Radio Frequency Spectrum Management Workshop

Mayaguez, Puerto Rico
May 23 - 27, 2016

National Radio Regulations

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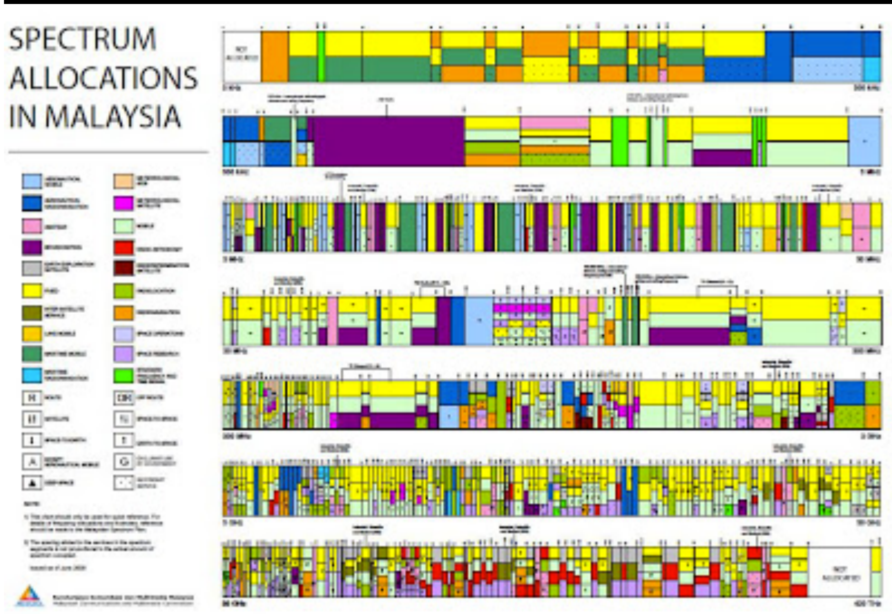
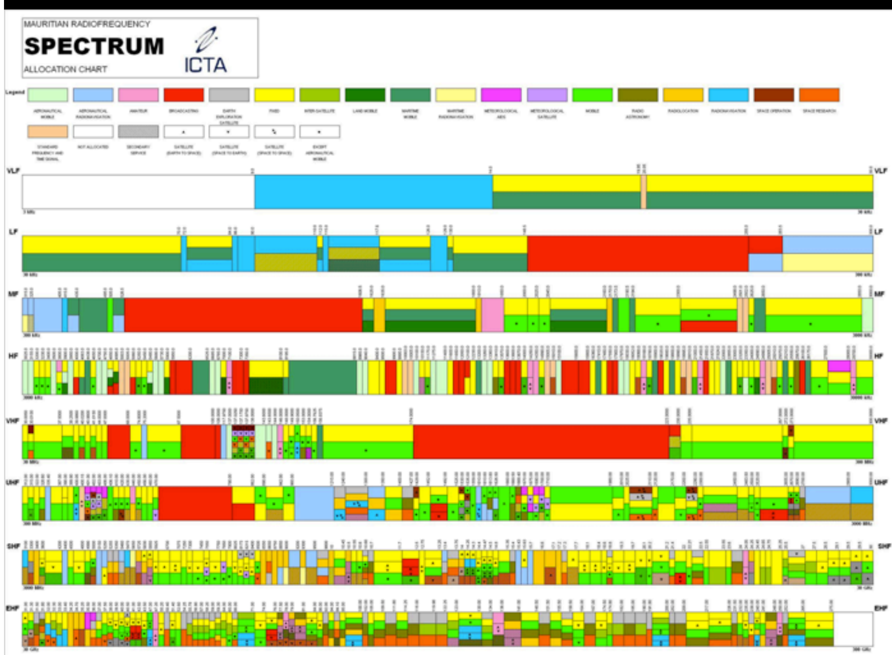

SPECTRUM
ALLOCATIONS
IN MALAYSIA
NOT ALLOCATED


Republic of the
PHILIPPINES
FREQUENCY
ALLOCATIONS
THE RADIO FREQUENCY SPECTRUM
NOT ALLOCATED

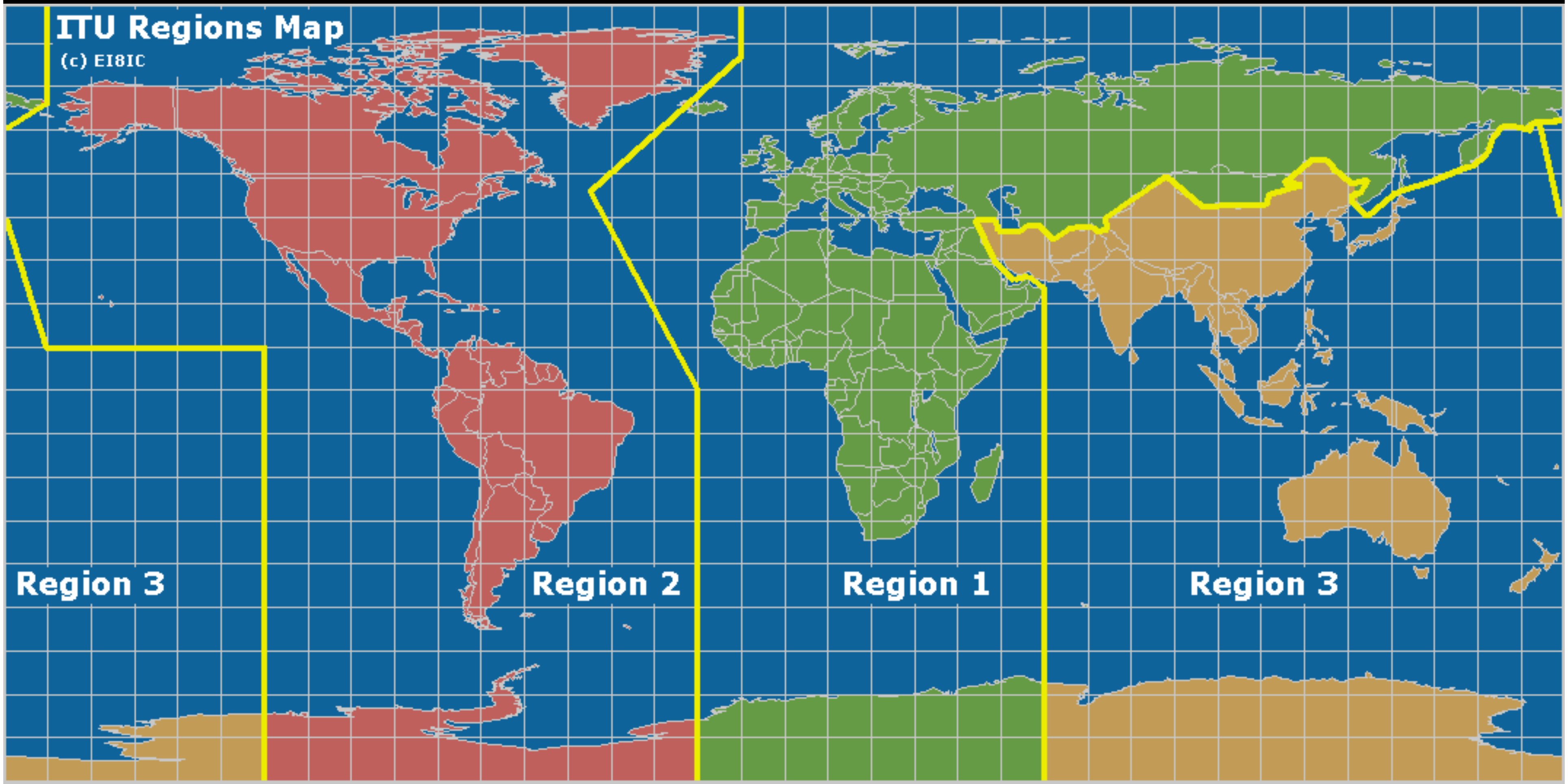

MAURITIAN RADIOFREQUENCY
SPECTRUM
ALLOCATION CHART
ICTA
VLF
LF
MF
HF
VHF
UHF
SHF
EHF


EGYPTIAN
RADIO
SPECTRUM
ALLOCATION
CHART
NTRA
ARAB REPUBLIC OF EGYPT
National Telecommunications Regulatory Authority - NTRA
Radio Spectrum Management Sector
Radio Services Legend
August 2008

How is Spectrum Management Done?

- International uses of the radio spectrum are regulated by the International Telecommunication Union (ITU), a specialized agency of the United Nations, through
  - Radio Regulations (RR)
  - International Table of Allocations
- Countries are sovereign with regard to the uses and the regulation of the radio spectrum within national borders and are under no obligation to adopt or follow the International Table of Allocations within their territory, but mostly do so out of convenience.

ITU Regions



EI8IC's Ham Radio
Resources Website

UN – ITU

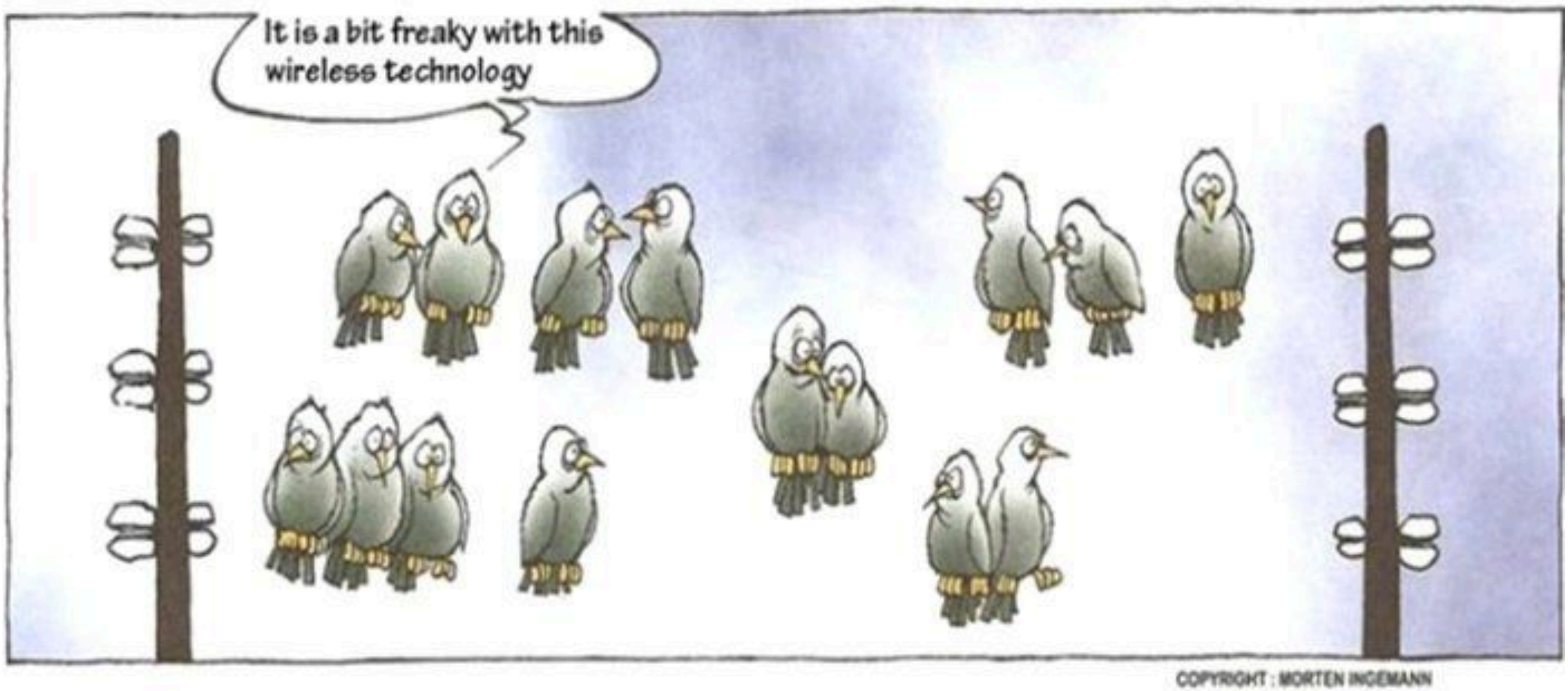
- Formed in 1865: 1st int'l body! (UN in 1945)
- HQ is in Geneva
- National groups correspond to ITU Study Groups & Working Parties
- U.S. participation:

  Coordinated by the

  State Dept.

  - Federal: NTIA
  - Non-Fed: FCC

Questions?


It is a bit freaky with this wireless technology
COPYRIGHT : MORTEN INGEMANN

References

- Handbook of Frequency Allocations and Spectrum Protection for Scientific Uses, CORF, National Academies, 2007
- Spectrum Management for the 21st Century
- NTIA, Handbook on Radio Regulations, 2013
- A.Clegg, 4th IUCAF School, Presentation, Chile, 2014
- T. Gergely, 4th IUCAF School, Presentation, Chile, 2014
- http://www.naic.edu/~rfiuser/smarg-iridium.html
- NASA, NOAA, ITU websites
- C. Renée James, What has Astronomy done for you Lately? www.Astronomy.com
- ITU Handbook on Radio Astronomy, 2013
- A Strategy for Active Remote Sensing Amid Increased Demand for Radio Spectrum, The National Academies Press, Sept 2015

Useful knowledge

For RF Spectrum Managers

- **RF systems; mixers, oscillators, transmission line propagation, etc.**
- **Filter design**
- **Harmonics**
- **Fourier, time-domain, frequency-domain**
- **Microwave and millimeter remote sensors: both passive and active**
- **Research using these bands: C-band, S-band, X-band, Ku-band, K-band, Ka-band, W-band**
- **Microwave Remote Sensing:Atmospheric Attenuation and Propagation, Mie Scattering, Bragg scattering, Rayleigh Scattering**
- **Rain, hail and other hydrometeor effect in atmospheric path delay**
- Radiometer design
- Power flux density, dB/m^2/Hz, Jy
- dBW, dBm, …
- Radar Equation
- Radar range resolution
- Bandwidth – and relation to pulse width, integration time
- Received power Budget (a.k.a. Friis equation)
- Sensitivity equation S/N
- Noise/Interference
- Antenna theory and design; Sidelobes, radiation patterns, beamwidth, Gregorian dish,
- Antenna arrays (interferometry)

Radiometer- Sensitivity

The sensitivity of an observation in radio astronomy can be defined in terms of the smallest power level change ΔP in the power level P at the radiometer input that can be detected and measured. The sensitivity equation is:

$$\frac{\Delta P}{P} = \frac{1}{\sqrt{\Delta f_0 t}} \qquad (1)$$

Detrimental Level Interference Criterion

where:

P and ΔP: power spectral density of the noise

Δf_0: bandwidth

t: integration time. P and ΔP in equation (1) can be expressed in temperature units through the Boltzmann's constant, k:

$$\Delta P = k\, \Delta T; \quad \text{also} \quad P = k\, T \qquad (2)$$

Thus we may express the sensitivity equation as:

$$\Delta T = \frac{T}{\sqrt{\Delta f_0 t}} \qquad (3)$$

At RF frequencies Rayleigh-Jeans applies and *P* is proportional to *T* radiometric Temperature

where:

$$T = T_A + T_R$$

$$T = T_A + T_R$$

This result applies for one polarization of the radio telescope. T is the sum of T_A (the antenna noise temperature contribution from the cosmic background, the Earth's atmosphere and radiation from the Earth) and T_R, the receiver noise temperature. Equations (1) or (3) can be used to estimate the sensitivities and interference levels for radio astronomical observations. The results are listed in Tables 1 and 2. An observing (or integration) time, t, of 2000 s is assumed, and interference threshold levels, ΔP_H, given in Tables 1 and 2 are expressed as the interference power within the bandwidth Δf that introduces an error of 10% in the measurement of ΔP (or ΔT), i.e.:

Assumes t ~ ½ hr
t = integration time = 2000s

$$\Delta P_H = 0.1 \, \Delta P \, \Delta f \qquad (4)$$

The interference can also be expressed in terms of the pfd incident at the antenna, either in the total bandwidth or as a spectral pfd, S_H, per 1 Hz of bandwidth. The values given are for an antenna having a gain, in the direction of arrival of the interference, equal to that of an isotropic antenna (which has an effective area of $c^2/4\pi f^2$, where c is the speed of the light and f the frequency). The gain of an isotropic radiator, 0 dBi, is used as a general representative value for the side-lobe level, as discussed under § 1.3.

Antenna gain is assumed = 1dBi

pfd= power flux density

Values of $S_H \, \Delta f$ (dB(W/m^2)), are derived from ΔP_H by adding:

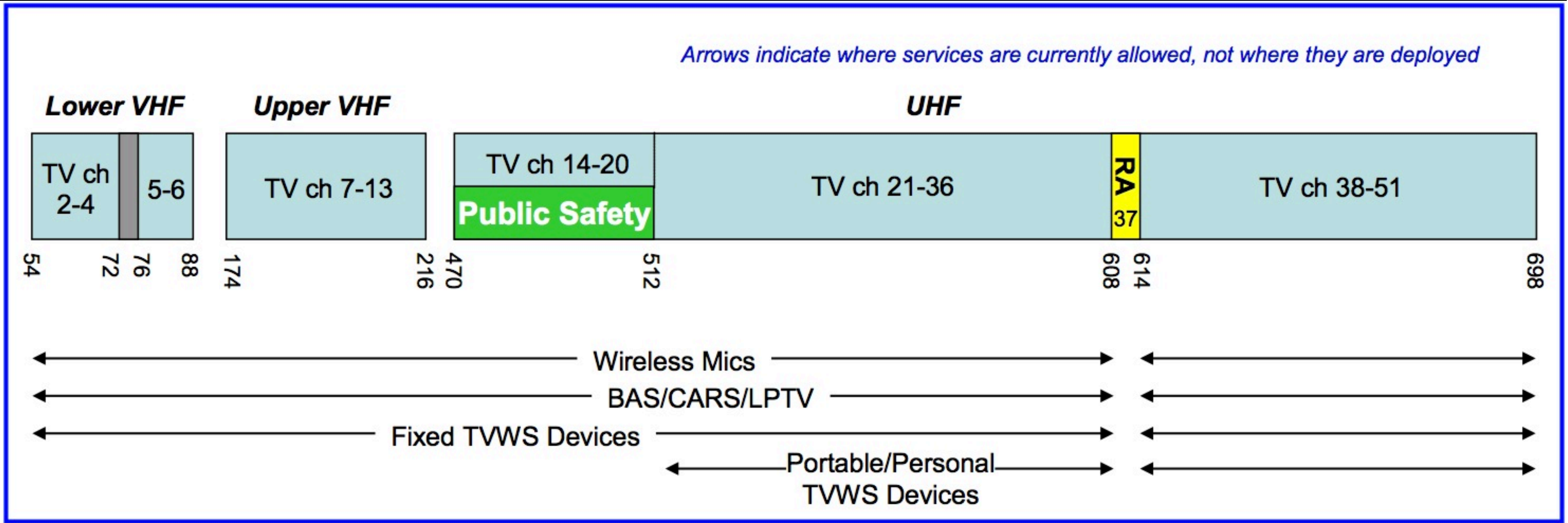
Isotropic $A^i_e = c^2/4\pi$
10 A^i_e =-158.5dB

$$20 \log f - 158.5 \quad \text{dB} \qquad (5)$$

This is the Sensitivity of radiometers like Arecibo

where f (Hz). S_H is then derived by subtracting 10 log Δf (Hz) to allow for the bandwidth.

Channel 37



Arrows indicate where services are currently allowed, not where they are deployed
Lower VHF
Upper VHF
UHF
TV ch 2-4
5-6
TV ch 7-13
TV ch 14-20
Public Safety
TV ch 21-36
RA 37
TV ch 38-51
54
72
76
88
174
216
470
512
608
614
698
Wireless Mics
BAS/CARS/LPTV
Fixed TVWS Devices
Portable/Personal TVWS Devices

The Bizarre Case of LightSquared and GPS

March 23, 2011 11:55 AM Filed in: GPS | FM/ILS | GPS/LightSquared

> FUD (fud) n. 1. a method of disparaging an opponent by avoiding the specifics of an issue and creating a smoke screen of "fear, uncertainty, and doubt"

The spectrum struggle of LightSquared to obtain permission to use its spectrum for terrestrial broadband use in addition to the mobile satellite use it is already licensed for looks like it will be a classic one at FCC, bringing back elements of previous epic struggles like Northpoint/MVDDS, UWB, AWS-3/M2Z, and PCS H block. These all involved a proposed new spectrum use that threatened incumbent users with possible interference.