

# **Electromagnetic Green Spaces for Research and Recreation**

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# **The Electromagnetic Spectrum is a Resource**

This talk has only one point:

Conservation is OK

To get started, define Electromagnetic Spectrum:

For the purposes of this talk:

Radio Frequencies from 10 Hz through 1 THz.

Examples:

AM Broadcast Band 550 - 1710 kHz

FM Broadcast Band 88 - 108 MHz

Cell phone bands, WiFi, Weather Radar, GPS...

The Electromagnetic Spectrum according to:

NTIA

[http://www.ntia.doc.gov/files/ntia/publications/spectrum\\_wall\\_chart\\_aug2011.pdf](http://www.ntia.doc.gov/files/ntia/publications/spectrum_wall_chart_aug2011.pdf)

Randall Monroe

[http://imgs.xkcd.com/comics/electromagnetic\\_spectrum.png](http://imgs.xkcd.com/comics/electromagnetic_spectrum.png)

# THE ELECTROMAGNETIC SPECTRUM

THESE WAVES TRAVEL THROUGH THE ELECTROMAGNETIC FIELD. THEY WERE FORMERLY CARRIED BY THE AETHER, WHICH WAS DECOMMISSIONED IN 1897 DUE TO BUDGET CUTS.

## ABSORPTION SPECTRA:

HYDROGEN:



HELIUM:



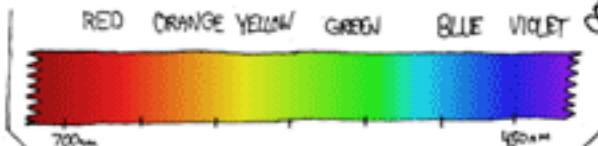
DEPENDS®:



TAMPAX®:



RED ORANGE YELLOW GREEN BLUE VIOLET



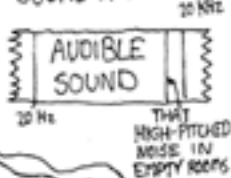
VISIBLE LIGHT

## OTHER WAVES:

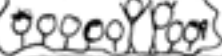
SLINKY WAVES



SOUND WAVES



THE WAVE



SHOUTING CAR DEALERSHIP COMMERCIALS

CIA (SECRET)

HAM RADIO

KOSHER RADIO

CELL PHONE CANCER RAYS

GRAVITY

SPACE RAYS CONTROLLING STEVE BALLMER

99.3 "THE FOX"

101.5 "THE BAGGERS"

102.3 "THE FROGHEIVED SQUIREL"

ALIENS SETI

23 1/2 NPR PLEDGE DRIVES

WIFI

BRAIN WAVES

SUPERMAN'S HEAT VISION

JACK BLACK'S HEAT VISION

SUNLIGHT

MAIN DEATH STAR LASER

POTATO

BLOGORAYS

MAIL-ORDER X-RAY GLASSES

SINISTER GOOGLE PROJECTS

CENSORED UNDER PATRIOT ACT

POWER & TELEPHONE

RADIO & TV

MICROWAVES

TOASTERS

IR

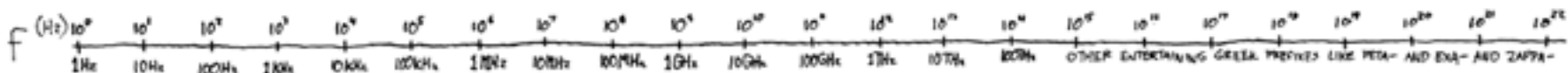
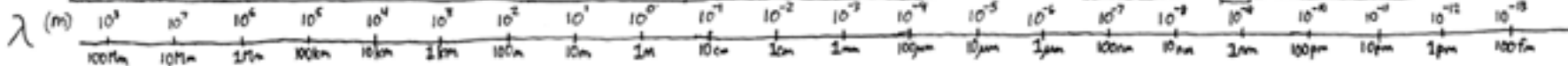
VISIBLE LIGHT

UV

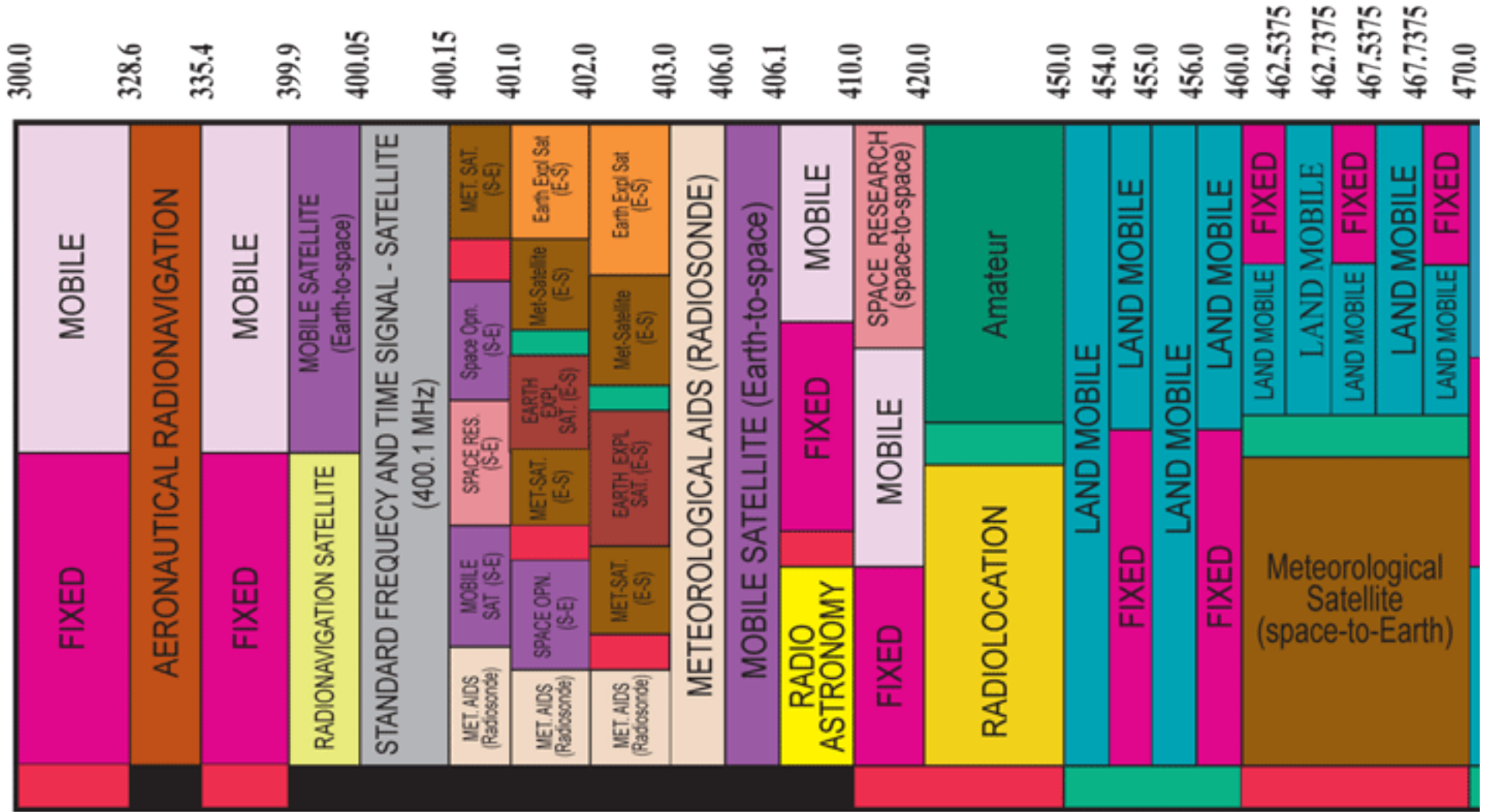
INFRARED LIGHT

X-RAYS

GAMMA/COSMIC RAYS



# Frequency Allocations:



Details of a thin slice, from 300 MHz to 470 MHz

Constant pressure on the electromagnetic  
environment

current example: Cognitive Radio

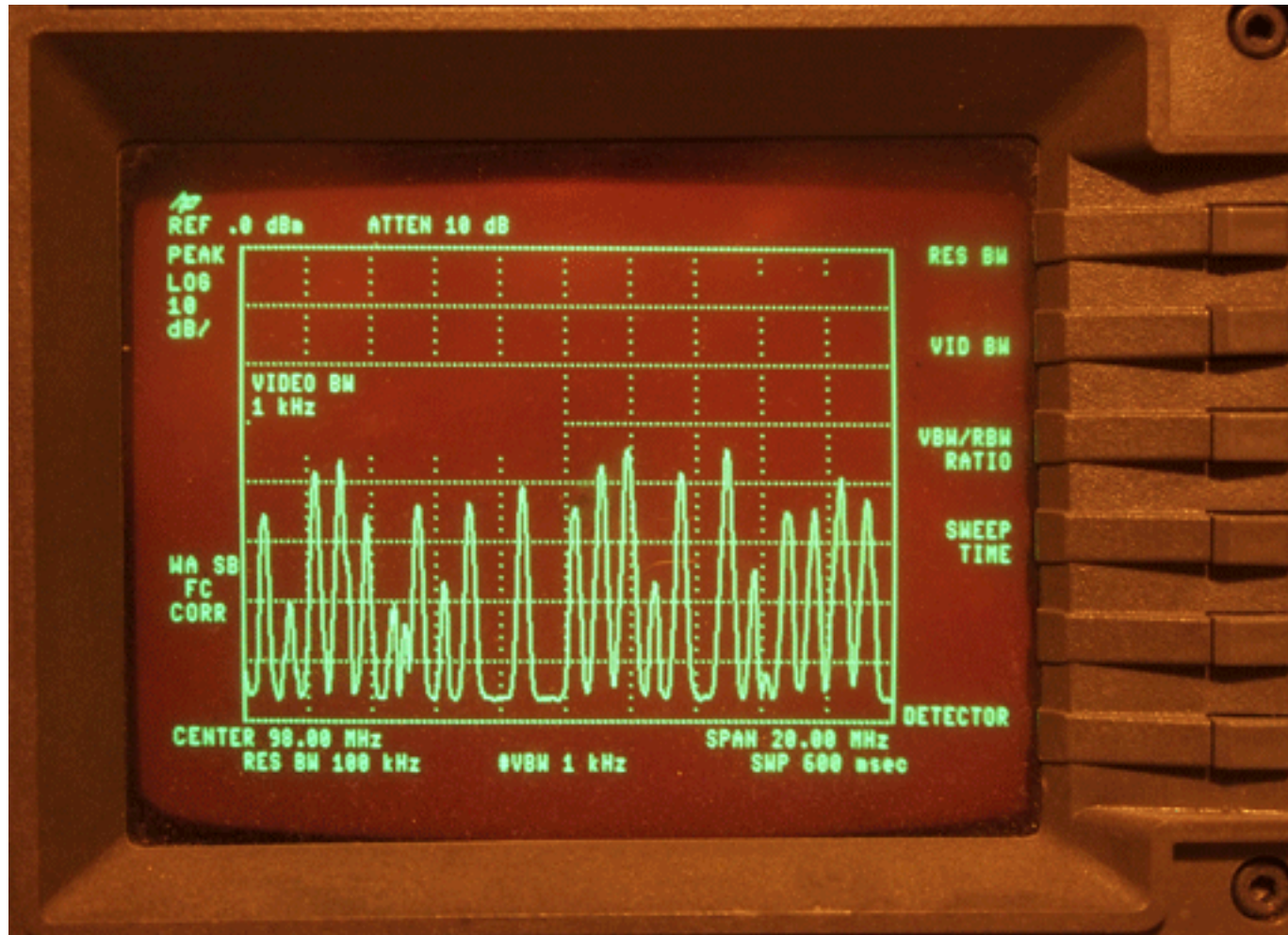
Three points of view on Spectrum Allocation:

Science

Public Policy

Stewardship

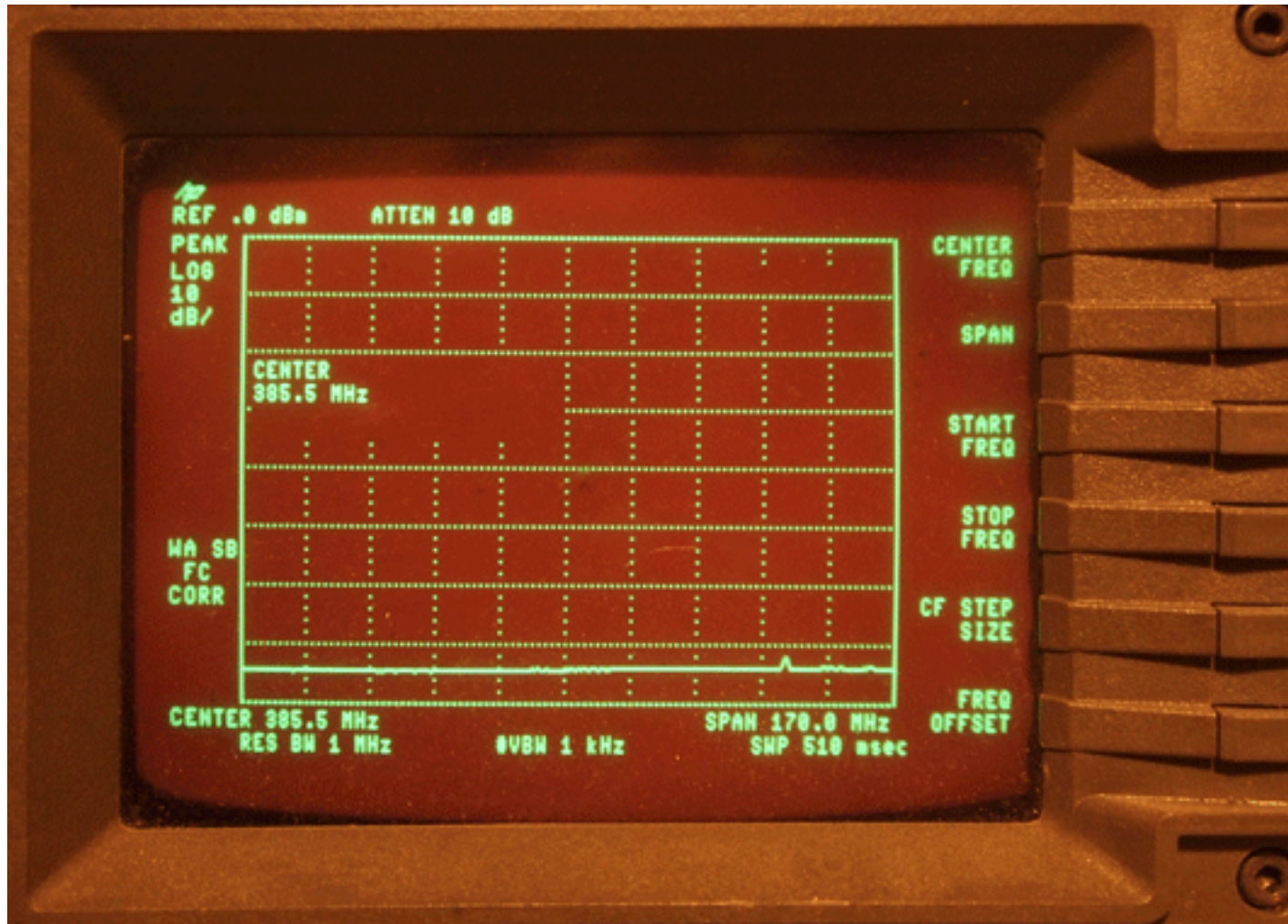
# Science -- Basic tool is a Spectrum Analyzer



FM Broadcast Band 88 - 108 MHz



# Cognitive Radio sees an open field



300 MHz - 470 MHz

There is obviously nothing there. ...but:

Boltzmann's constant  $1.38 \times 10^{-23}$  watts/Hz-Kelvin

room temperature on Earth  $\sim 290\text{K}$

$\sim 4 \times 10^{-21}$  watts/Hz

room temperature of Universe  $\sim 3\text{K}$

CMB  $\sim 4 \times 10^{-23}$  watts/Hz

above spectrum analyzer sensitivity  $\sim 10^{-13}$  watts

Scientists and Radio Amateurs routinely work with signals below Earth's noise floor, and Scientists resolve the Cosmic Microwave Background to nano-Kelvin resolution when measuring the shape of the universe.

But to the CTO of a company hungry for spectrum, signals in those broad expanses are as rare as electoral votes in National Parks.

Which leads us to...

# Public Policy

How to become an FCC Commissioner in the 21st Century:

(This space intentionally left blank)

The process was different in the era of Einstein, Roosevelt, Fermi, Costas at GE Labs, Villard at Stanford, Bell Labs, the MIT Rad Lab...

In Public Policy, old ideas that have stood the test of time are not necessarily bad.

Today, stewardship of resources is often left to amateurs: Trout Unlimited, Ducks Unlimited, The Audubon Society, American Radio Relay League...

Radio Amateurs are famous stewards of their frequency allocations. The term “self-policing” appears often in FCC memos

But Radio Amateurs are more than stewards--they also push the state of the art.

Three examples from among my close friends:

Al Katz EME

Fritz Raab MF Propagation

Mark Hansen HF Propagation

Who are these guys?

Al Katz Amateur Radio Station K2UYH  
Princeton, NJ

Bouncing signals off the moon at 432 MHz since 1974. Editor of Journal on EME Communications, Organizer of annual international symposium, IEEE Fellow, professor, and CEO of high tech company.

Al's amateur radio station has mentored several generations of young microwave engineers.

Earth-Moon-Earth path loss ~260 dB

Fritz Raab Amateur Radio Station W1FR  
New Hampshire

Organizer of 500 kHz propagation experiment after FCC decommissioned Shipboard Distress frequency. Result--World Administrative Radio Conference recommissioned that band at most recent meeting. IEEE Fellow, CEO of high tech company.

Mentor of several generations of young Radio Frequency engineers.



Mark Hansen Radio Station KI7N  
Oregon

Combined Arduino keyer and 20 foot indoor wire antenna with 10 milliwatt lab signal generator tuned to 10.140 MHz. His signals has been copied using DSP to dig deep into the noise floor via ionospheric weather... in Florida.

Young dad, local Oregon kid, Cascade Microtech  
1/f Noise Expert.

The Electromagnetic Spectrum is a shared resource, and has open spaces protected from commercial development.

For the past century we have been able to experience radio waves with simple and profound technology, just as we can use simple and profound technology to explore the rest of the natural world.

Example: Sunrise over Timothy lake in the Oregon Cascades, courtesy of PGE.



## Summary:

Science: There is more than you can see with a spectrum analyzer or mobile device.

Public Policy: Those old guys were smart and good stewards--we should make changes cautiously.

Stewardship: Amateurs and Radio Scientists are good stewards and actively advancing the state of the art--consider joining them...

<http://www.arrl.org>

When it comes to the Electromagnetic Spectrum,  
Conservation is OK



p.s. note the Marconi rig