

White Space Strategies

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TV Spectrum Availability

- 6 MHz TV channels 2-69
 - VHF: 54-72, 76-88, 174-216 MHz
 - UHF: 470-806 MHz
- *November 4, 2008* FCC allowed unlicensed use of TV White Spaces
- *June 12, 2009* transition from analog to digital TV freed up channels 52-69 due to higher spectral efficiency of digital TV
- **TVBD** = TV Band Device



White Spaces Radio Technology



- FCC Docket 04-186 requires the use of cognitive radio technology to determine whether a channel is available prior to transmitting.
- Methods for detecting licensed transmissions:
 - An internal GPS could be used in conjunction with a database to determine whether the TVBD is located far enough away from licensed stations.
 - TVBD could incorporate sensing capabilities to detect whether licensed transmitters are in its range. If licensed devices are detected, the TVBD would have to search for another channel.

FCC Rules

- Devices require geolocation capability and Internet access to a database of protected radio services. The TVBDs must first access the database before operating.
- Fixed devices may operate on any channel between 2 and 51, except 3, 4 and 37
- Up to 4 Watts EIRP (Effective Isotropic Radiated Power)
- Channels 2 – 20 are restricted for used by fixed devices to protect wireless microphones
- Fixed and personal portable devices must sense TV broadcasting and wireless microphone signals

Frequency Allocation of TV Channels by the FCC

	Channel #	Frequency Band	
Fixed TVBDs only	2-4	54-72 MHz	VHF
	5-6	76-88 MHz	
	7-13	174-216 MHz	
	14-20	470-512 MHz**	UHF
21-51*	512-692 MHz		

*Channel 37 (608-614 MHz) is reserved for radio astronomy

**Shared with public safety

<http://www.fcc.gov/mb/engineering/usallochrt.pdf>

Search Results For:

225 Cedar Hill Street, Marlborough, MA 01752



Available Channels

2	✓	12	✗	22	✓	32	✗	42	✗
3	✗	13	✗	23	✗	33	✓	43	✗
4	✗	14	✗	24	✓	34	✓	44	📶
5	✓	15	✗	25	✓	35	✗	45	✓
6	✓	16	✗	26	✗	36	📶	46	✓
7	✗	17	✗	27	✗	37	✗	47	✗
8	✓	18	✗	28	✓	38	✗	48	✓
9	✗	19	✗	29	✗	39	✗	49	✗
10	✗	20	✗	30	✗	40	✗	50	✓
11	✓	21	✗	31	✗	41	✗	51	✗

Legend



location is within the service area of a TV station or other licensed user and this channel cannot be used by a TVBD

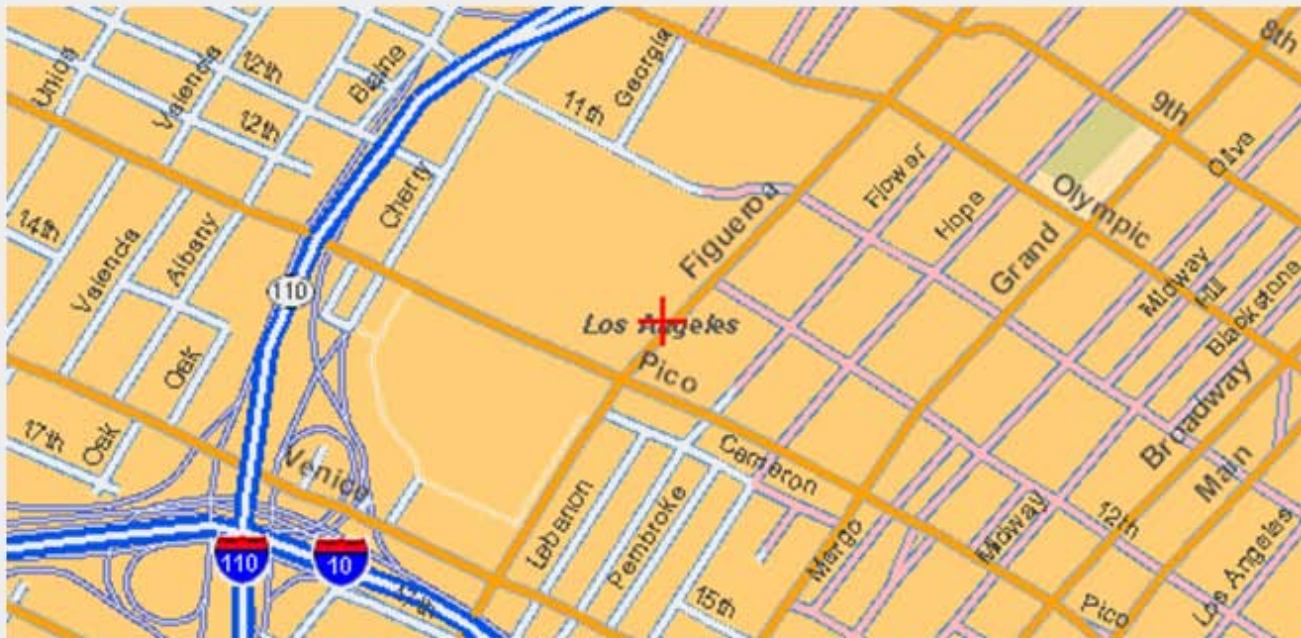
this channel is vacant and can be used by a TVBD

this channel is vacant and can be used by a TVBD, but personal portable devices may not be used on channels 2-20

this channel is in a major metropolitan area and reserved for wireless microphone use only.

Search Results For:

1201 South Figueroa Street, Los Angeles, CA 90015

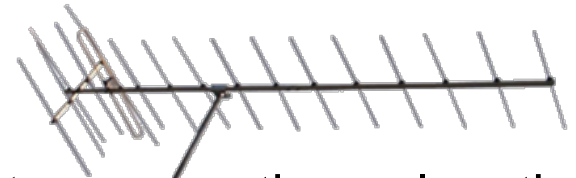


Available Channels

2	✓	12	✗	22	📶	32	✗	42	✗
3	✗	13	✗	23	✗	33	✗	43	✗
4	✗	14	✗	24	✗	34	✗	44	✗
5	✗	15	✗	25	✗	35	✗	45	✗
6	✗	16	✗	26	✗	36	✗	46	📶
7	✗	17	✗	27	✗	37	✗	47	✗
8	✗	18	✗	28	✗	38	✗	48	✗
9	✗	19	✗	29	✗	39	✗	49	✗
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11	✗	21	✗	31	✗	41	✗	51	✗

Beach-front Property?

- Lower frequencies experience lower attenuation in free space and through obstructions, e.g. buildings
- However, when propagating through metal frames in modern buildings, Fresnel zone gets constricted and attenuation is introduced



Antenna – optimum length is a multiple of $\frac{1}{4}$ wavelength

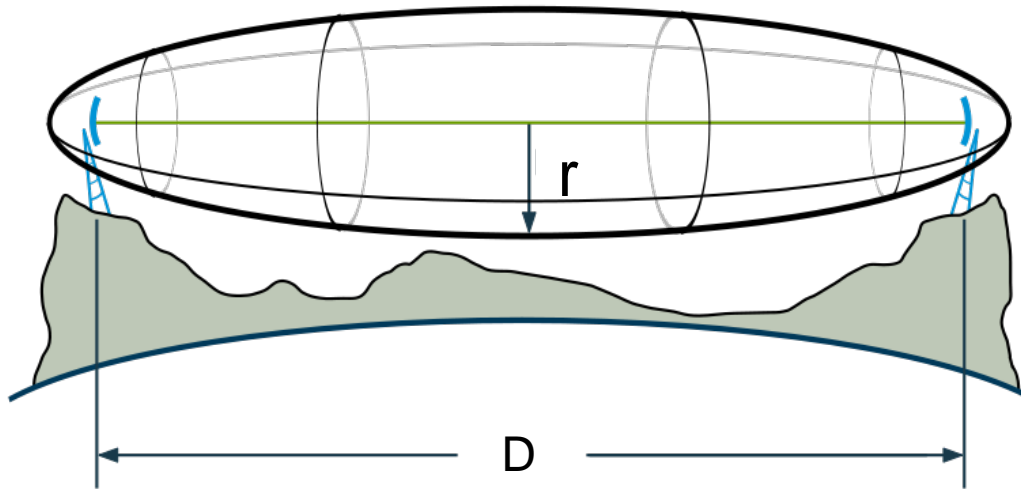
3.3 feet for 70 MHz

4" for 700 MHz

1" for 2.4 GHz

Longer antennas required for UHF may be problematic for handheld devices

Antenna Fresnel Zone



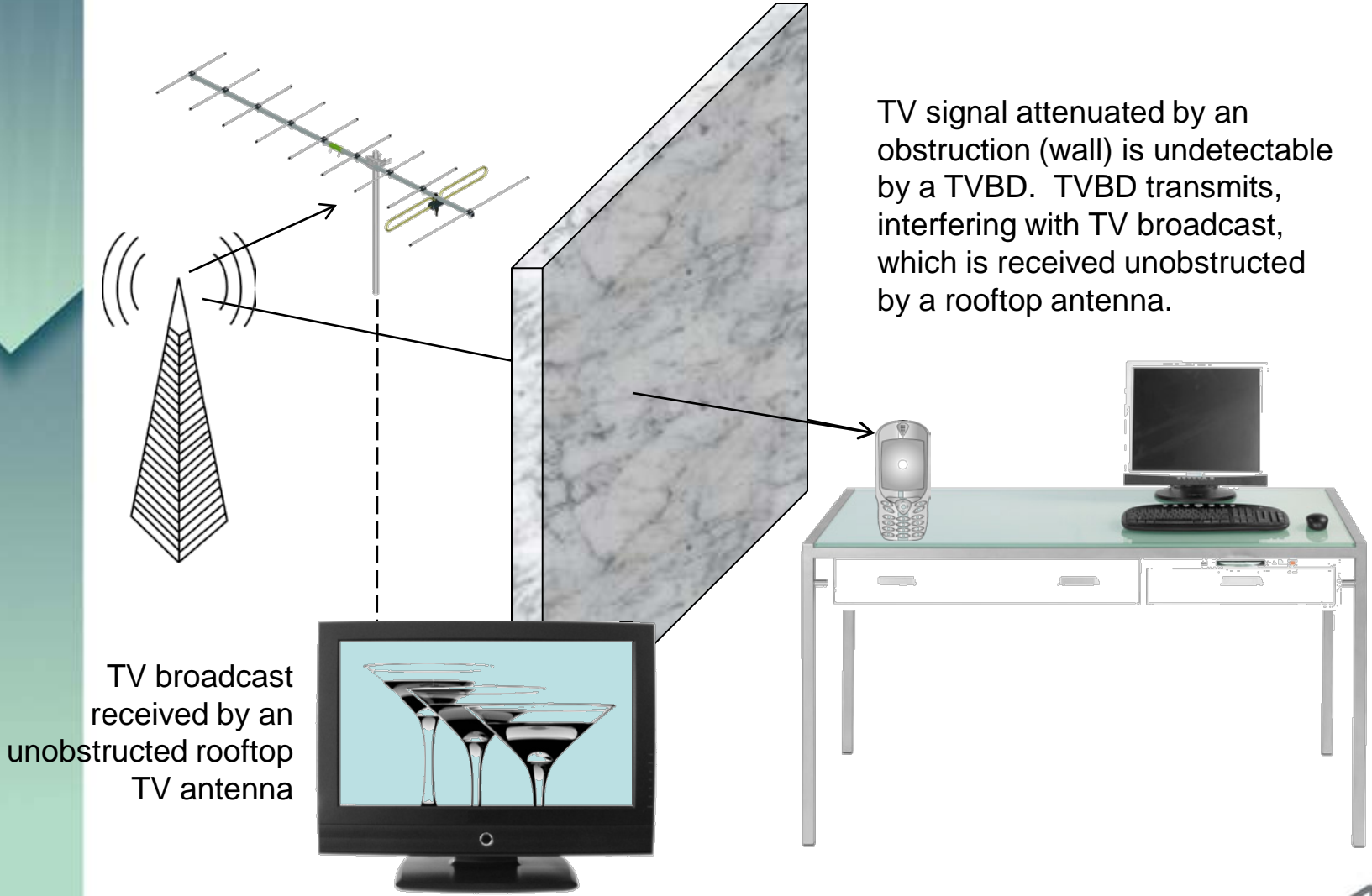
$$r = 72.05 \sqrt{\frac{D}{4f}}$$

- **Fresnel zone** is the shape of electromagnetic signal and is a function of frequency
- Constricting the Fresnel zone introduces attenuation and signal distortion

r = radius in feet
D = distance in miles
f = frequency in GHz

Example: D = 0.5 mile
r = 30 feet for 700 MHz
r = 16 feet for 2.4 GHz
r = 10 feet for 5.8 GHz

Hidden Node Scenario



TV signal attenuated by an obstruction (wall) is undetectable by a TVBD. TVBD transmits, interfering with TV broadcast, which is received unobstructed by a rooftop antenna.

TV broadcast received by an unobstructed rooftop TV antenna

Hidden Node – an Issue?

- Analysis and field testing done by ITU-R, FCC and other organizations demonstrate that even when a TVBD is deep inside a building, the signal reaching it is likely to be at most 30 dB lower than the signal at a rooftop antenna.
- The 802.22 draft sets the detection threshold 30 dB below a tuner's lowest receive level and states that an unlicensed device must detect a broadcast within 2 seconds and with probability of $\geq 90\%$.

White Spaces Communications Standards

- IEEE 802.22
 - Based on 802.16d
 - Ongoing effort for almost 5 years
 - Worked with the FCC on White Spaces regulations
- IEEE 802.19
 - Coexistence standards
- IEEE 802 Study Group
- Work now starting in the 802.11 White Spaces Study Group

What's to Come...

- Products expected in about 2 years
- Wi-Fi may be the first protocol to make use of white spaces
- Contentious standardization process





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