

Fernando Mendoza
Computer Engineer
UCSB
Gorman Scholar

Enhancing Spectral Usage Through Full Duplex Communication

Electrical and Computer Engineering
Advisor : Jim Buckwalter
Mentor: Hussam AlShammary

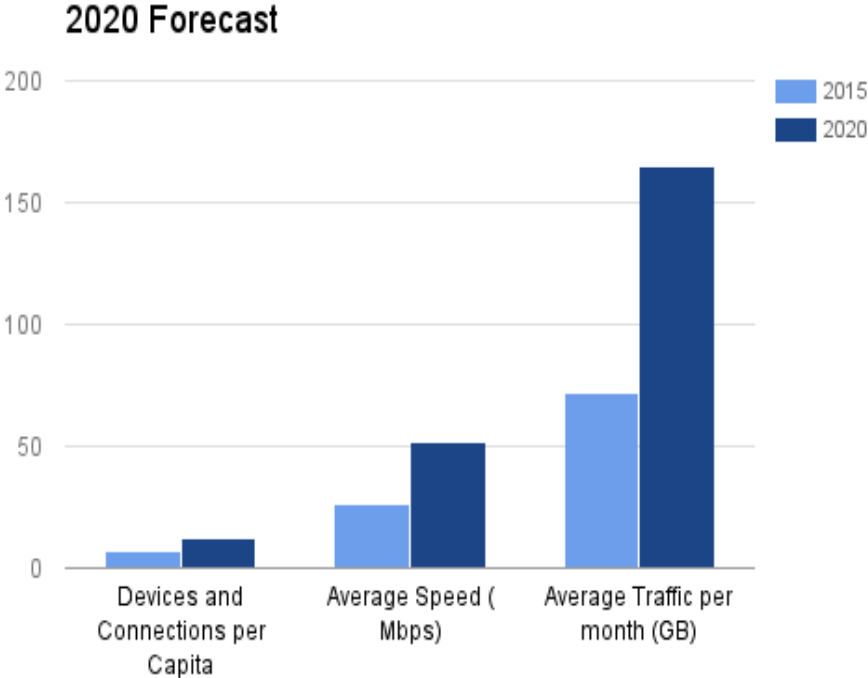
Today's average phone data speed is 26.1 Mbps, what will the average data speed be in the year 2020 ? **A: 52.1Mbps** **B: 62.1Mbps** **A: 42.1Mbps**

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A: 52.1Mbps

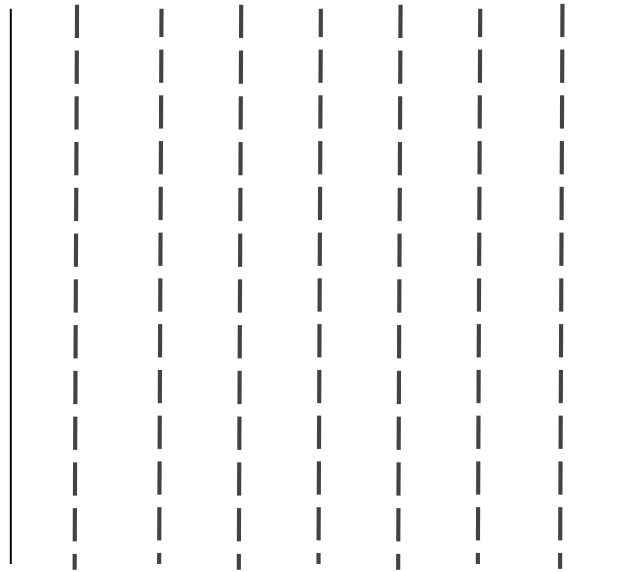
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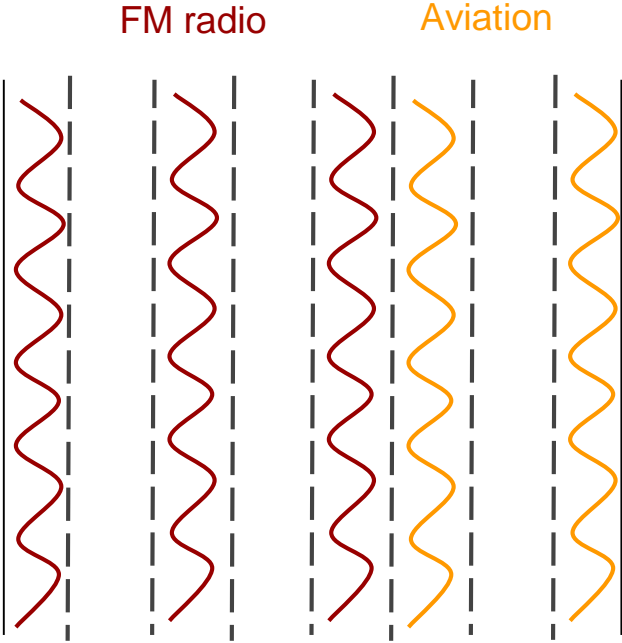
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Radio Spectrum

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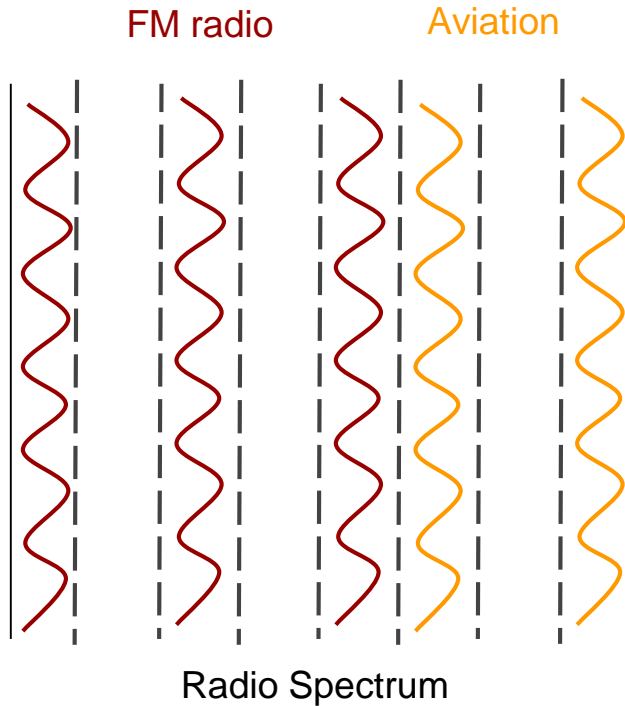


Radio Spectrum

- FCC allocates bands to services.
- Many services leave frequencies unused.

Today's average phone data speed is 26.1 Mbps, what will the average data speed be in the year 2020 ?

A: 52.1Mbps



- FCC allocates bands to services.
- Many services leave frequencies unused.
- Need to understand how spectrum works now.
- Spectrum will be prioritized.

Analysing the Radio Spectrum

What frequencies are being used?

Analysing the Radio Spectrum

What frequencies are being used?

What services own these frequencies?

Analysing the Radio Spectrum

What frequencies are being used?

What services own these frequencies?

How they use it?

Analysing the Radio Spectrum

What frequencies are being used?

Frequent Users

What services own these frequencies?

Less Frequent Users

How they use it?

Night Users

Day Users

Hypothetical Radio Spectrum (future)

Free Spectrum



Acquiring Signals from a Software Defined Radio



SDR

Acquiring Signals from a Software Defined Radio



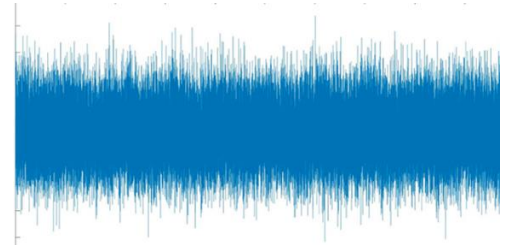
SDR



Matlab
LabView



Amplitude



Time

Acquiring Signals from a Software Defined Radio



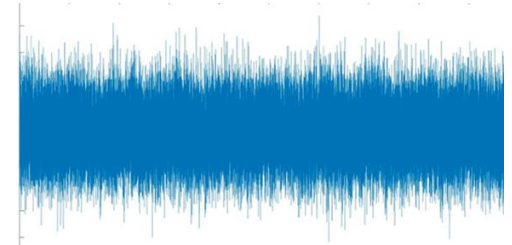
SDR



Matlab
LabView



Amplitude



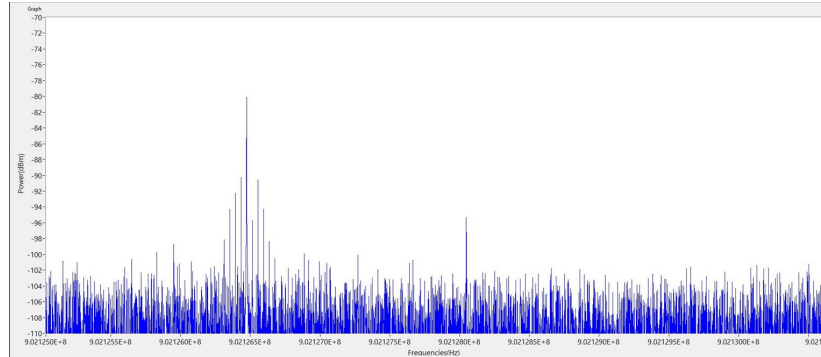
Time



Fast Fourier
Function (FFT)

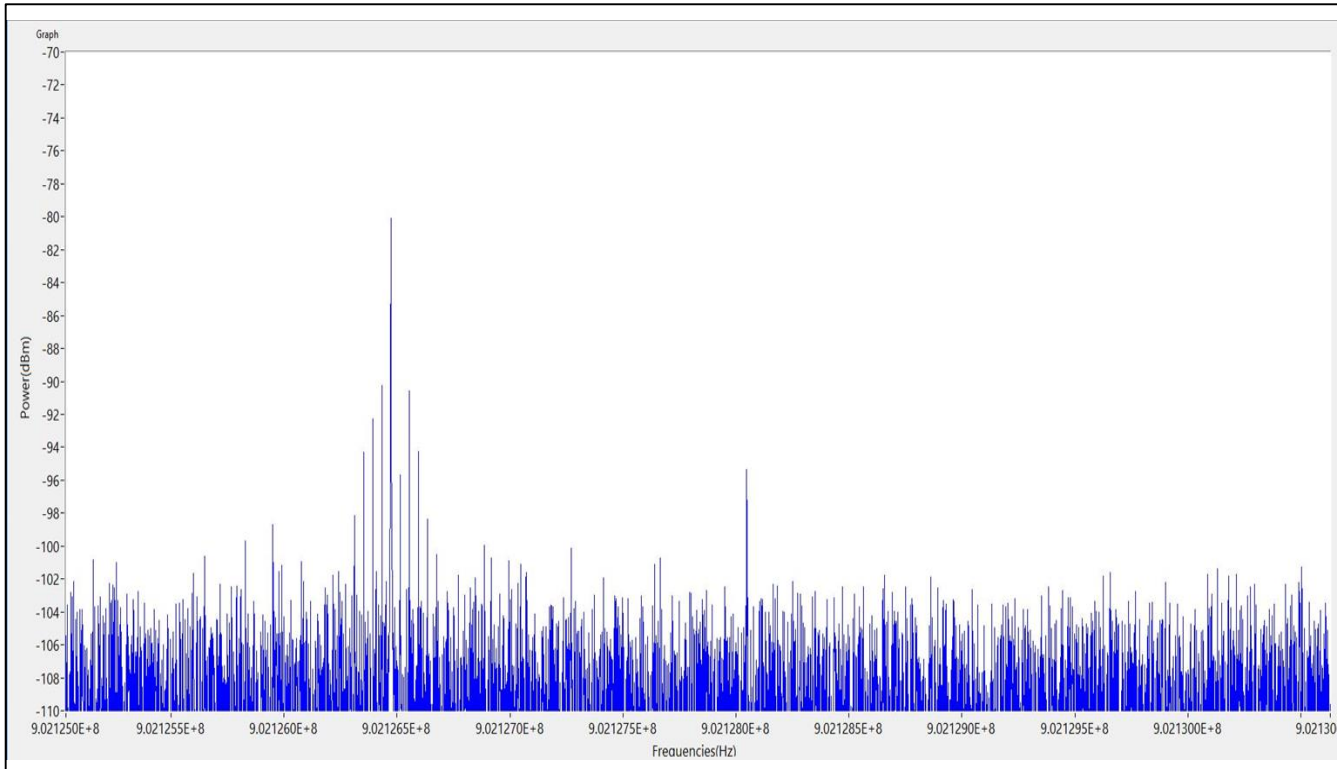


Power



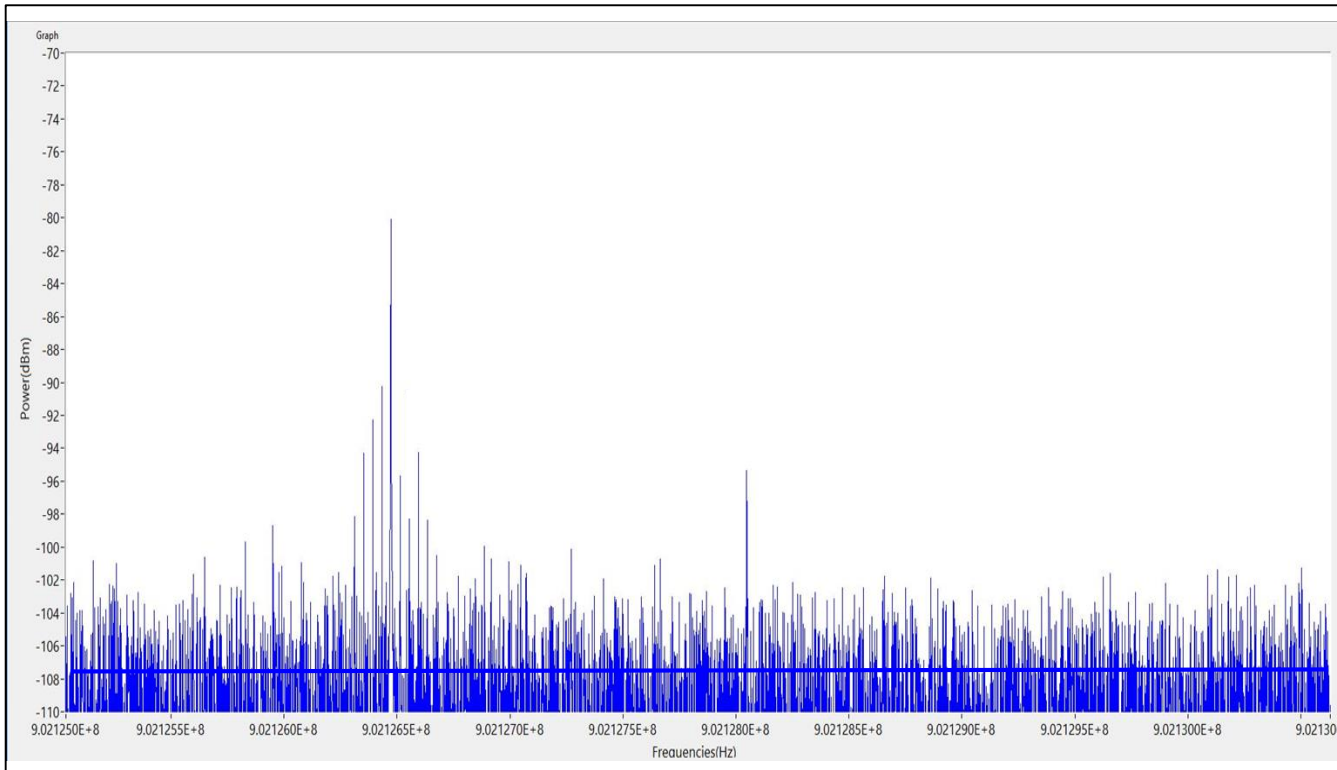
Frequency

Detecting the Power of Signals



Identifies the frequencies being used.

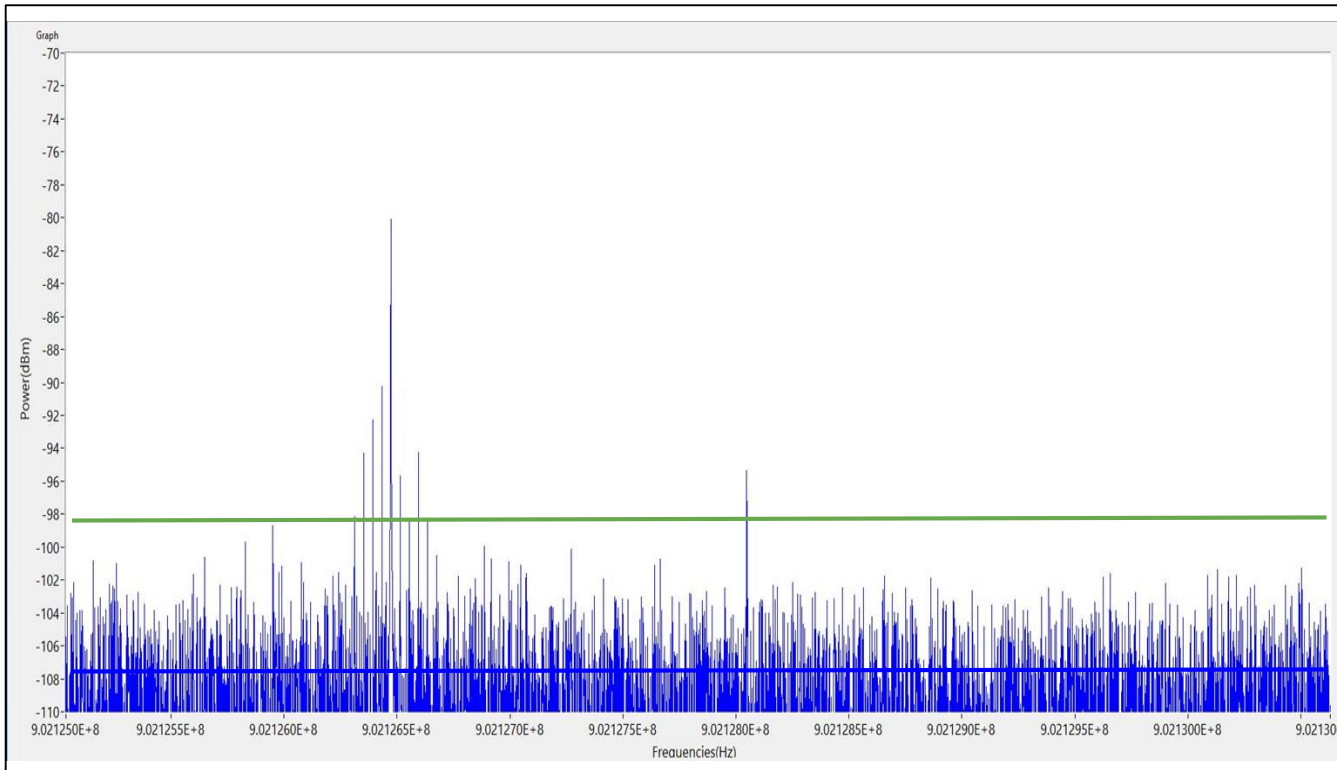
Detecting the Power of Signals



Identifies the frequencies being used.

Noise floor.

Detecting the Power of Signals

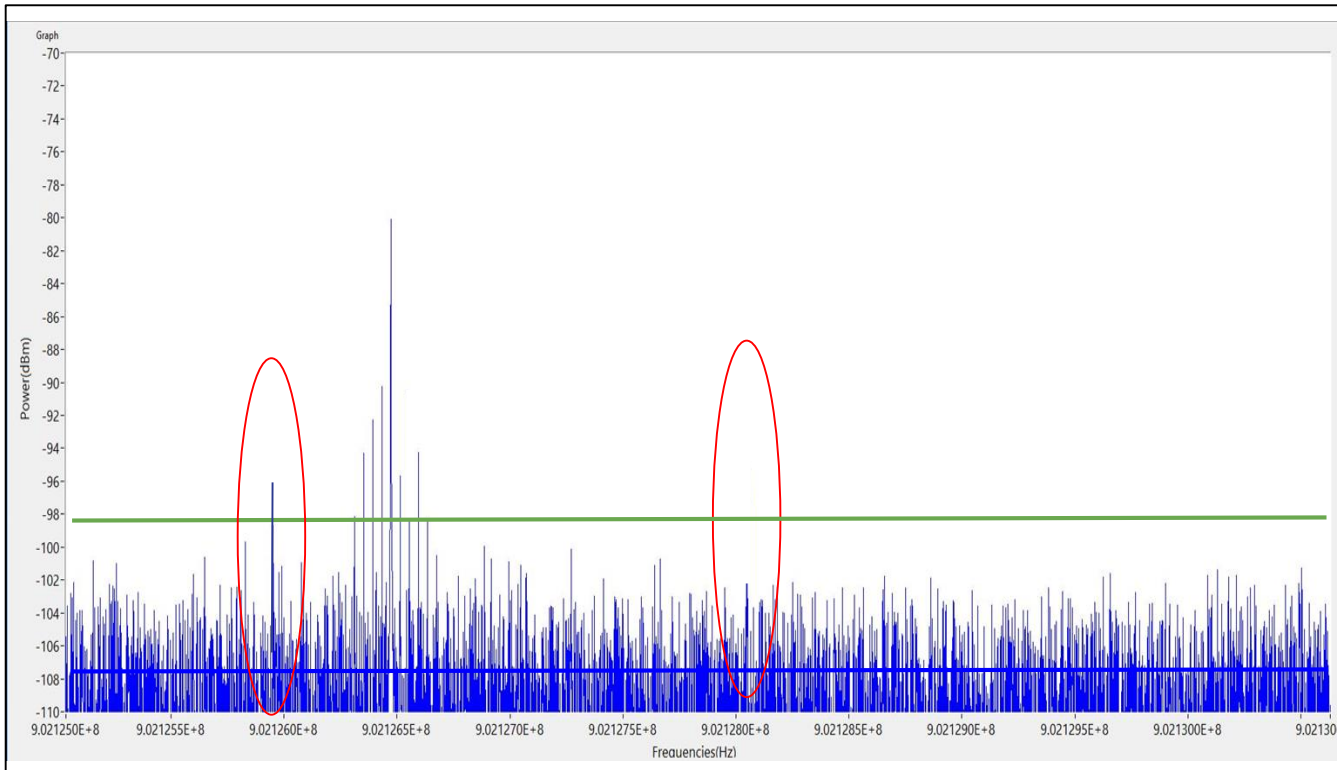


Identifies the frequencies being used.

Noise floor.

Threshold = 10 dBm above noise floor.

Detecting the Power of Signals



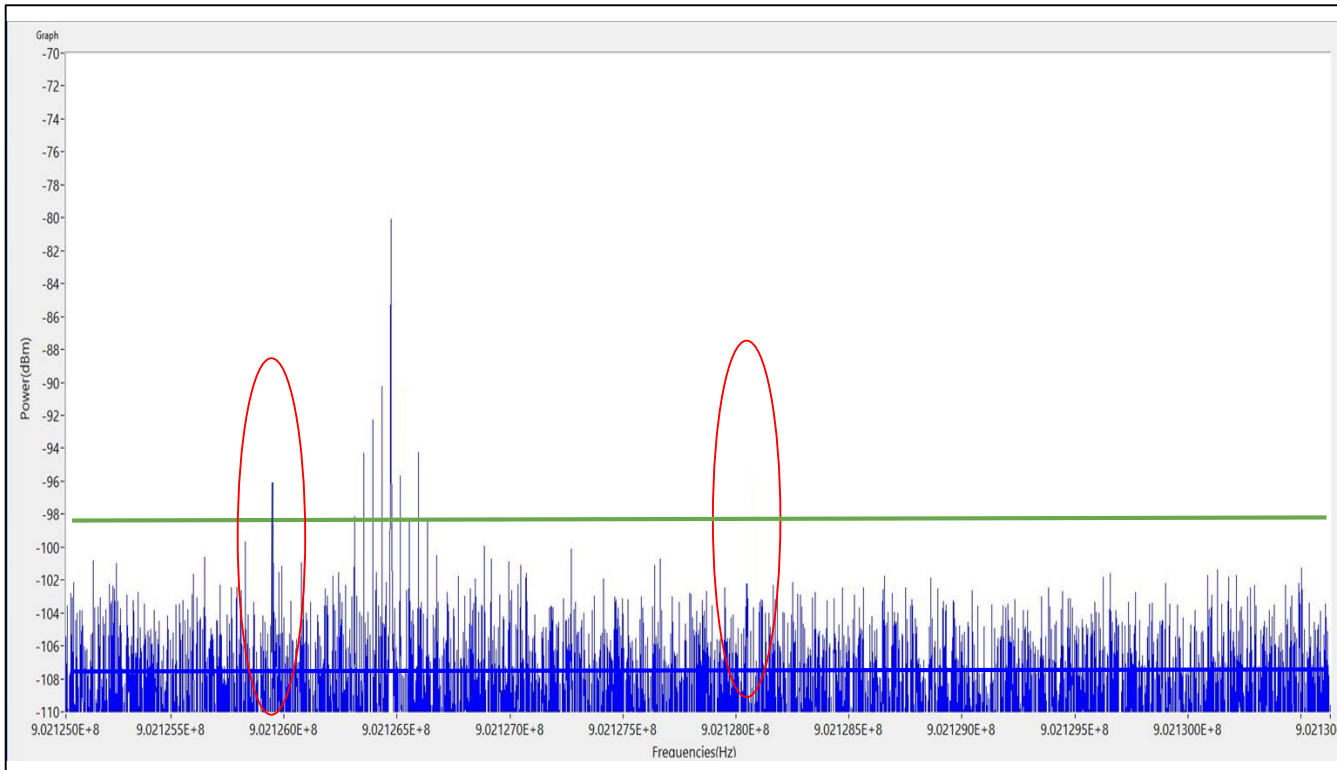
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Noise floor.

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Signals will fluctuate due to noise.

Detecting the Power of Signals



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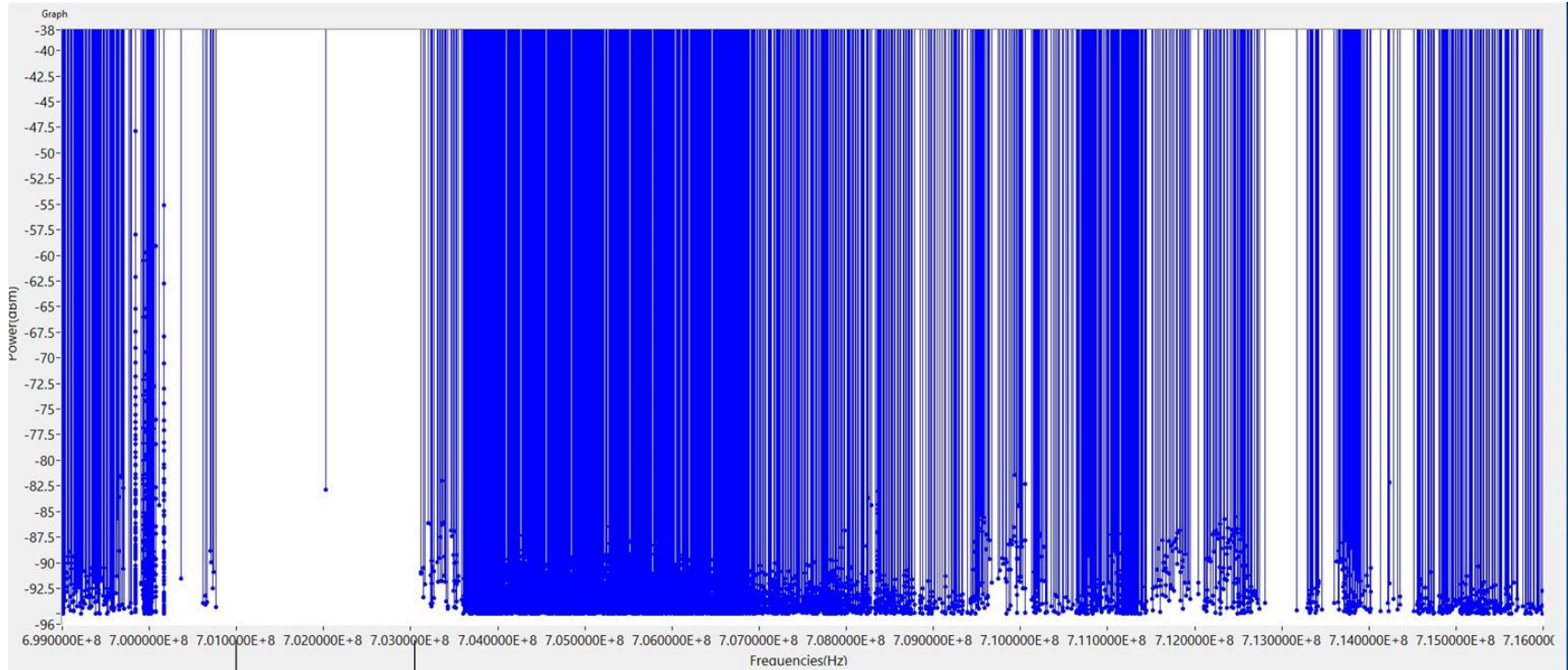
Noise floor.

Threshold = 10 dBm above noise floor.

Signals will fluctuate due to noise.

Increase samples to reduce error.

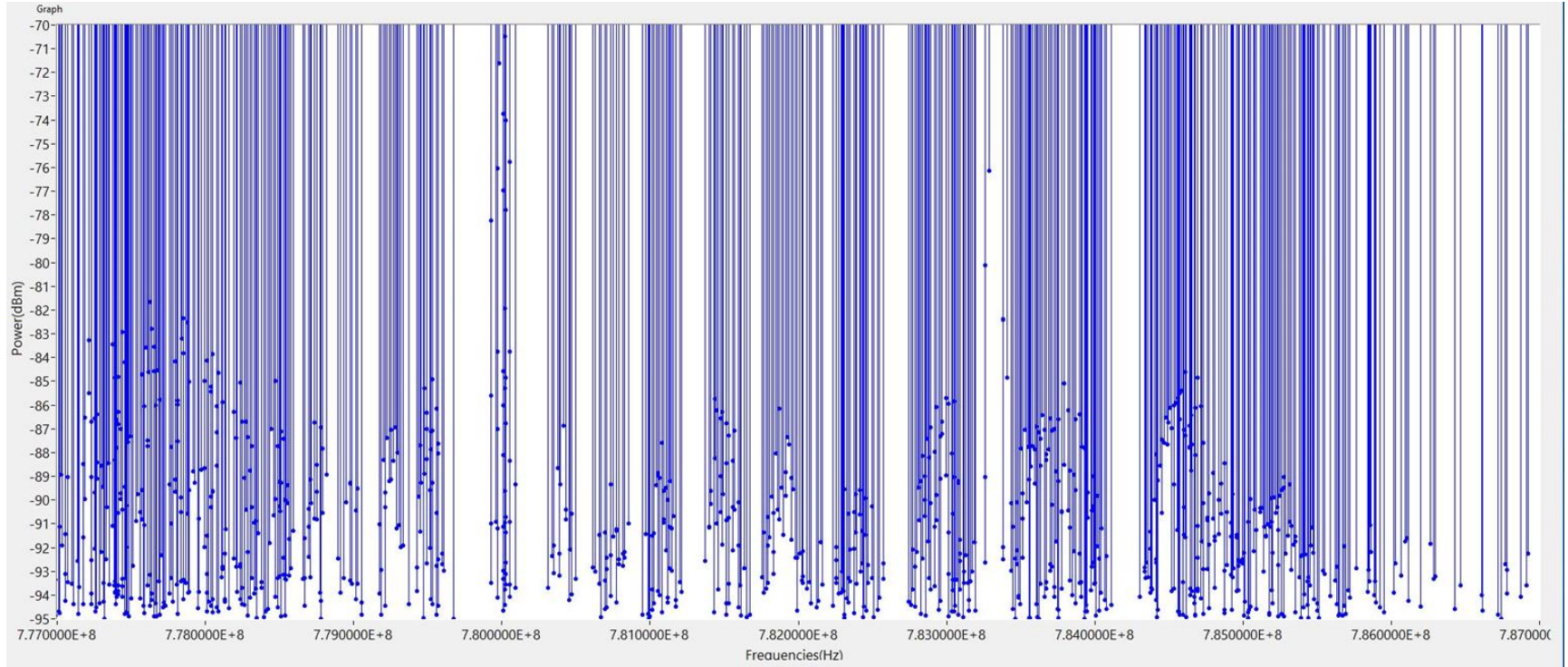
T-Mobile (699 MHz - 716 MHz) and AT&T (704 MHz - 716 MHz)



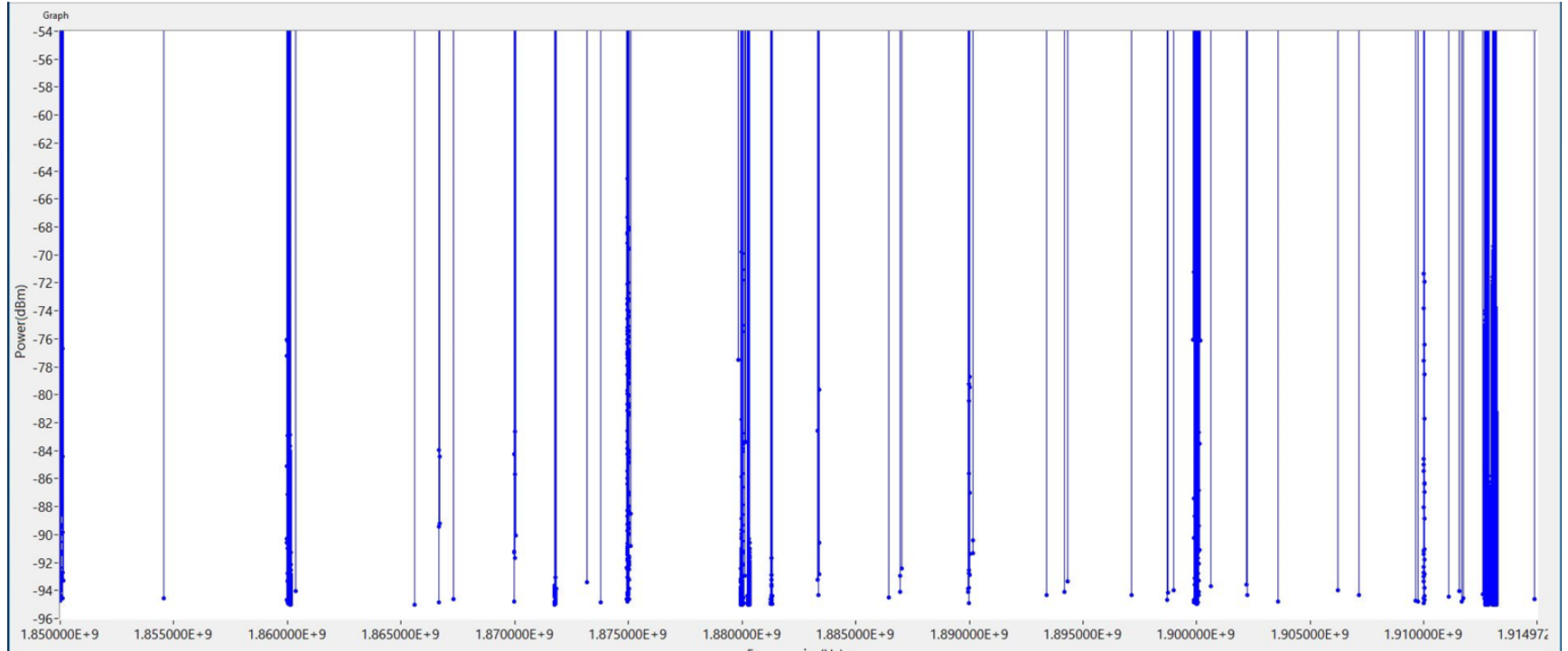
701 MHz

703 MHz

Verizon Preferred Band (777 MHz - 787 MHz)



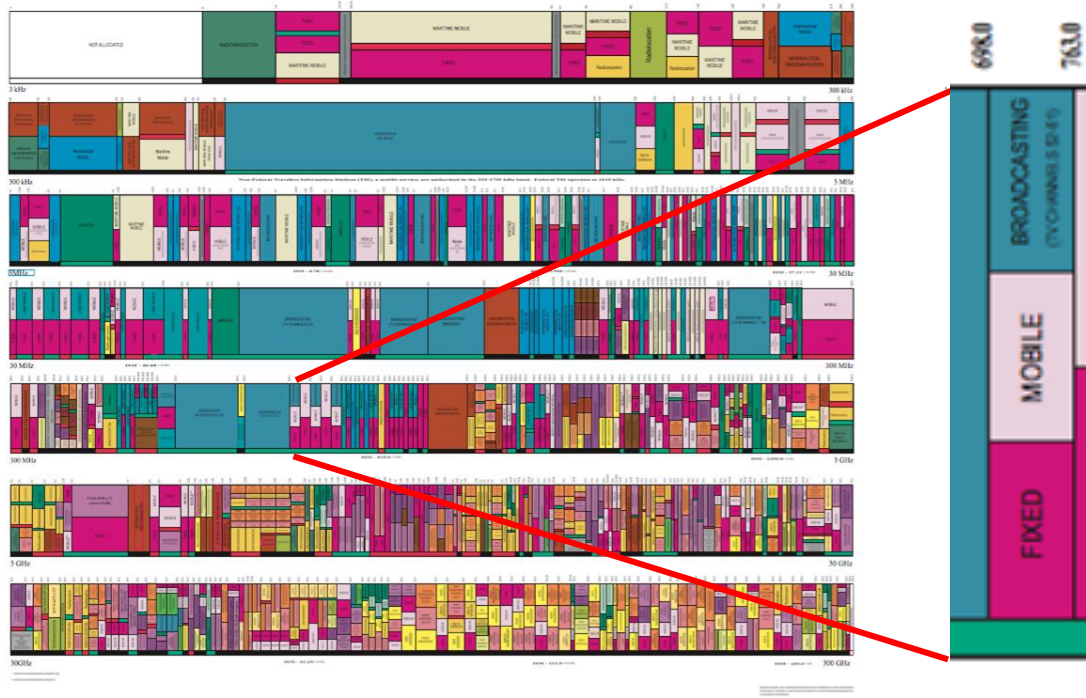
Sprint Preferred Band (1850 MHz - 1915 MHz)



Small Portion of Radio Spectrum

UNITED STATES FREQUENCY ALLOCATIONS

THE RADIO SPECTRUM



699 MHz - 716 MHz

Small Portion of Radio Spectrum

UNITED STATES FREQUENCY ALLOCATIONS

THE RADIO SPECTRUM

RADIO SERVICES COLOR LEGEND

- Amateur Service
- Common Carrier
- Fixed Service
- Mobile Service
- Broadcasting
- Other

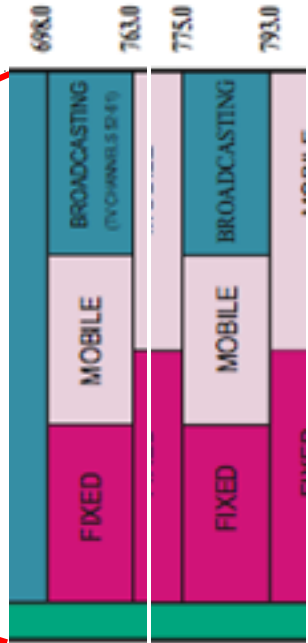
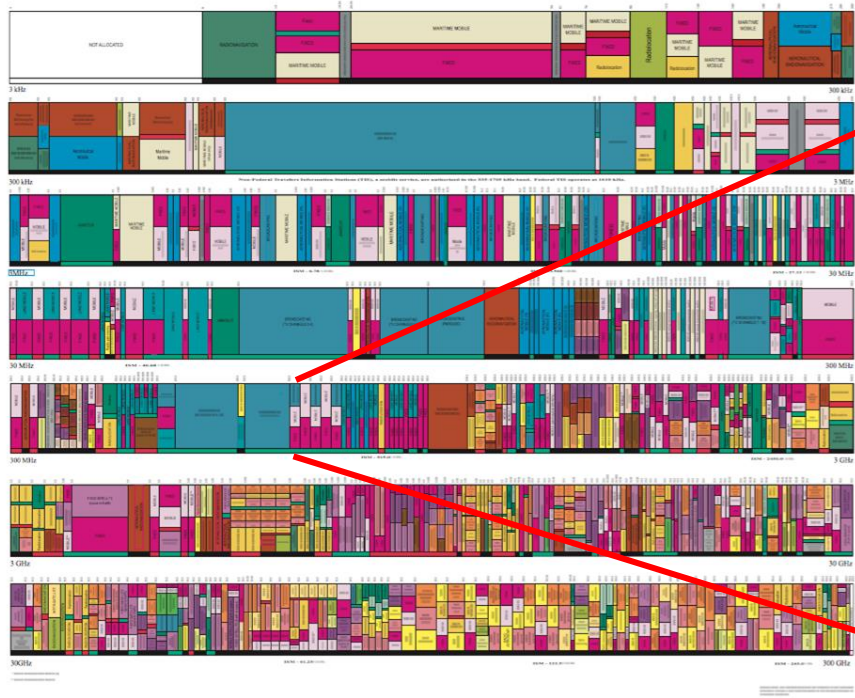
ACTIVITY CODE

- Primary
- Secondary
- Permit to Transmit
- Other

ALLOCATION USAGE DESIGNATION

LETTER	EXPLANATION	DESCRIPTION
M	Mobile	Mobile
F	Fixed	Fixed
B	Broadcasting	Broadcasting

U.S. DEPARTMENT OF COMMERCE
National Telecommunications and Information Administration
Radio Frequency Management
August 2011



699 MHz - 716 MHz

777 MHz - 787 MHz

Small Portion of Radio Spectrum

UNITED STATES FREQUENCY ALLOCATIONS

THE RADIO SPECTRUM

RADIO SERVICES COLOR LEGEND

Blue	Commercial Radio	Green	Mobile	Yellow	Fixed
Light Blue	Amateur Radio	Light Green	Mobile	Light Yellow	Fixed
Dark Blue	Amateur Radio	Dark Green	Mobile	Dark Yellow	Fixed
Light Purple	Amateur Radio	Light Cyan	Mobile	Light Orange	Fixed
Dark Purple	Amateur Radio	Dark Cyan	Mobile	Dark Orange	Fixed
Light Green	Amateur Radio	Light Blue	Mobile	Light Purple	Fixed
Dark Green	Amateur Radio	Dark Blue	Mobile	Dark Purple	Fixed
Light Blue	Amateur Radio	Light Purple	Mobile	Light Orange	Fixed
Dark Blue	Amateur Radio	Dark Purple	Mobile	Dark Orange	Fixed
Light Purple	Amateur Radio	Light Orange	Mobile	Light Green	Fixed
Dark Purple	Amateur Radio	Dark Orange	Mobile	Dark Green	Fixed
Light Orange	Amateur Radio	Light Green	Mobile	Light Blue	Fixed
Dark Orange	Amateur Radio	Dark Green	Mobile	Dark Blue	Fixed
Light Green	Amateur Radio	Light Blue	Mobile	Light Purple	Fixed
Dark Green	Amateur Radio	Dark Blue	Mobile	Dark Purple	Fixed
Light Blue	Amateur Radio	Light Purple	Mobile	Light Orange	Fixed
Dark Blue	Amateur Radio	Dark Purple	Mobile	Dark Orange	Fixed
Light Purple	Amateur Radio	Light Orange	Mobile	Light Green	Fixed
Dark Purple	Amateur Radio	Dark Orange	Mobile	Dark Green	Fixed

ACTIVITY CODE

Red	Primary	Black	Secondary
Green	Primary	Grey	Secondary

ALLOCATION USAGE DESIGNATION

LETTER	DESCRIPTION
A	Amateur
B	Broadcasting
C	Common
D	Domestic
E	Earth Station
F	Fixed
G	Government
H	Mobile
I	International
J	Land Mobile
K	Land Mobile
L	Land Mobile
M	Mobile
N	Naval
O	Other
P	Primary
Q	Quasi-Primary
R	Radio
S	Secondary
T	Terrestrial
U	Unrestricted
V	Voice
W	Worldwide
X	Experimental
Y	Yacht
Z	Zenith



699 MHz - 716 MHz

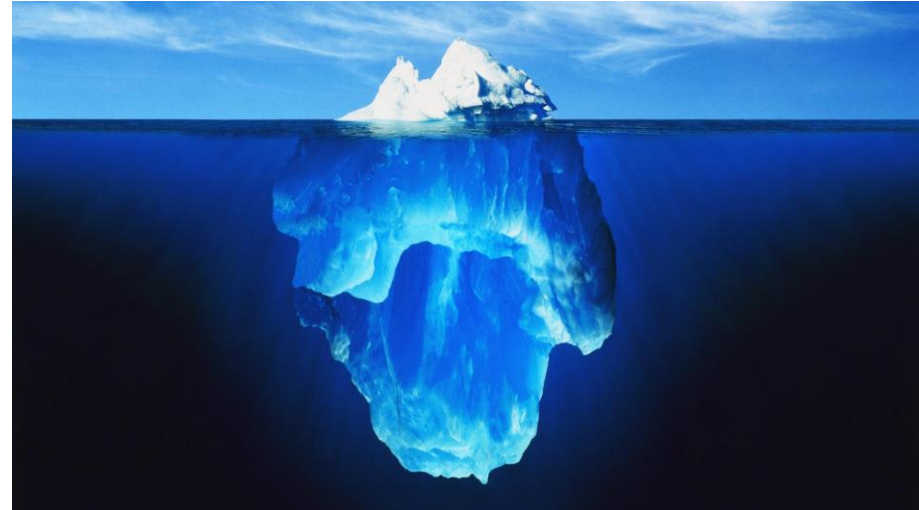
777 MHz - 787 MHz

1850 MHz - 1915 MHz

The Tip of the Iceberg

Future work should:

- Look to analyze a larger range of frequencies
- Increase the efficiency of looking for used frequencies



Huge Thanks to:

CSEP

Gorman Scholar

UCSB

**Dean Pierre Wiltzius and Office of the
Dean, Math, Life & Physical Sciences**

James Buckwalter
Hussam AlShammary