
Analog, Digital, and DECT

System Planning and Design

Management Tools for Wireless Microphones

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Wireless Microphone Basics

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Components of Wireless Microphones

- **Microphone** – A transducer that takes sound waves and turns them into an electronic audio signal
- **Radio Transmitter** – A device that takes an electronic audio signal and converts it to a radio signal
- **Antennas** – A conduit that generates or captures a radio wave
- **Radio Receiver** – A device that takes a radio signal and converts it to an electronic audio signal
- **Radio Transceiver** – In some systems devices can both send and receive radio signals

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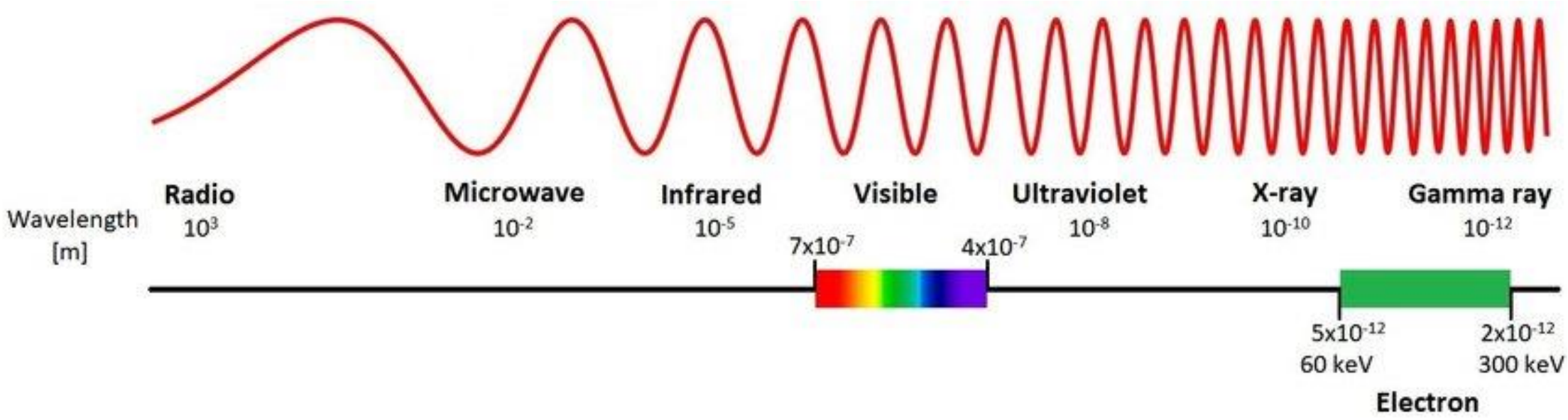
Waves – A closer look

- **Sound Waves**– (Mechanical waves) that propagate through a physical medium (i.e. air, water, solid objects, or plasma)

- **Radio Waves** – (Electromagnetic waves) charged particles and don't need a physical medium to propagate.



Waves and Frequencies - Wireless Microphones

- **Wave Propagation** – Longer wavelengths are able to pass through and around physical barriers easier than shorter wavelengths.
- **Reflection** – Shorter wavelengths reflect off structure more than longer wavelengths.
- **Range**– Shorter wavelengths require more power to cover the same distance as longer wavelengths. (Shorter – More Power)
- **Cable Loss**– Shorter wavelengths have more loss than longer wavelengths over the same distance of 50 Ohm cable.
- **Antenna Length** – Longer Wavelengths require longer antennas than Shorter Wavelengths.

Effects of Physical Structure on RF

- **Highly Reflective** – Metal Structure, Underground
- **Reflective** – Concrete, Masonry, Stone
- **Partially Transparent** – Wood, Drywall, Windows*
- **Transparent** – Outdoor Environments

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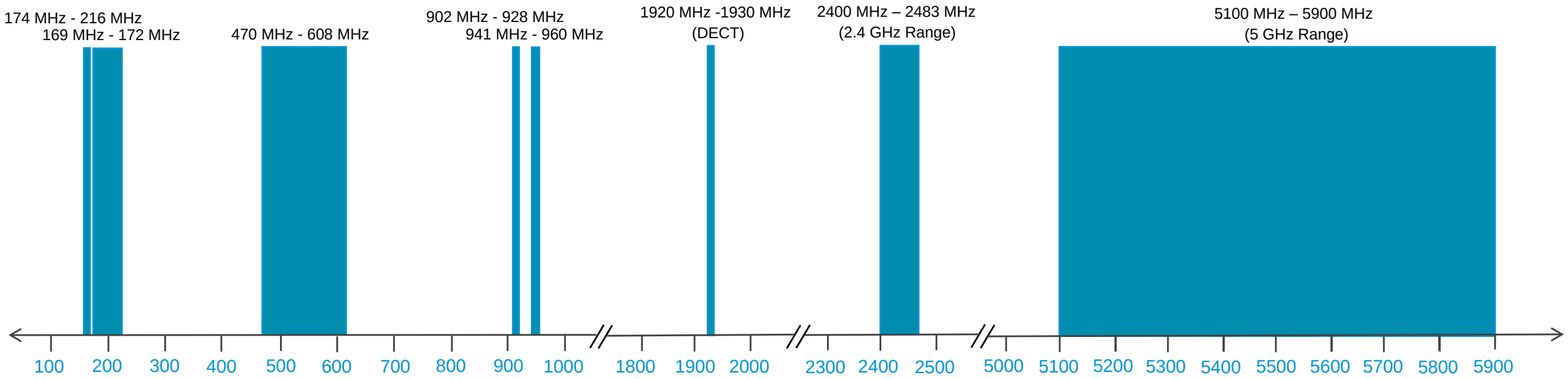
Frequency Ranges For Wireless Microphones (North America)



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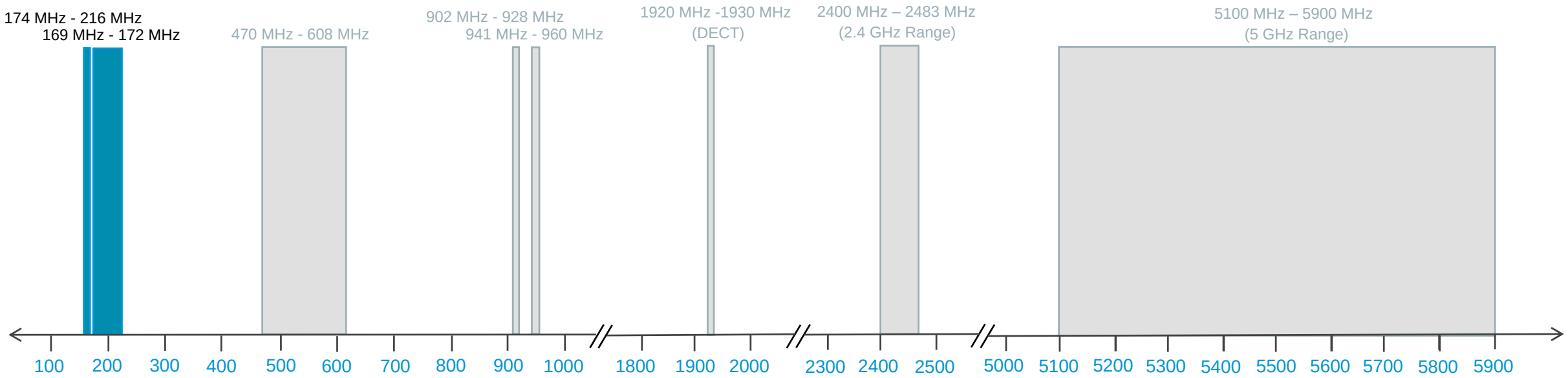
Frequency Ranges For Wireless Microphones (North America)



VHF (169 MHz-172 MHz, 174–216 MHz)

- Good wave propagation, Longer antennas than UHF
- Interference from DTV similar to UHF

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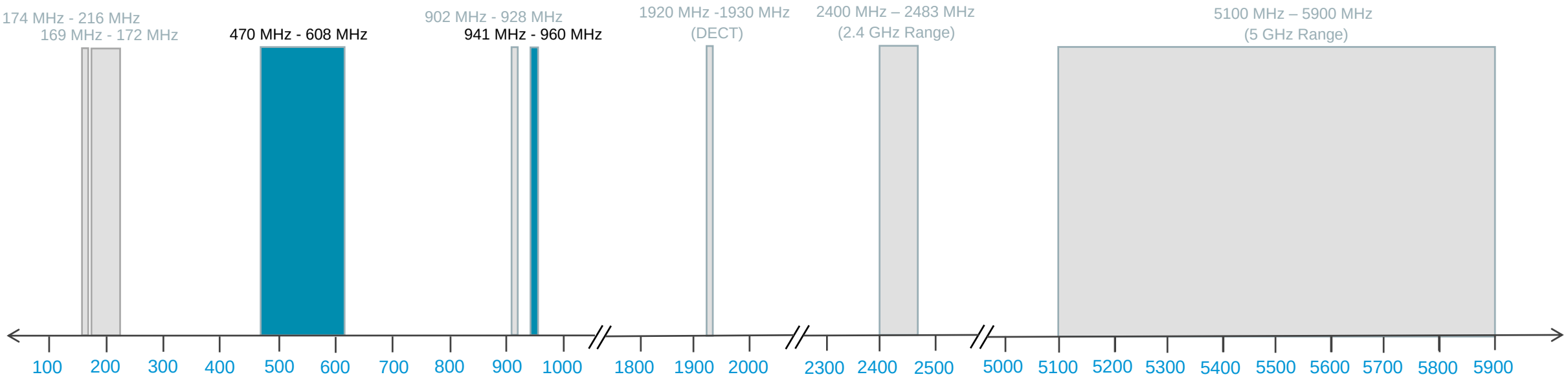
Frequency Ranges For Wireless Microphones (North America)



UHF (470-608 MHz), **STL Band** (941 MHz-960 MHz)

- Good wave propagation, Reasonable antenna length
- Interference from DTV re-packing requires frequency planning/Unlicensed WSD (White Space Devices)
- 50mW maximum RF transmission power in US, Typical 10mW – 30 mW

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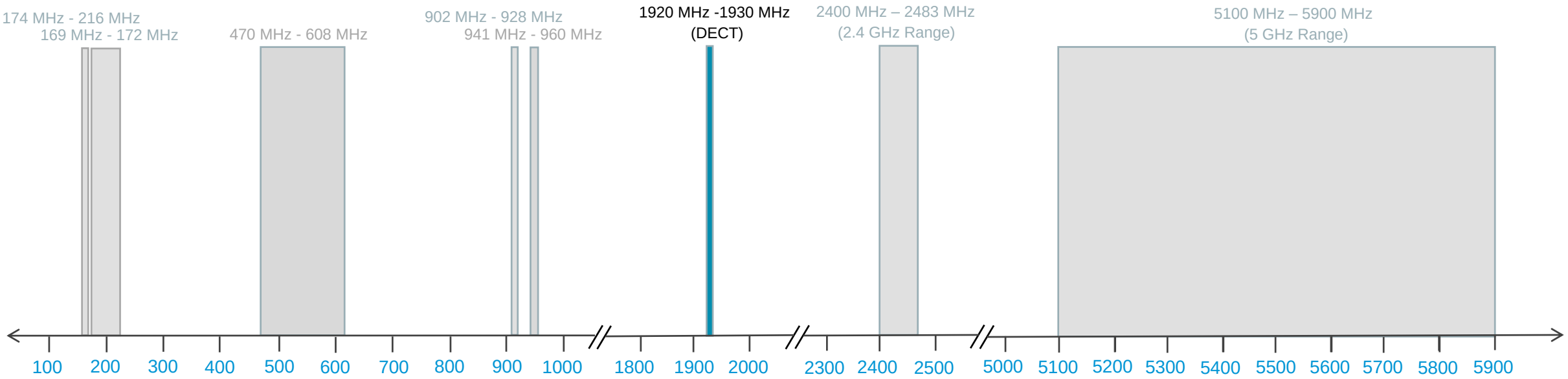
Frequency Ranges For Wireless Microphones (North America)



DECT (1920-1930 MHz US, 1880-1900 MHz Europe, Some contries use 1910-1930 MHz)

- More reflective than UHF signals
- Bi-Directional communication between mobile and stationary devices, coordinates frequencies automatically
- 250mW maximum RF transmission power in US, can adjust power down to low levels (example 0.3mW)

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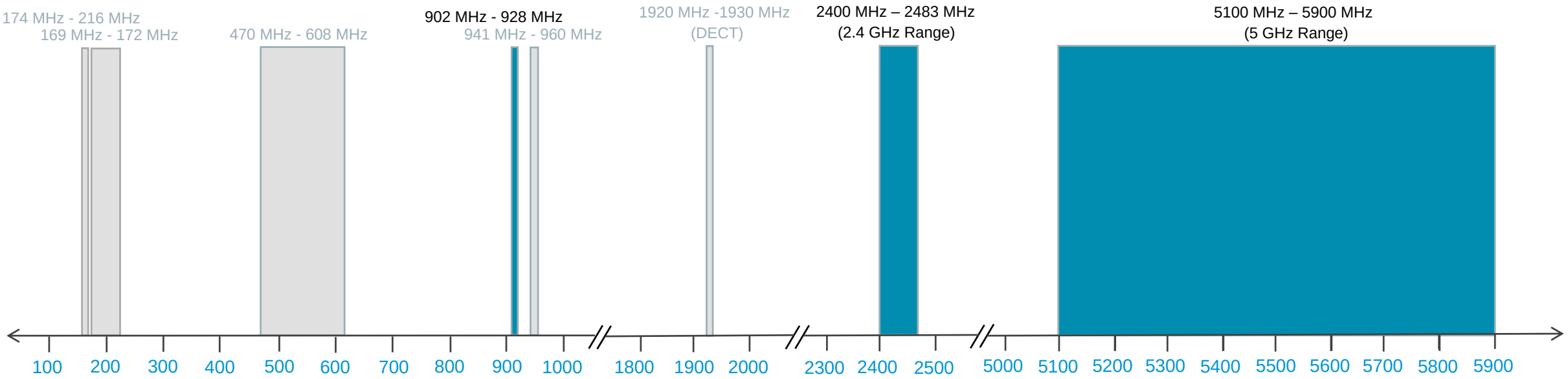
Frequency Ranges For Wireless Microphones (North America)



Unlicensed Bands

- WiFi traffic in the 2.4 and 5 GHz ranges make wireless mic operation unpredictable
- Amateur radio and consumer devices are common in the 902 – 928 MHz range
- With the expansion of IOT, these ranges are becoming more congested

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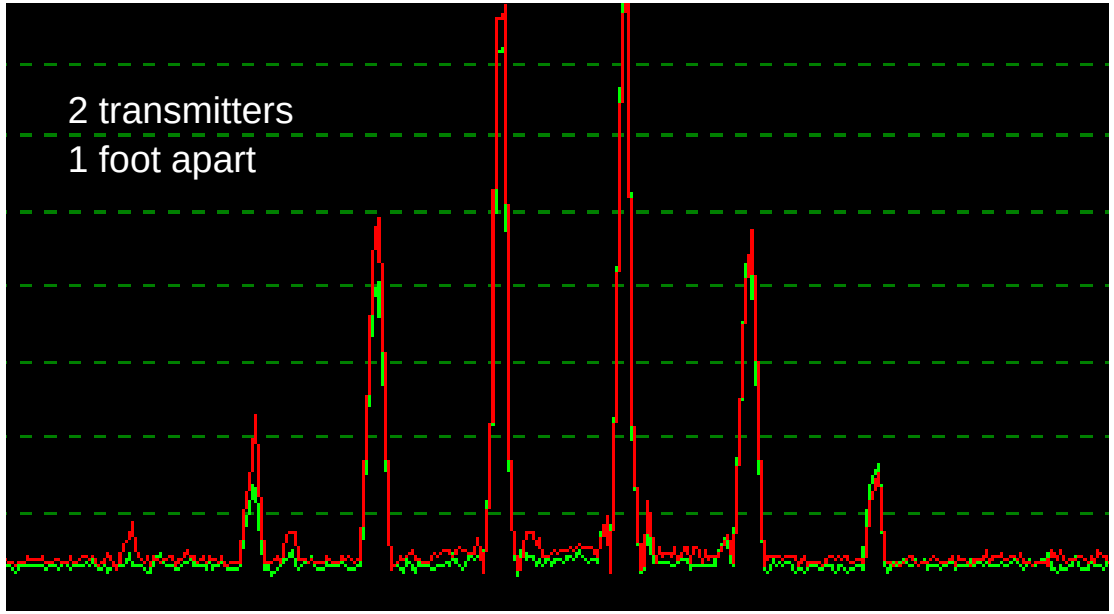
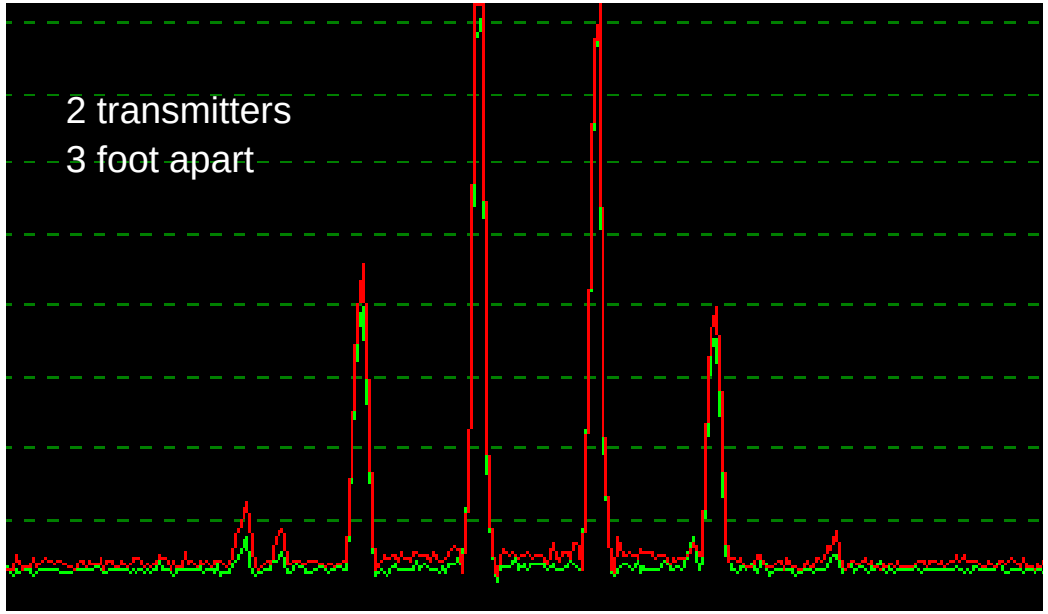
Interference from Intermodulation

- **Intermodulation** – When two or more wireless microphone transmitters are operating too close to one another the electronic components can be overdriven to create a type of interference called **intermodulation**.
- We can predict which frequencies intermodulation might occur on and choose frequencies that avoid interference.

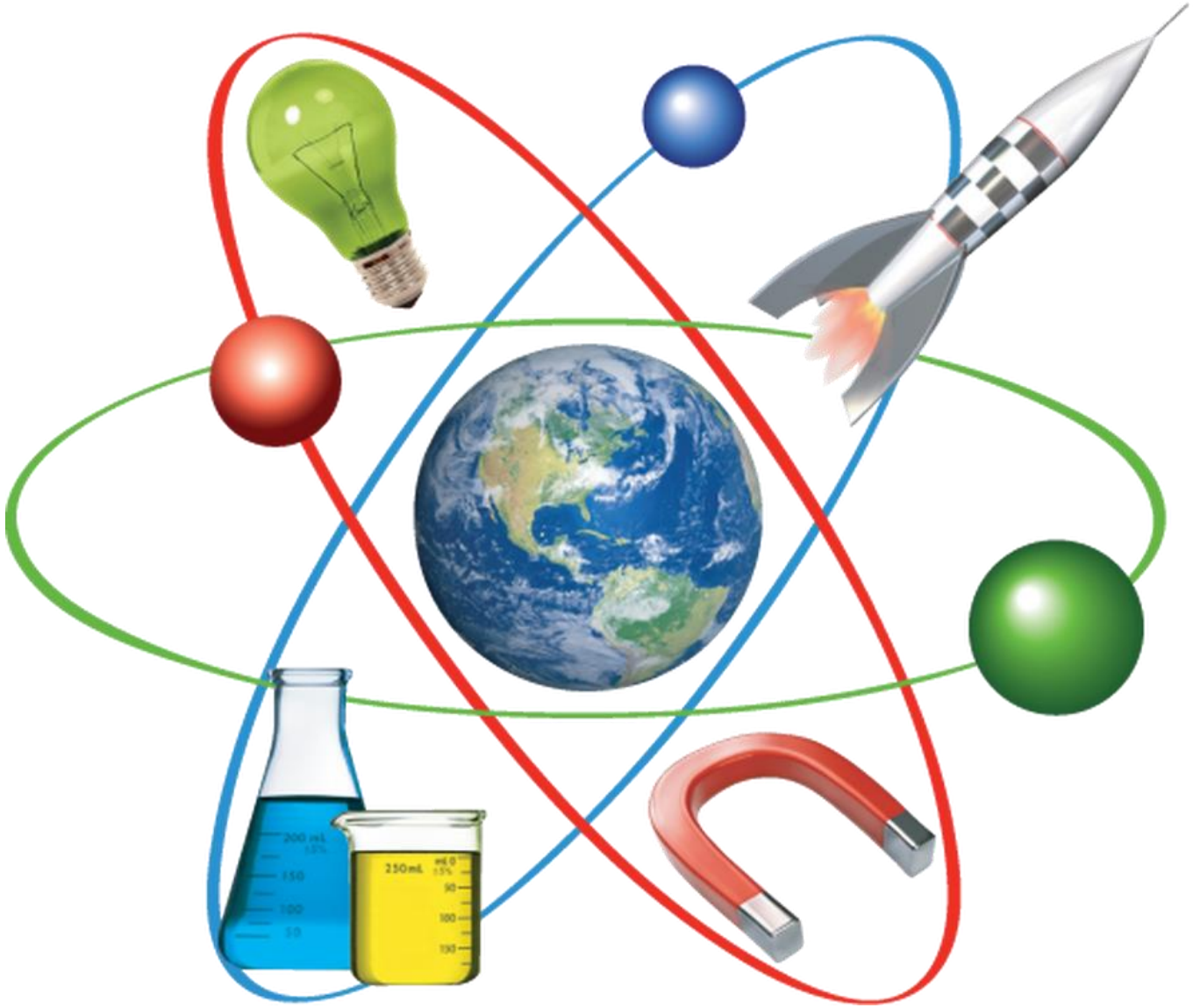
Frequency 1	**500.000 MHz**
Frequency 2	**501.000 MHz**
2nd Order	1000 MHz
2nd Order	1002 MHz
Lower 3rd	499.000 MHz
Upper 3rd	502.000 MHz
Lower 5th	498.000 MHz
Upper 5th	503.000 MHz





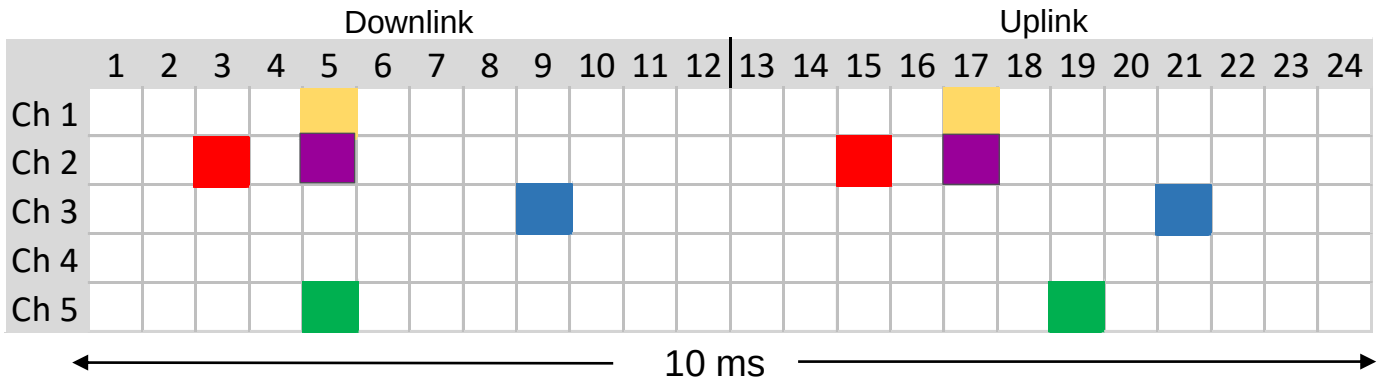
Science Experiment

- Intermodulation
- UHF Analog and Digital



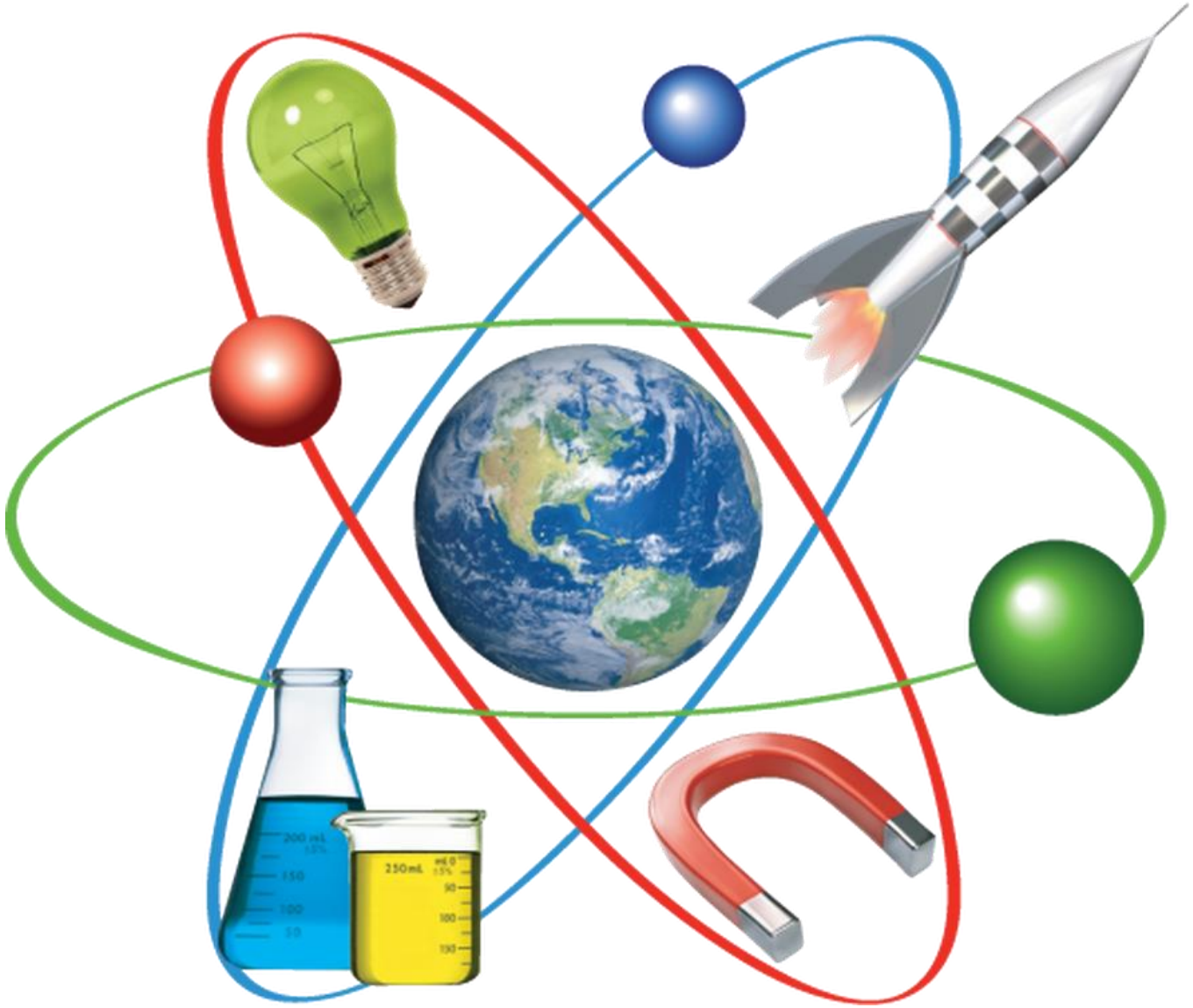
1.9 GHz DECT Wireless Microphones

- **DECT – „D**igital **E**nhanced **C**ordless **T**elecommunications“
- **In North America** DECT devices operate between 1920 and 1930 MHz (10 MHz)
- **Five** channels (in North America)
- **Bi-directional** communication
- **TDMA**
  - Time Division Multiple Access
  - Allows for multiple devices to share the same channel by dividing the signal into different time slots
  - Latency



Science Experiment

- DECT



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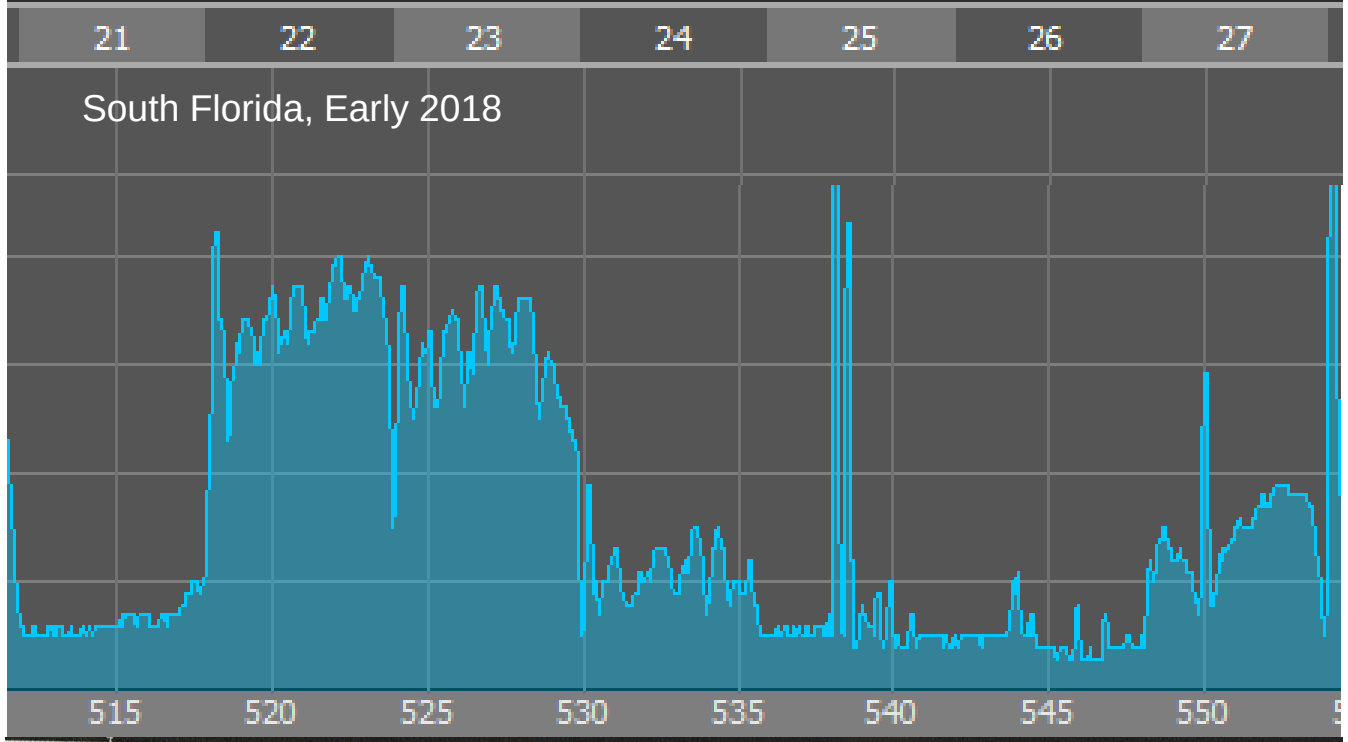
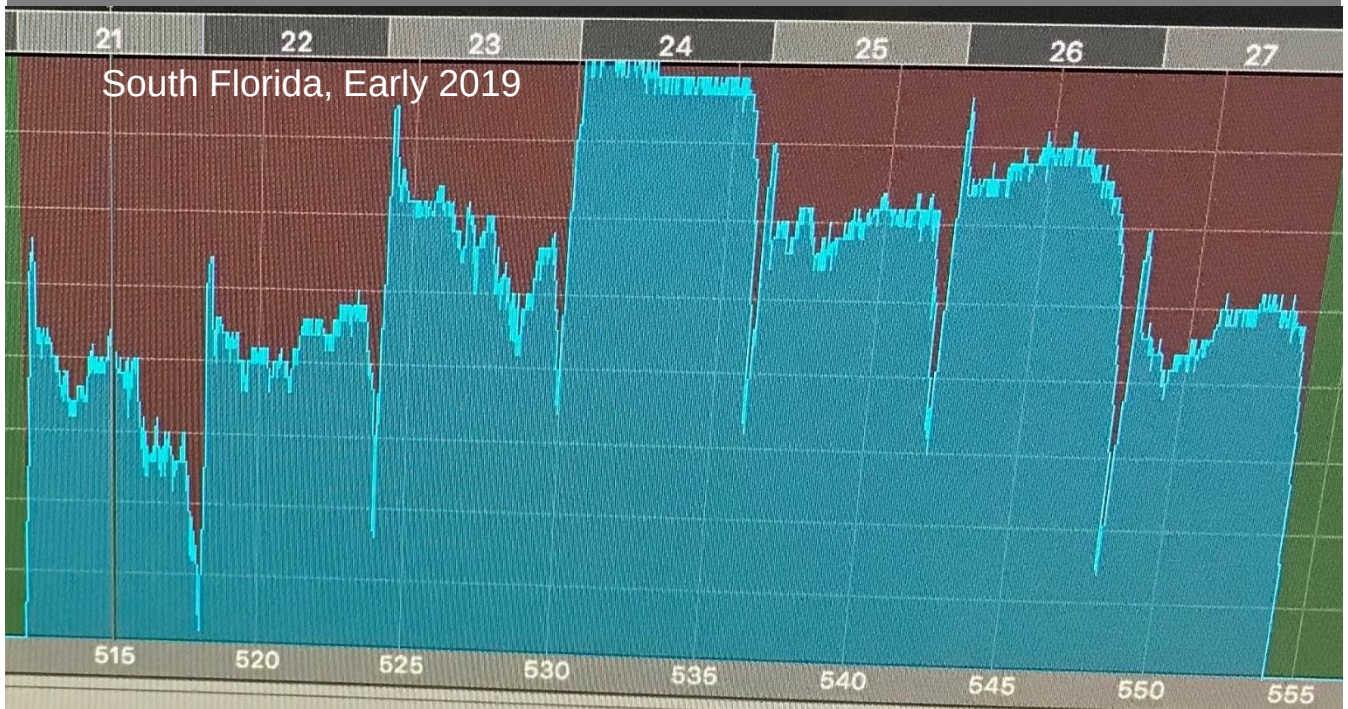
Frequency Planning
DTV (Digital Television)

- Varies by market
- Each DTV channel is 6 MHz wide in the US





Frequency Planning
DTV (Digital Television)

- Varies by market
- Each DTV channel is 6 MHz wide
- Changes with new regulations
- **Resources**
  - FCC's **DTV Reception Map**

https://www.fcc.gov/media/engineering/dtvmaps

DTV Coverage

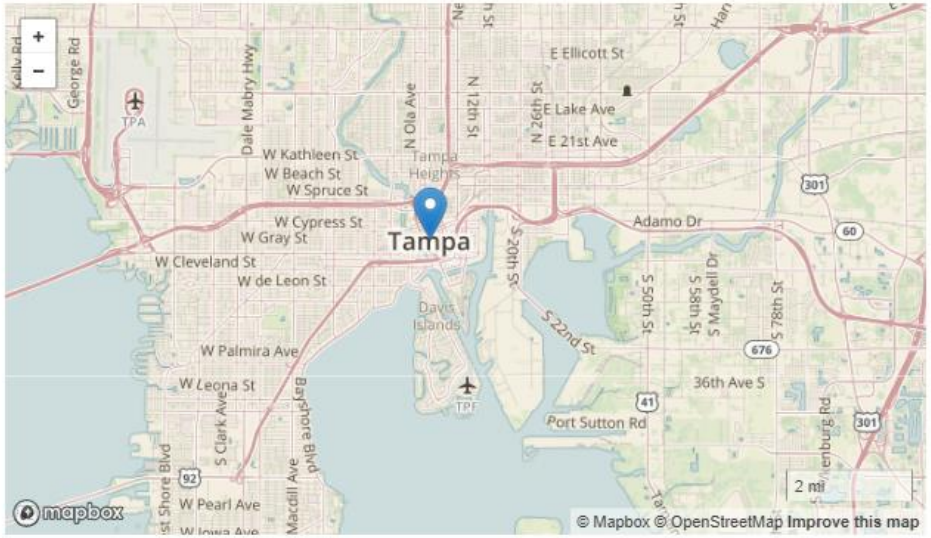
Signal Legends

Strong	Moderate	Weak	No Signal

Incentive Auction (IA) Information

Mouse over the letter for more details about that callsign.

Callsign	Network	Ch#	Band	IA
Click on callsign for detail				
WCLF	IND	22	UHF	
WMOR-TV	IND	32	UHF	R
WVEA-TV	UNIM	50	UHF	R
WFTT-TV	UNIV	62	UHF	
WEDQ	PBS	16	UHF	OS
WTOG	THE	44	UHF	R
WFTS-TV	ABC	28	UHF	R
WXPX-TV	ION	66	UHF	R
WTSP	CBS	10	Hi-V	
WTVT	FOX	13	Hi-V	
WFLA-TV WTTA	NBC MyNe	8 38	Hi-V	R
WEDU	PBS	3	Hi-V	
WARP-CD			UHF	R
WWSB	ABC	40	UHF	
WRMD-CD			UHF	R
WSVT-LD			UHF	
WSPF-CD			UHF	R
WXAX-CD			UHF	
WZRA-CD			UHF	R



Please note:

These predictions are based on a terrain-sensitive propagation model resembling but not identical to the propagation model used when calculating service and interference contours for licensed broadcast television stations. Actual signal strength may vary based on a variety of factors, including, but not limited to, building construction, neighboring buildings and trees, weather, and specific reception hardware. Your signal strength may be significantly lower in extremely hilly areas. Click on a callsign for details about that station's Incentive Auction repacking plans.

Frequency Planning

- **Built in Tools**
  - Walk Test
  - Built in Scanning
  - Pre-coordinated Frequencies
- **Monitoring** and **Coordination** Software
  - Wireless Systems Manager
  - SIFM (Sennheiser Intermodulation Frequency Manager)
- **RF Scanner** these can vary in different types, feature sets and price points.
  - RF Explorer: $200
  - Signal Hound: $1000
  - Tektronix RSA306: $3000

Channel	Bank 1	Bank 2	Bank 3	Bank 4	Bank 5	Bank 6	Bank 7	Bank 8	Bank 9	Bank 10
1	470,100	476,100	488,100	494,100	500,100	506,100	470,200	488,200	476,200	488,400
2	470,500	476,500	488,500	494,500	500,500	506,500	470,600	488,600	476,600	488,850
3	471,050	477,050	489,050	495,050	501,050	506,950	471,150	489,150	477,150	489,450
4	471,750	478,200	489,750	495,750	501,750	507,450	471,850	489,850	477,850	490,300
5	472,200	488,100	490,200	496,200	502,200	508,000	472,300	490,700	478,300	490,800
6	472,800	488,600	490,800	496,800	502,800	508,600	472,900	491,300	506,800	491,450
7	473,650	489,450	491,550	497,550	503,600	509,250	473,650	492,600	507,700	492,350
8	474,750	490,050	492,750	498,750	504,800	510,000	474,850	493,050	508,350	493,050
9	475,250	491,050	506,100	499,750	505,650	510,800	506,300	470,250	509,550	493,600
10	506,150	491,800	507,200	471,400	471,700	511,700	508,550	470,750	510,300	471,500
11	506,950	492,250	509,250	473,750	472,450	470,100	509,400	472,250	510,900	473,150
12	511,000	492,900	510,700	474,250	474,350	474,950	511,750	473,050	511,700	474,150
13	508,500	473,200	511,600	475,150	475,650	481,500	504,250	477,750	502,850	485,700
14	512,300	506,150	502,300	475,800	470,250	471,700	503,350	482,900	500,850	484,300
15	514,350	508,250	505,600	470,100	478,050	477,100	501,500	475,500	500,350	483,500
16	515,550	511,800	510,050	504,850	480,300	473,000	504,900	483,950	503,900	476,000

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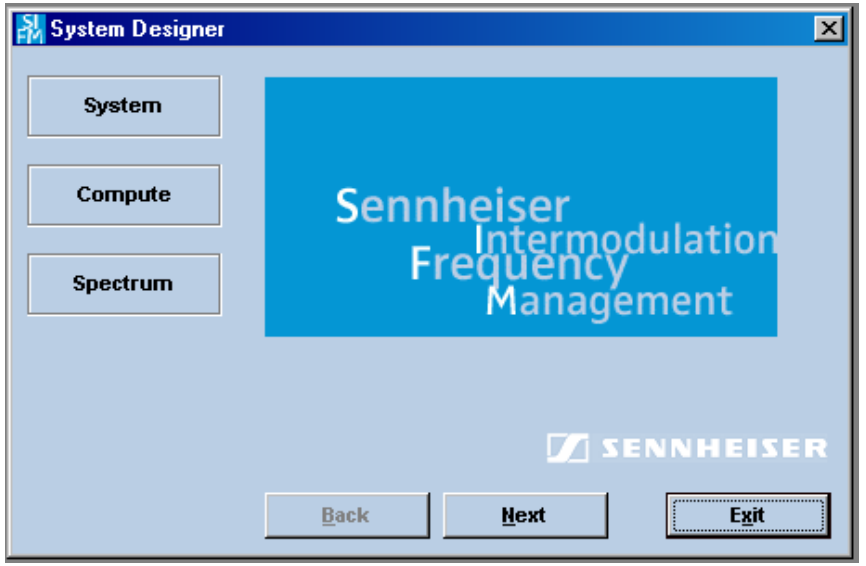
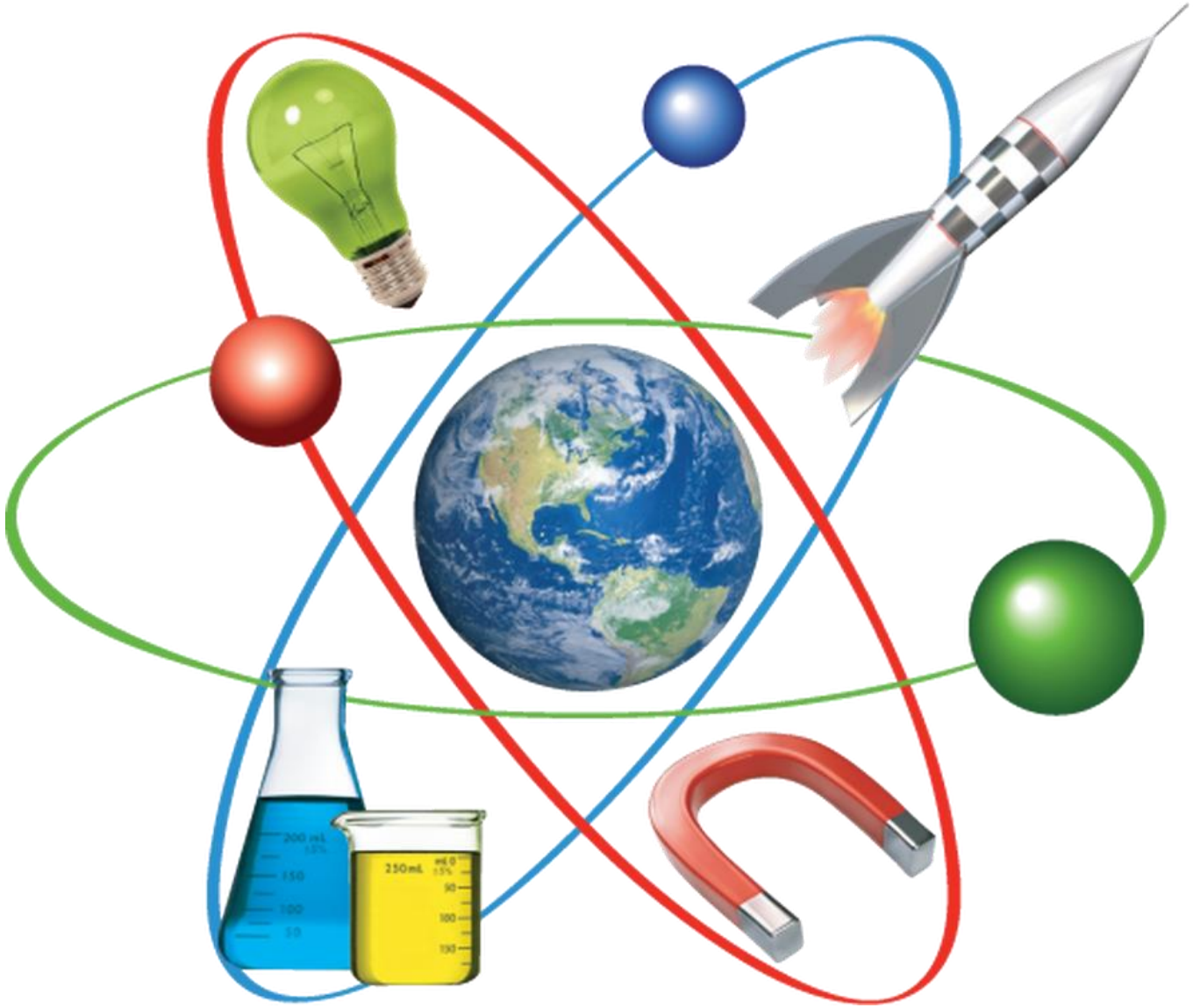


Science Experiment

- Receiver Scan



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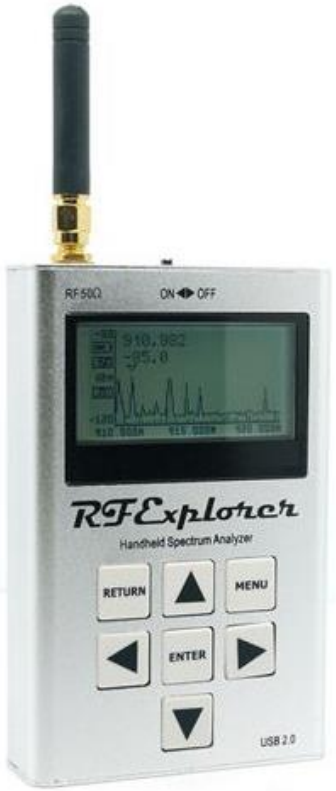


System Design

Remote antennas

- RF cable in a system creates loss between the receiving antenna and the receiver
- Some antennas create gain as part of their design, this can overcome cable loss
- When more than -6dB of cable loss is present the system make become unstable
  - Antenna Gain
  - RF Boosters
- When more than +4 dB of gain is present the receiver can be overdriven
- www.qsl.net/co8tw/Coax_Calculator.htm

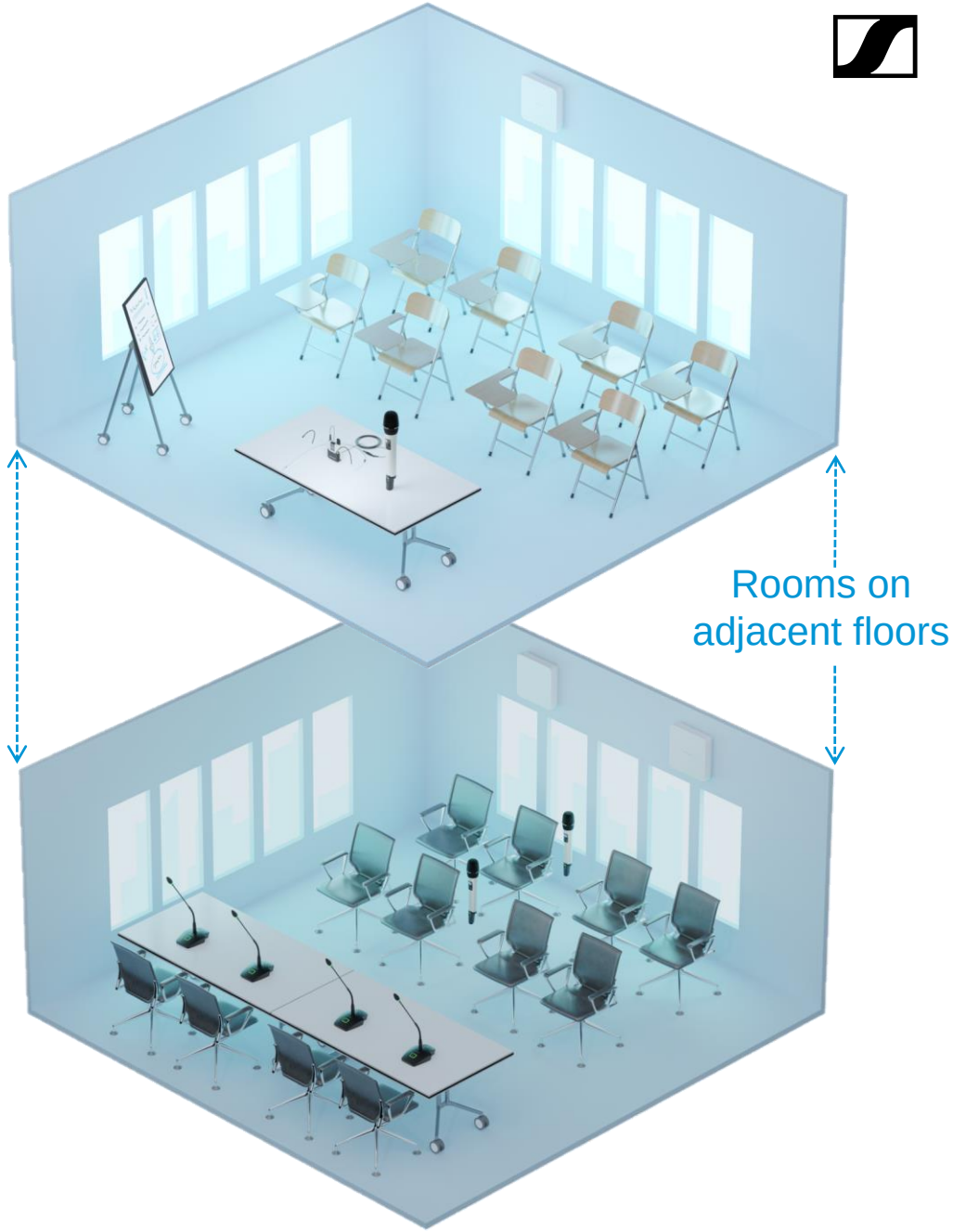
50 Ohm Coaxial Cable Data:

Cable Type	Frequency [MHz]	Attenuation [db/100']	Attenuation [dB/100m]	Cable diameter
RG-174/U	400 700	19.0 27.0	62.3 88.6	0.110 / 2.8
RG-58/U	400 700	9.1 12.8	29.9 42.0	0.195 / 4.95
RG-8X	400 700	6.6 9.1	21.7 29.9	0.242 / 6.15
RG-8/U	400 700	4.2 5.9	13.2 19.4	0.405 / 10.3
RG-213	400 700	4.5 6.5	14.8 21.8	0.405 / 10.3
Belden 9913	400 700	2.7 3.6	8.9 11.8	0.405 / 10.3
Belden 9913F	400 700	2.9 3.9	9.5 12.8	0.405 / 10.3

Zoning Wireless Microphones

UHF Microphones on Adjacent Floors

- **Frequency coordination** - Plan to avoid the primary carriers and IM3 products in rooms on adjacent floors.
- **Reduce transmit power** - set the transmitter RF power to the lowest setting that allows you to walk the entire room without a dropout
- **Localize antennas** - Utilize remote receiving antennas or locate receivers in the room

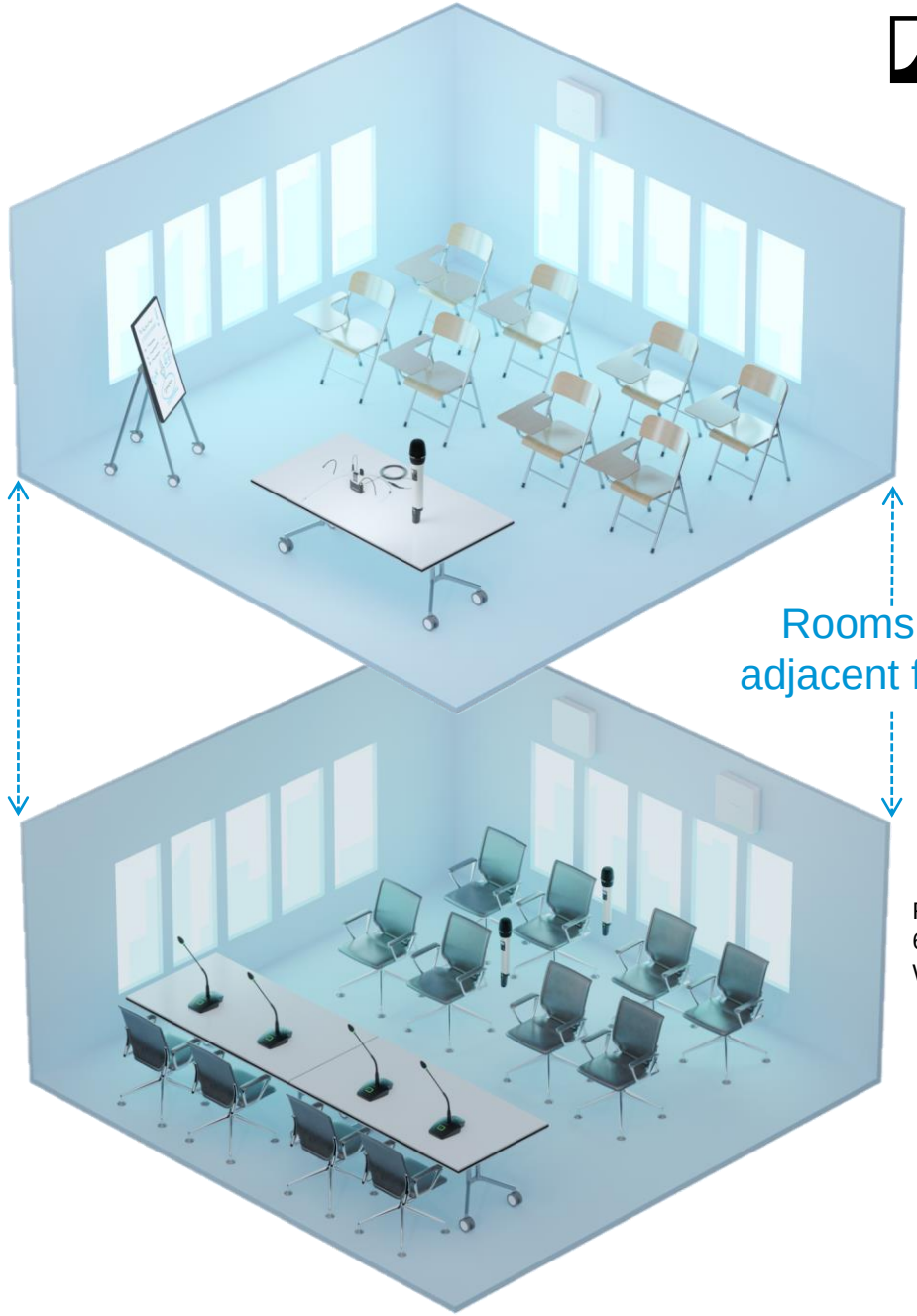


Zoning Wireless Microphones

UHF Microphones on Adjacent Floors

▶ Frequency coordination

Channel	Bank 1	Bank 2	Bank 3	Bank 4	Bank 5	Bank 6	Bank 7	Bank 8	Bank 9	Bank 10
1	470,100	476,100	488,100	494,100	500,100	506,100	470,200	488,200	476,200	488,400
2	470,500	476,500	488,500	494,500	500,500	506,500	470,600	488,600	476,600	488,850
3	471,050	477,050	489,050	495,050	501,050	506,950	471,150	489,150	477,150	489,450
4	471,750	478,200	489,750	495,750	501,750	507,450	471,850	489,850	477,850	490,300
5	472,200	488,100	490,200	496,200	502,200	508,000	472,300	490,700	478,300	490,800
6	472,800	488,600	490,800	496,800	502,800	508,600	472,900	491,300	506,800	491,450
7	473,650	489,450	491,550	497,550	503,600	509,250	473,650	492,600	507,700	492,350
8	474,750	490,050	492,750	498,750	504,800	510,000	474,850	493,050	508,350	493,050
9	475,250	491,050	506,100	499,750	505,650	510,800	506,300	470,250	509,550	493,600
10	506,150	491,800	507,200	471,400	471,700	511,700	508,550	470,750	510,300	471,500
11	506,950	492,250	509,250	473,750	472,450	470,100	509,400	472,250	510,900	473,150
12	511,000	492,900	510,700	474,250	474,350	474,950	511,750	473,050	511,700	474,150
13	508,500	473,200	511,600	475,150	475,650	481,500	504,250	477,750	502,850	485,700
14	512,300	506,150	502,300	475,800	470,250	471,700	503,350	482,900	500,850	484,300
15	514,350	508,250	505,600	470,100	478,050	477,100	501,500	475,500	500,350	483,500
16	515,550	511,800	510,050	504,850	480,300	473,000	504,900	483,950	503,900	476,000

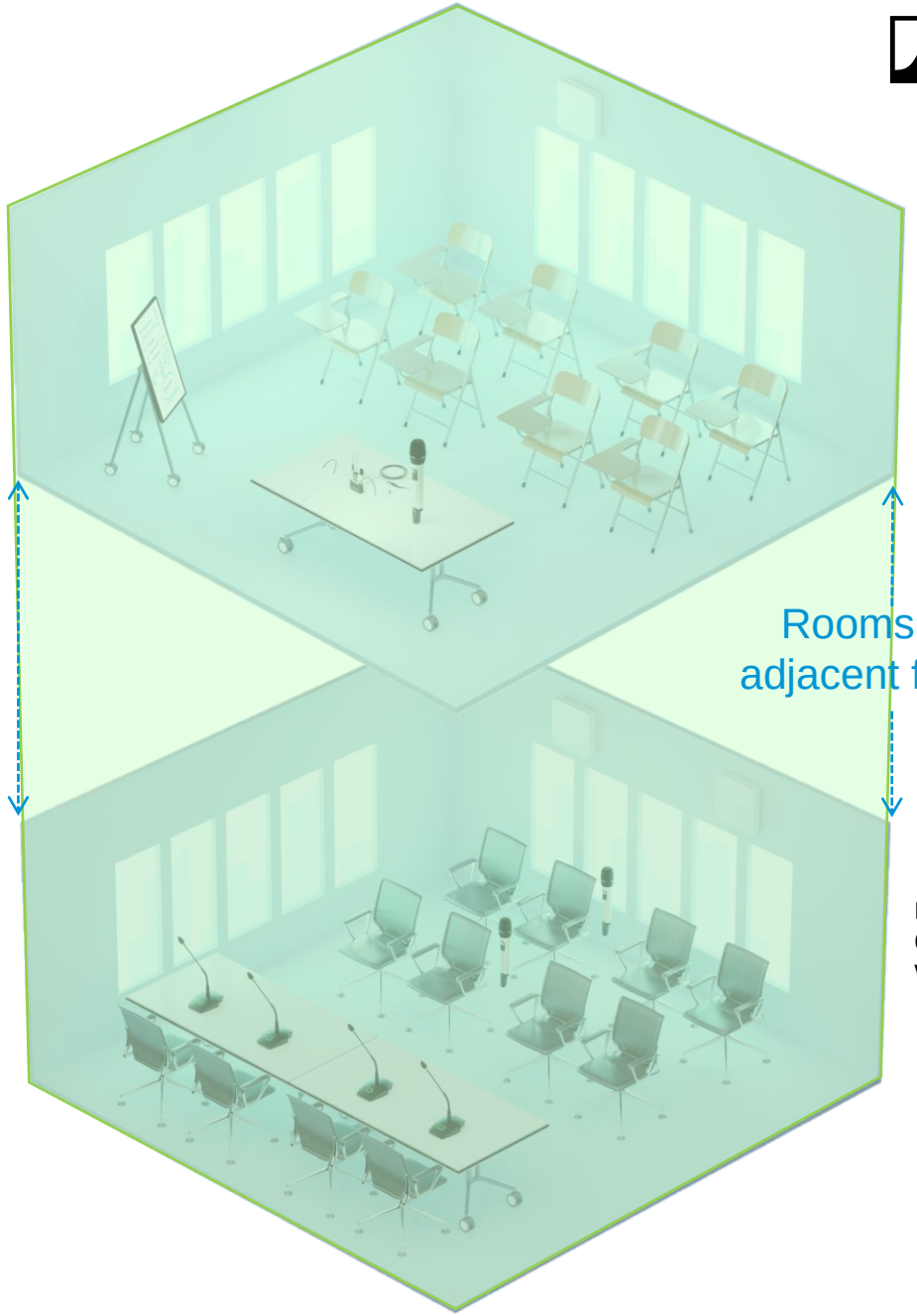


Zoning Wireless Microphones

UHF Microphones on Adjacent Floors

▶ Scan Results

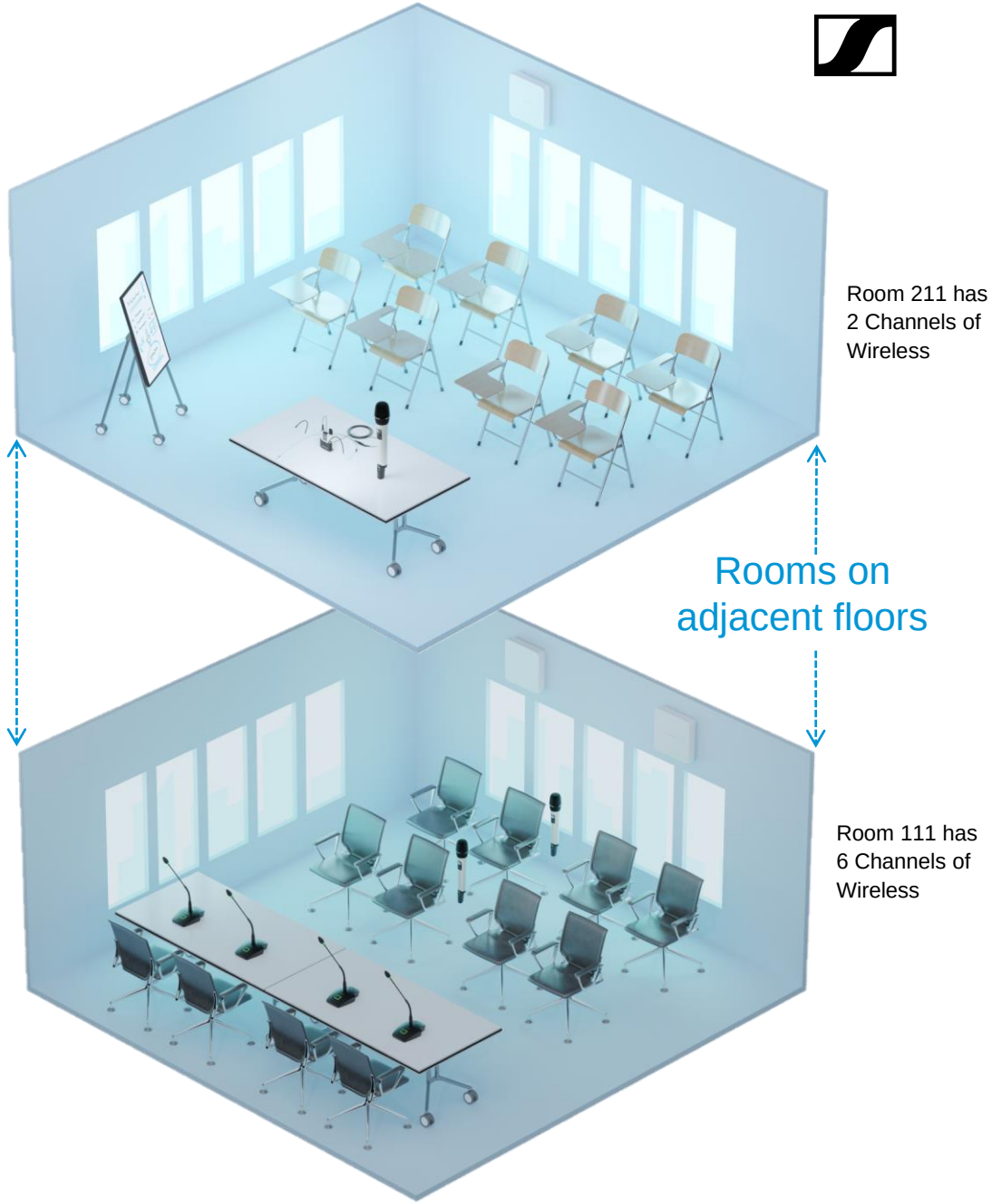
	3	12	11	10	11	2	4	12	9	12
Channel	Bank 1	Bank 2	Bank 3	Bank 4	Bank 5	Bank 6	Bank 7	Bank 8	Bank 9	Bank 10
1	470,100	476,100	488,100	494,100	500,100	506,100	470,200	488,200	476,200	488,400
2	470,500	476,500	488,500	494,500	500,500	506,500	470,600	488,600	476,600	488,850
3	471,050	477,050	489,050	495,050	501,050	506,950	471,150	489,150	477,150	489,450
4	471,750	478,200	489,750	495,750	501,750	507,450	471,850	489,850	477,850	490,300
5	472,200	488,100	490,200	496,200	502,200	508,000	472,300	490,700	478,300	490,800
6	472,800	488,600	490,800	496,800	502,800	508,600	472,900	491,300	506,800	491,450
7	473,650	489,450	491,550	497,550	503,600	509,250	473,650	492,600	507,700	492,350
8	474,750	490,050	492,750	498,750	504,800	510,000	474,850	493,050	508,350	493,050
9	475,250	491,050	506,100	499,750	505,650	510,800	506,300	470,250	509,550	493,600
10	506,150	491,800	507,200	471,400	471,700	511,700	508,550	470,750	510,300	471,500
11	506,950	492,250	509,250	473,750	472,450	470,100	509,400	472,250	510,900	473,150
12	511,000	492,900	510,700	474,250	474,350	474,950	511,750	473,050	511,700	474,150
13	508,500	473,200	511,600	475,150	475,650	481,500	504,250	477,750	502,850	485,700
14	512,300	506,150	502,300	475,800	470,250	471,700	503,350	482,900	500,850	484,300
15	514,350	508,250	505,600	470,100	478,050	477,100	501,500	475,500	500,350	483,500
16	515,550	511,800	510,050	504,850	480,300	473,000	504,900	483,950	503,900	476,000



Zoning Wireless Microphones

DECT Microphones on Adjacent Floors

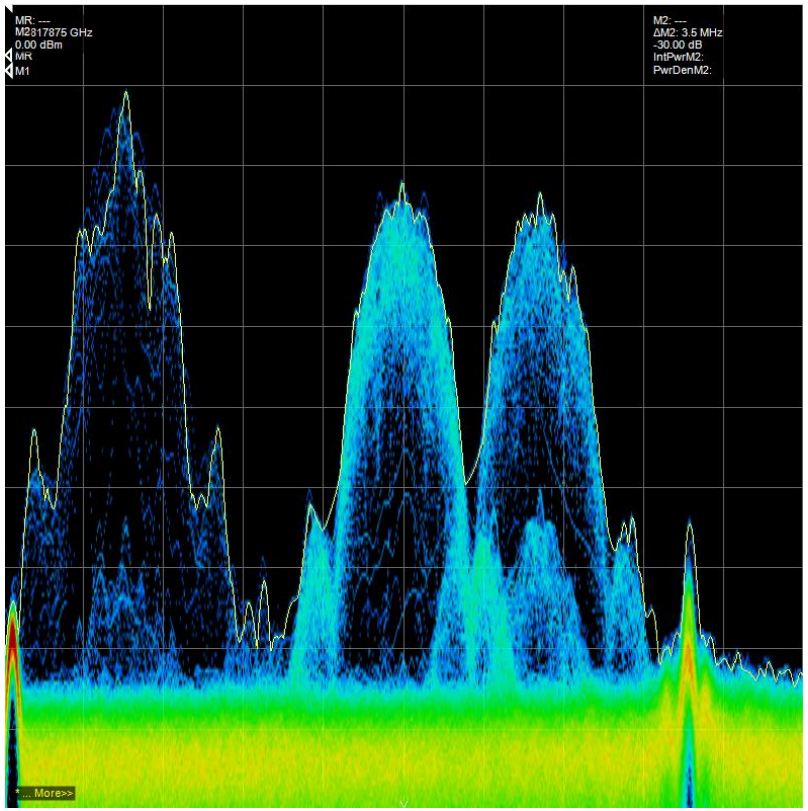
- **Frequency coordination** – DECT microphones coordinate frequencies automatically. There will be a maximum specified per room by the manufacturer
- **Reduce transmit power** - set the transmitter to the lowest setting that allows you to walk the entire room without a dropout. RF should drop when you leave the room.
- **Localize** - Mobile and Stationary devices should have a line of sight to each other.

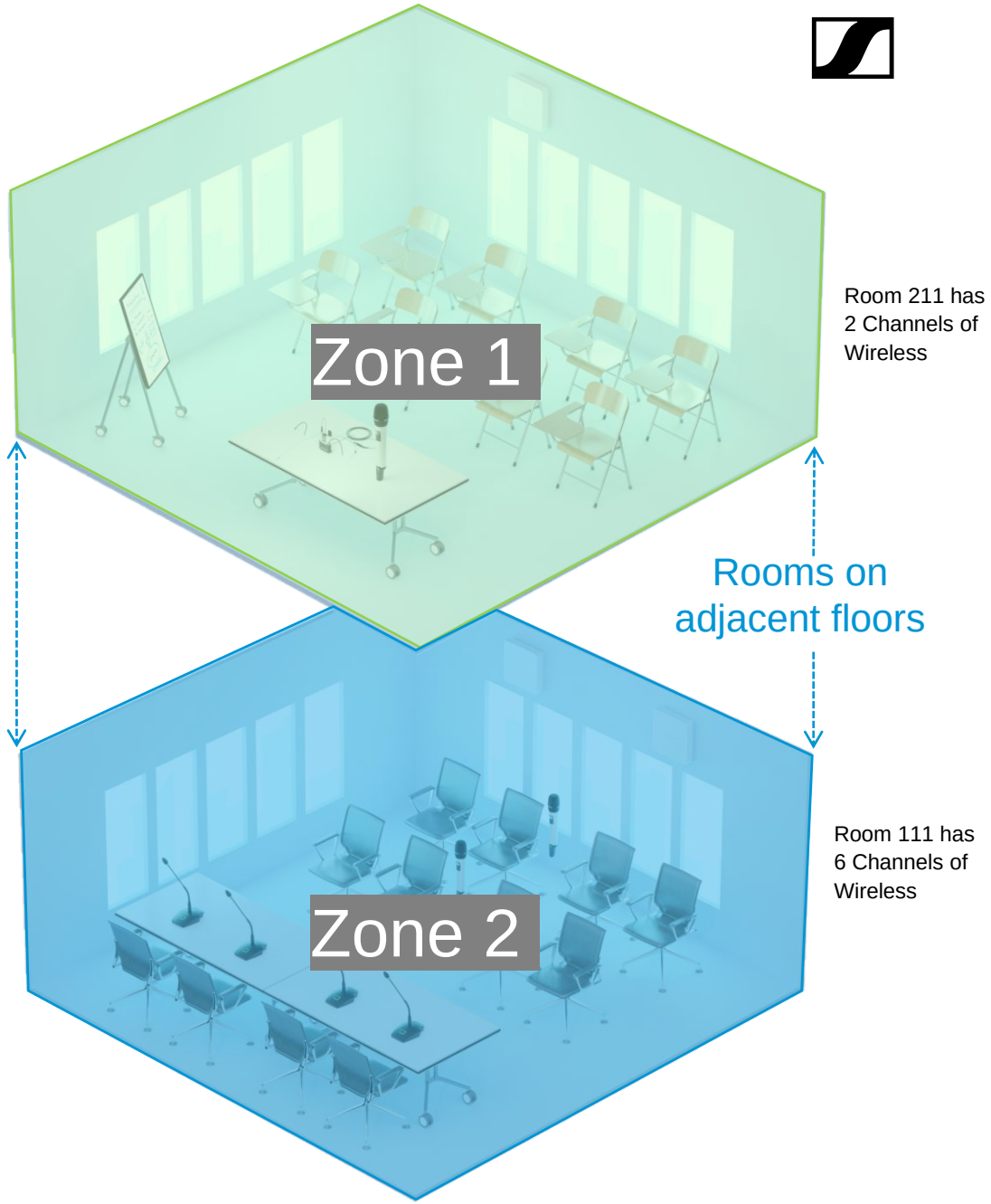


Zoning Wireless Microphones

DECT Microphones on Adjacent Floors

- When RF energy is adjusted to remain inside the room, each space becomes an independent zone

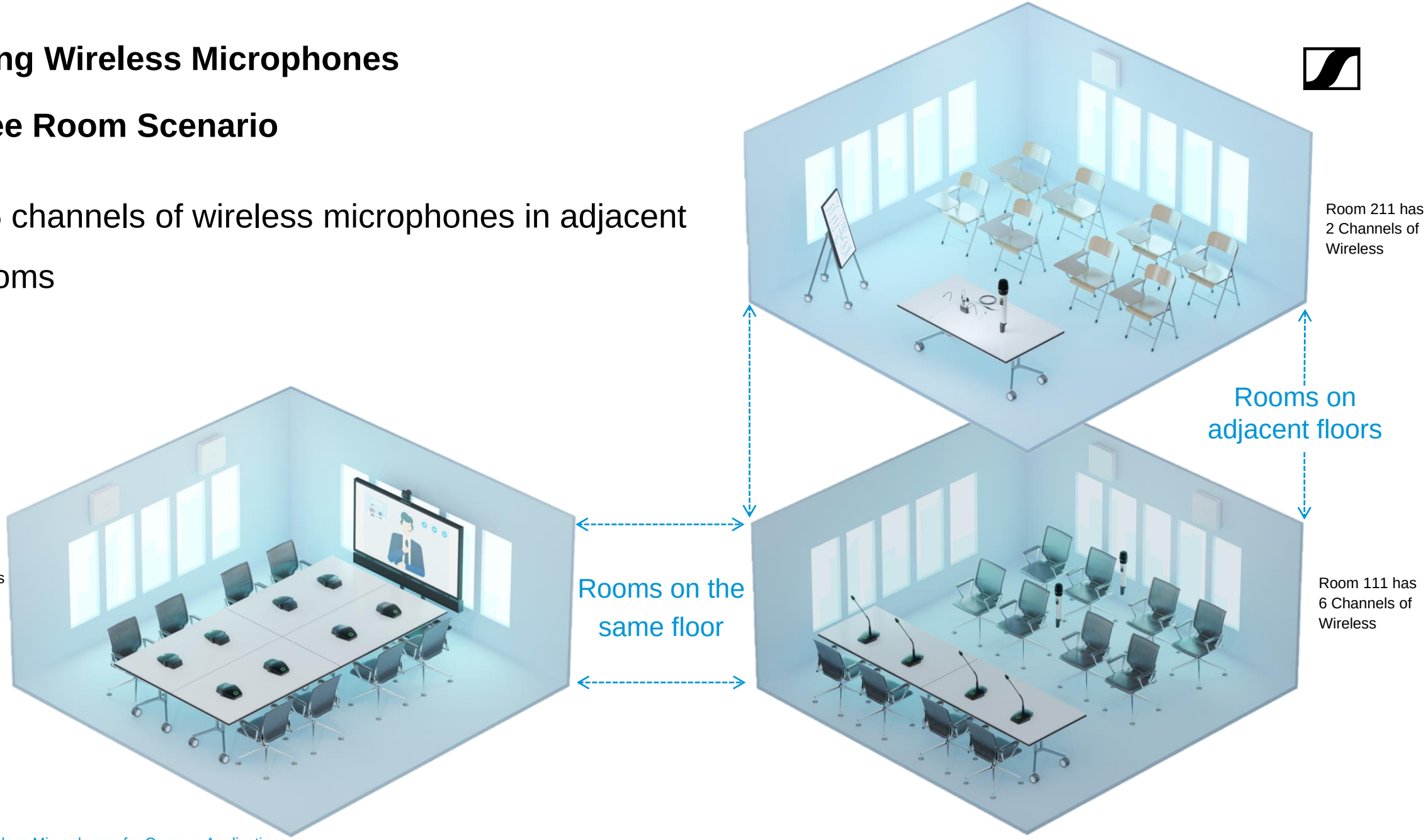




Zoning Wireless Microphones

Three Room Scenario

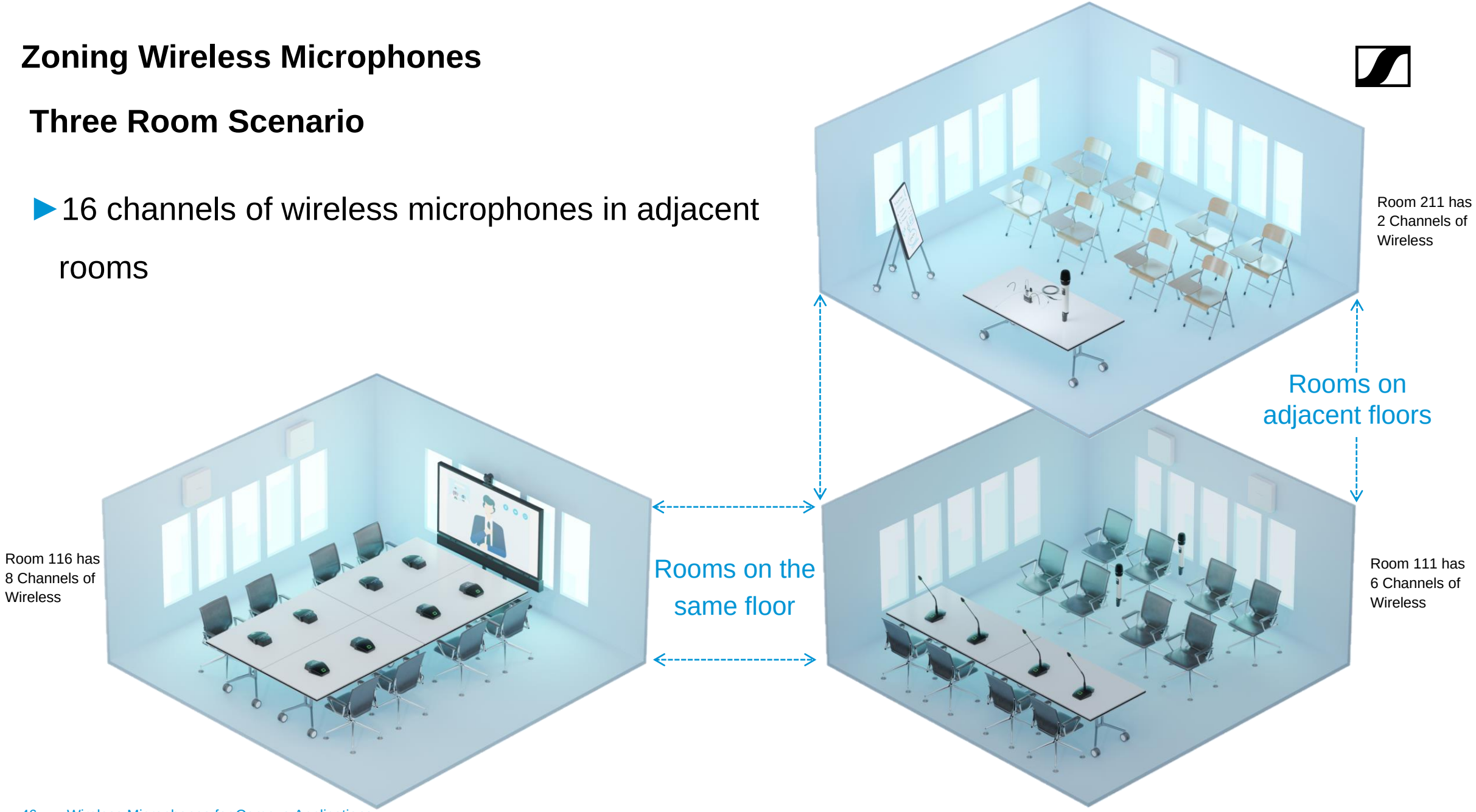
- 16 channels of wireless microphones in adjacent rooms



Zoning Wireless Microphones

Three Room Scenario

- 16 channels of wireless microphones in adjacent rooms



Zoning Wireless Microphones

Three Room Scenario

- In this scenario none of the banks provide enough channels to safely coordinate all three room
  - We can create custom frequency coordination
  - An easier solution may be to install a different frequency range in one of the three rooms

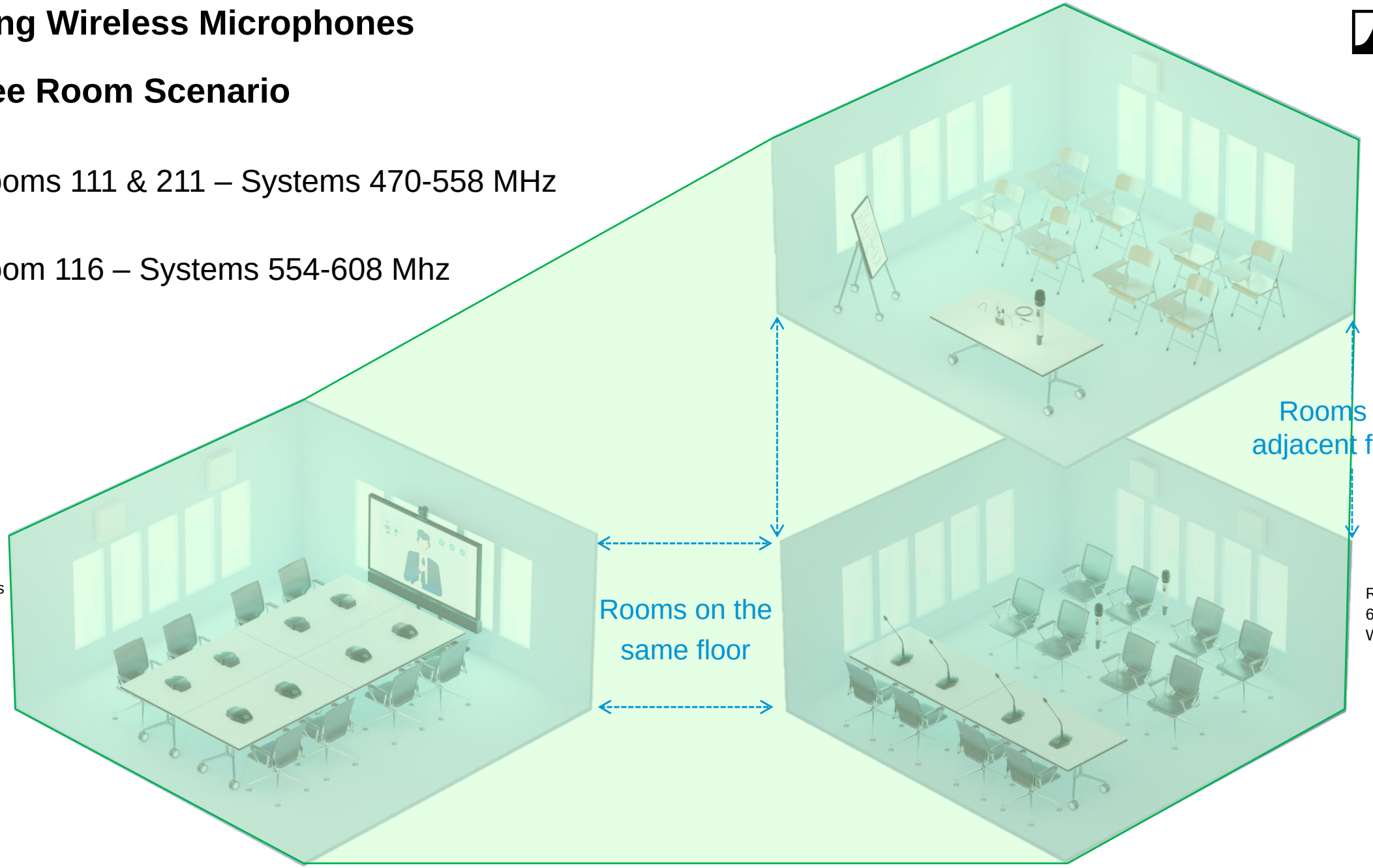
Scan Results

	3	12	11	10	11	2	4	12	9	12
Channel	Bank 1	Bank 2	Bank 3	Bank 4	Bank 5	Bank 6	Bank 7	Bank 8	Bank 9	Bank 10
1	470,100	476,100	488,100	494,100	500,100	506,100	470,200	488,200	476,200	488,400
2	470,500	476,500	488,500	494,500	500,500	506,500	470,600	488,600	476,600	488,850
3	471,050	477,050	489,050	495,050	501,050	506,950	471,150	489,150	477,150	489,450
4	471,750	478,200	489,750	495,750	501,750	507,450	471,850	489,850	477,850	490,300
5	472,200	488,100	490,200	496,200	502,200	508,000	472,300	490,700	478,300	490,800
6	472,800	488,600	490,800	496,800	502,800	508,600	472,900	491,300	506,800	491,450
7	473,650	489,450	491,550	497,550	503,600	509,250	473,650	492,600	507,700	492,350
8	474,750	490,050	492,750	498,750	504,800	510,000	474,850	493,050	508,350	493,050
9	475,250	491,050	506,100	499,750	505,650	510,800	506,300	470,250	509,550	493,600
10	506,150	491,800	507,200	471,400	471,700	511,700	508,550	470,750	510,300	471,500
11	506,950	492,250	509,250	473,750	472,450	470,100	509,400	472,250	510,900	473,150
12	511,000	492,900	510,700	474,250	474,350	474,950	511,750	473,050	511,700	474,150
13	508,500	473,200	511,600	475,150	475,650	481,500	504,250	477,750	502,850	485,700
14	512,300	506,150	502,300	475,800	470,250	471,700	503,350	482,900	500,850	484,300
15	514,350	508,250	505,600	470,100	478,050	477,100	501,500	475,500	500,350	483,500
16	515,550	511,800	510,050	504,850	480,300	473,000	504,900	483,950	503,900	476,000

Zoning Wireless Microphones

Three Room Scenario

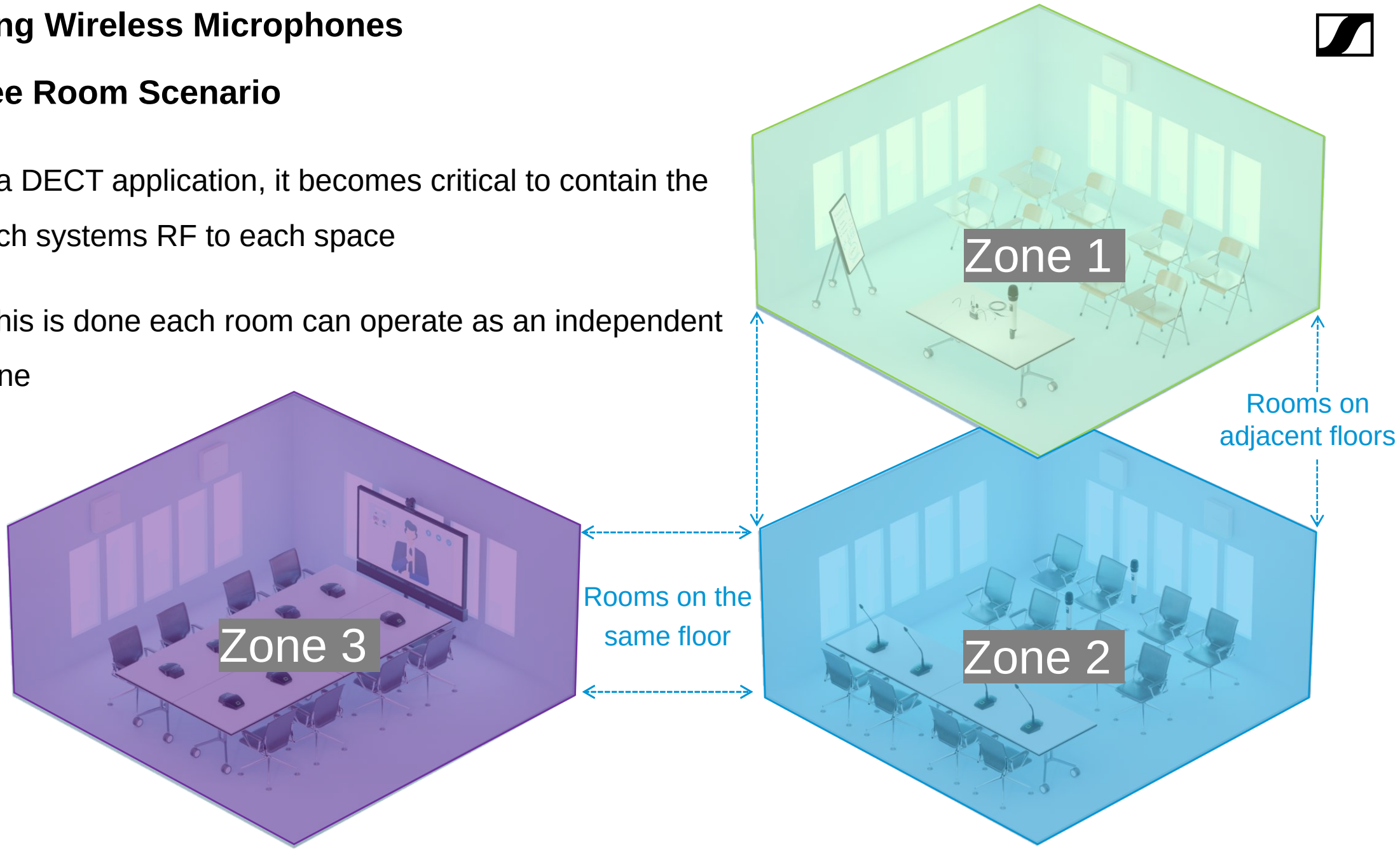
- Rooms 111 & 211 – Systems 470-558 MHz
- Room 116 – Systems 554-608 Mhz



Zoning Wireless Microphones

Three Room Scenario

- In a DECT application, it becomes critical to contain the each systems RF to each space
- If this is done each room can operate as an independent Zone



Agenda

Wireless Microphone Basics

Wireless Microphone Components
RF Theory
Frequencies for Wireless Microphones
Analog, Digital, and DECT

System Planning and Design

Management Tools for Wireless Microphones

Network Management of Wireless Microphone Systems

- **Transmitter and Receiver systems (UHF)** – Although these systems have a one way relationship, it can be possible to monitor battery life of the transmitter, RF power, System status

- **Transceiver Systems (DECT)** – These systems have a bi-directional relationship and offer the ability to both monitor and adjust settings on both the mobile and stationary devices while the system is in use. Frequency coordination is automatic.


MICHIGAN STATE
UNIVERSITY

ABOUT

MICHIGAN STATE UNIVERSITY

- 5300-acre campus
- 563 buildings
- 5700 Faculty and academic staff

Client Services

Staff members: Eight

Coverage from: 6:30AM to 10PM

A/V IT Integration

1 Manager
1 Engineer
3 A/V Technicians
1 Equipment Coordinator
1 Office facilitator

Wireless MIC Locations

Classrooms

- Roughly 500 wireless mic systems on campus

Stadiums

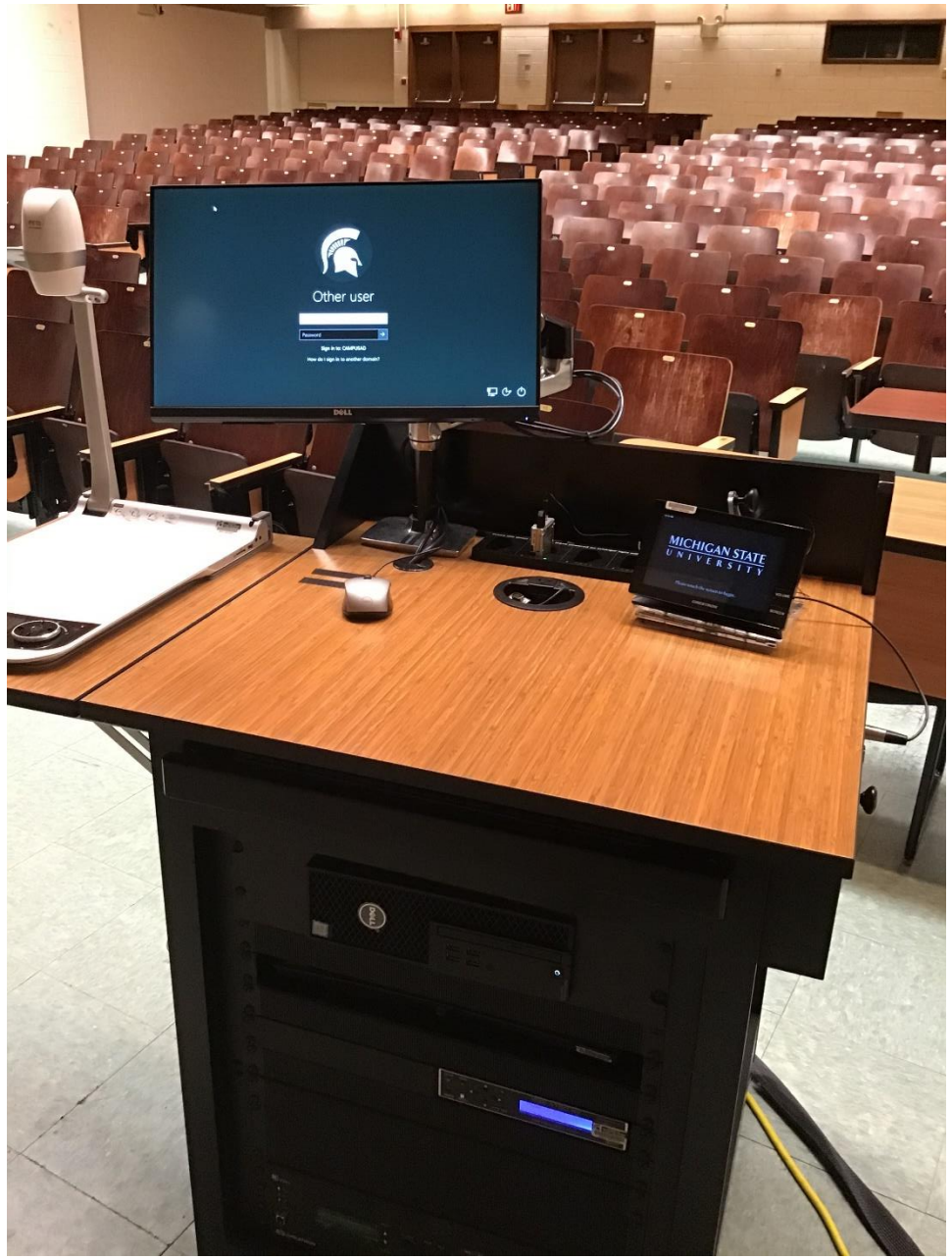
- Multiple sporting arenas

Press conferences

- Media center
- On location

Conference rooms

Live events



Classrooms

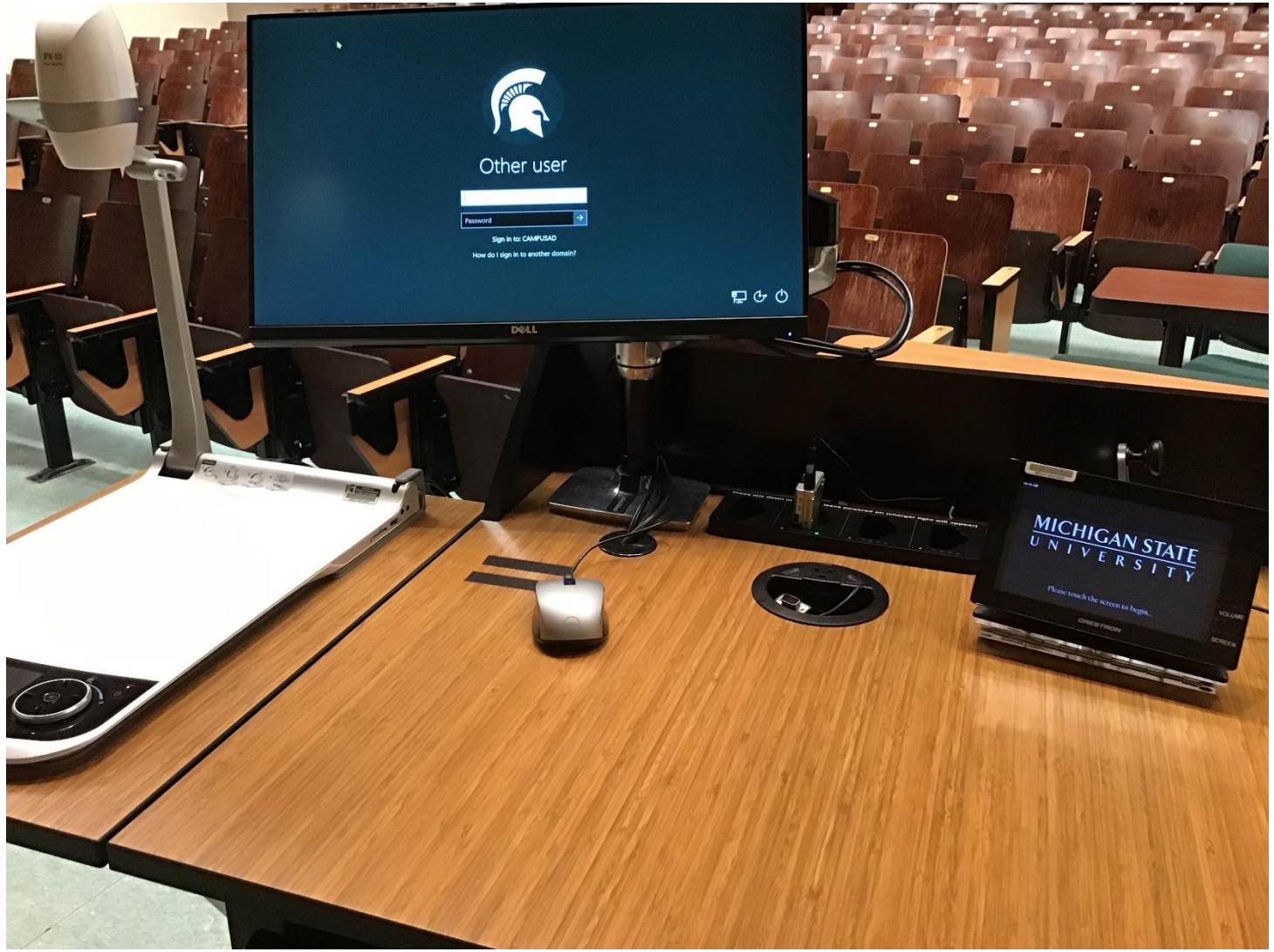
- 500 wireless mic systems
- Wireless mic is key for Hearing assistance system
- Mic needed for closed captioning
- Mic needed for virtual classroom

Wireless System Monitoring

Type	Name	Location	Device Information	Battery Level	Battery Health	Identify
	CHARGER	AKR 136		– – – –	– – – –	
	CHARGER	AKR 140		100% – – –	99% – – –	
	CHARGER	AKR 138		100% – – –	100% – – –	
	CHARGER	AKR 134		– 100% – –	– 100% – –	
	CHARGER	AKR 135		100% – – –	100% – – –	
	CHARGER	EB 1234		– – – 100%	– – – 100%	
	CHARGER	FEE E111		– – 100% –	– – 99% –	

Microphone Tier 2 Support

- Live support
- Network collaboration
- Firmware Updates
- Maintenance Item monitoring-inventory



Stadiums

- 120 wireless mic systems
- Wireless Headsets
- Ref mics
- Press, TV
- Engagement areas

Press conferences

- Multiple Wireless
- Television feeds
- Radio feeds
- On site

Conference rooms

- Presenter feed for Video conferencing system

Live events

- Balance Up to 24 wireless mics


MICHIGAN STATE
UNIVERSITY

Thank you!

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Campus-Wide RF: Solutions for our Changing World

Q&A

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Web Seminar Editor
University Business

David Missall
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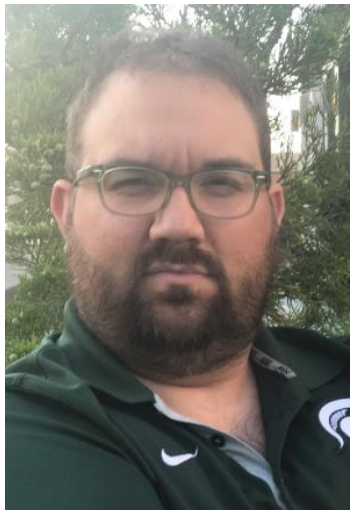
Sennheiser

Chris Phillips
Customer Development & Application Engineering
Sennheiser



Greg Koerner
Manager of Digital Classroom Services
Michigan State University Information Technology

Kenneth Fountain
Audio/Visual Engineer
Michigan State University

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Q&A

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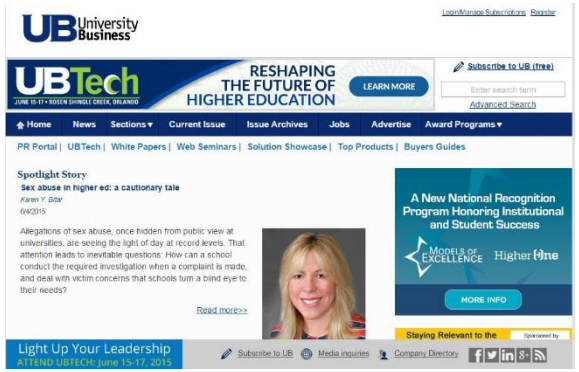

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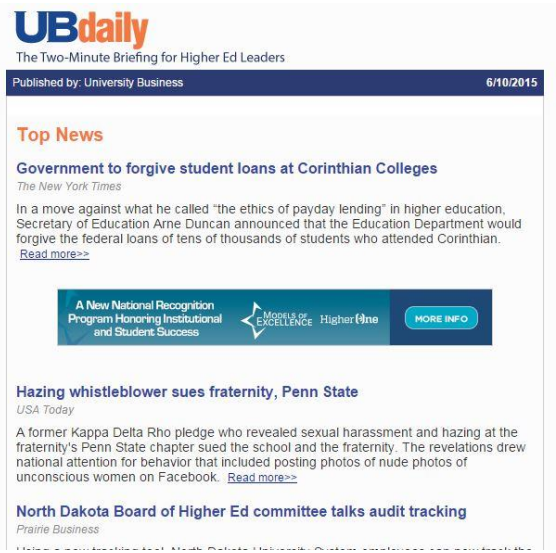

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