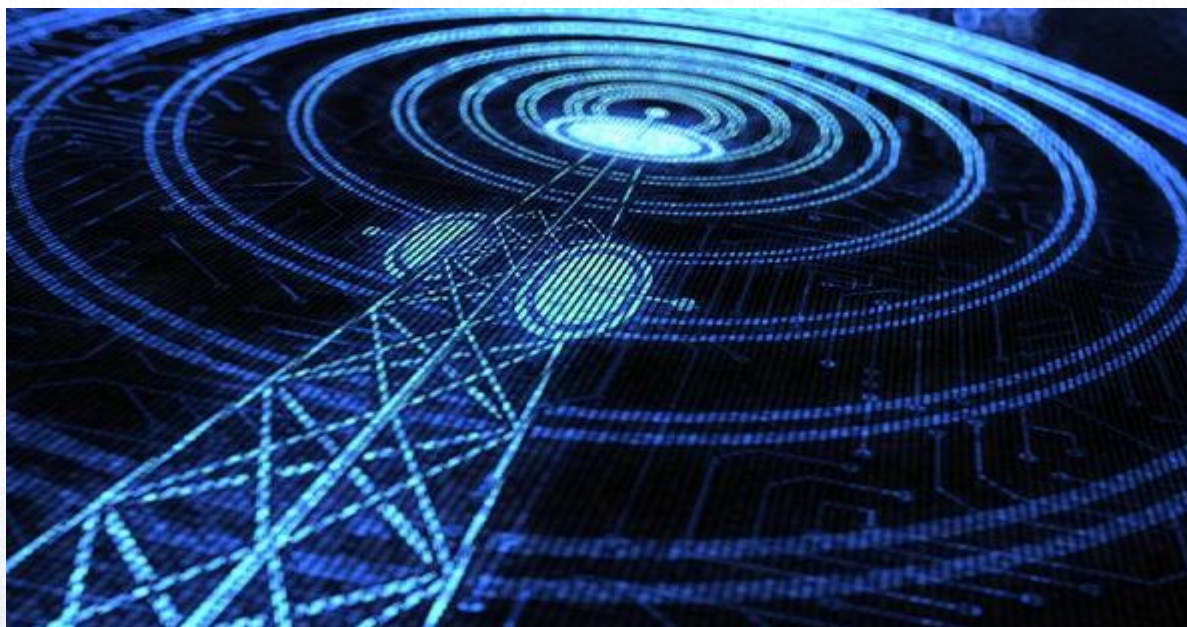


Wireless Spectrum Research and Development (WSRD)
Promoting Economic Efficiency in Spectrum Use

*Jumpstarting Investment
Investor and Legal Perspectives*



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Who We Are



Barlow Keener

- White Spaces regulation and transactions
- Muni-Wi-Fi and fiber optic construction legal issues
- Practicing telecommunications law for 20 years
- Represent fiber optic service providers
- Distributed Antenna System (DAS) projects
- Former in-house counsel for RBOC and CLEC
- B.A., University of the South
- M.A., North Carolina Central Univ.
- J.D., Emory University School of Law

J. Armand Musey

- President/Founder Summit Ridge Group, LLC
- Satellite, Media and Telecom Valuation and Financial Advisory
- Significant work in spectrum valuation
- Former top-ranked Wall Street research analyst
- Former partner in boutique investment bank
- Chartered Financial Analyst (CFA)
- B.A., University of Chicago
- M.A., Columbia University
- JD/MBA, Northwestern University

The Conflict The Opportunity

Exclusive
License
Auctions
1993

Verizon invests
\$10b annually



“Verizon Wireless alone
has invested more than
\$80 billion since
2000....

This investment relied,
in part, on the
Commission’s **exclusive-
use licensing** regime ”

Unlicensed White Spaces
Foundation 2008 -2010



Shared Spectrum



Small Cell 3.5 GHz 2012

- ↓ Exclusive Licenses
- ↓ LSA Licensed Shared Access
- ↓ ASA Authorized Shared Access
- ↓ Unlicensed

Unlicensed
Spectrum
2.4 GHz
1985

Public invests
\$10b annually

“Combined annual
contribution ..\$50 to
\$100 billion per year.”

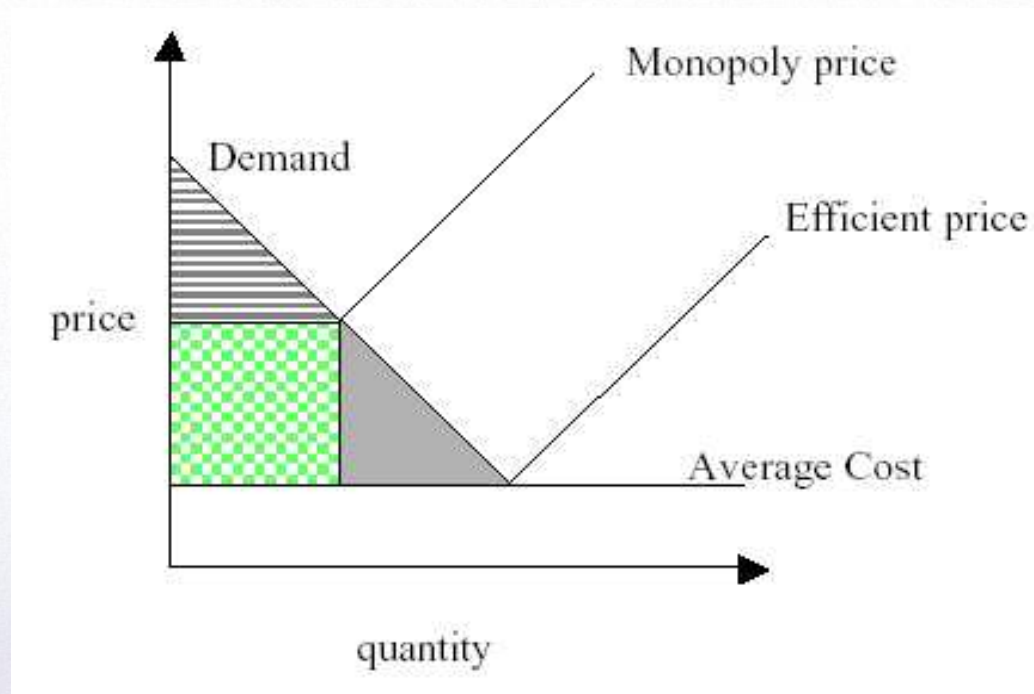


Wi-Fi: 800m homes 2016

U.S. 85m homes (65%)
Home Wi-Fi RANs =
Investment ~\$10 to \$4
billion annually home
Wi-Fi LAN

Licenses Provide Quasi Monopoly/Oligopoly type Competition

- Prevent competitors from entering
- Allows for abnormal non-competitive profits



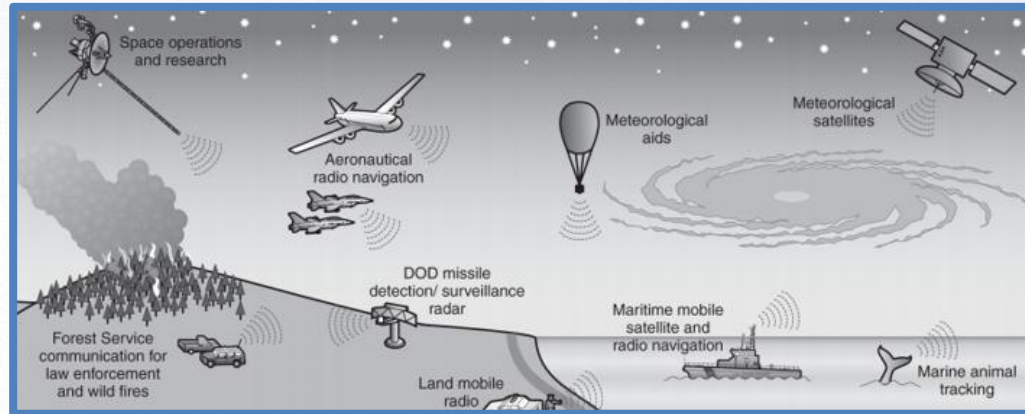
Source: http://www2.warwick.ac.uk/fac/soc/law/elj/lgd/2003_2/gupta/

No License – Investment Case is Hard

- Venture capital firms want chance at super-sized returns
 - Expect many portfolio firms to fail
 - Hope for a few “home runs”
- Hard to get “home runs” without barriers to entry
- Private equity firms want proven cash flow they can lever
- Hard to know capacity you will be getting – may only get a small fraction of spectrum capacity after making large investment
- Can be tough to find a spot for shared-spectrum service companies

The Spectrum Sharing Formula

Spectrum Sharing = Spectrum Demand + Technology Innovation + Regulation



Limited Licenses Granted for Use of a Public Asset

- **Particular Spectrum** like 692MHz to 698MHz (Channel 50)
- **Particular Spectrum size:** 6MHz – TV, 5MHz blocks mobile, 60MHz 2.4GHz
- **Limited Uses:** Fixed, Broadband, Land Mobile Radio (LMR), Radar, Mobile
- **Specified Technology:** Power, Antennas – for both receiver and transmitter
- **License Time Limitations:** 10 years (mobile) or 10 milliseconds



Examples of allocated uses									
	Maritime navigation signals	Navigational aids		AM radio, Maritime radio	Shortwave radio	Broadcast television, FM radio, navigational aids	Broadcast television, cellular telephone	Space and satellite communications, microwave systems	Radio astronomy
Frequency	3 kHz	30 kHz	300 kHz	3 MHz	30 MHz	300 MHz	3 GHz	30 GHz	300 GHz

Shared Spectrum Chronology

1985 2.4GHz Unlicensed - Part 15

1999 DARPA Paul Kolozody, XG program >> taken over by Preston Marshall

- **FCC Spectrum Policy Task Force:** Paul Kolozody & FCC Chairman Michael Powell

2004 FCC White Spaces Order

“feasible for new types of **unlicensed equipment to share spectrum** in the TV bands”

2008 FCC First Report & Order Database, Spectrum Sensing, Geo-location

2010 FCC 2nd Memorandum Opinion & Order Database Yes, But Sensing is Optional

Ofcom 2011, Priority European Union

PCAST 2012 LSA, ASA Priority using 1000 MHz federal spectrum

“The devices will use geo-location technology ... and **a database look-up** that identifies the unused channels that are available at their location. This type of “opportunistic use” of spectrum has great potential for enabling access to other spectrum bands and improving spectrum efficiency.”

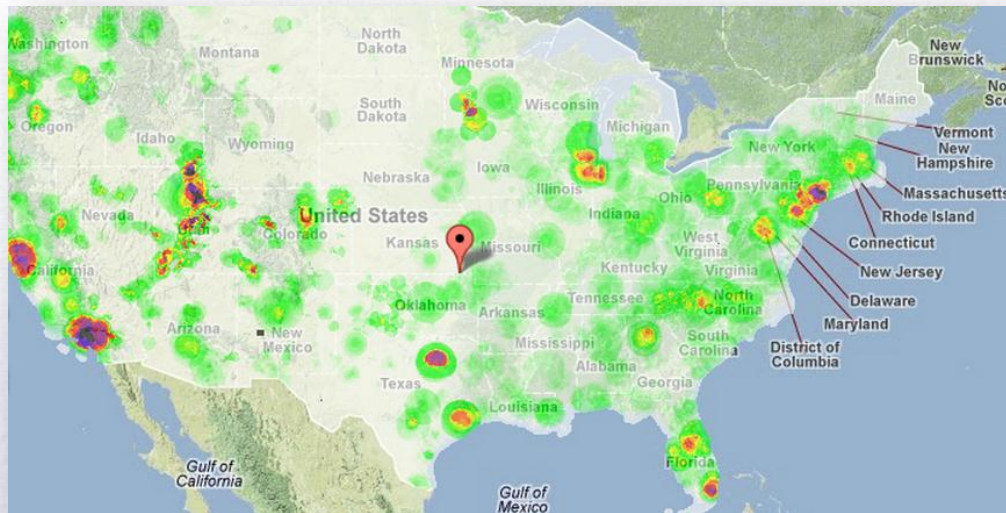
Sensing Out, Database In...

Investor Opportunity Like NPAC or ENUM

“... the geo-location and **database access method** ... will provide adequate and **reliable protection** ... so that spectrum sensing is not necessary.”

“... **spectrum sensing will continue to develop and improve.** ... spectrum sensing may very well be included in TVBDs on a voluntary basis for purposes ...”

Databases will incorporate spectrum sensing data from devices
Magnifying Sensing Data From Radios

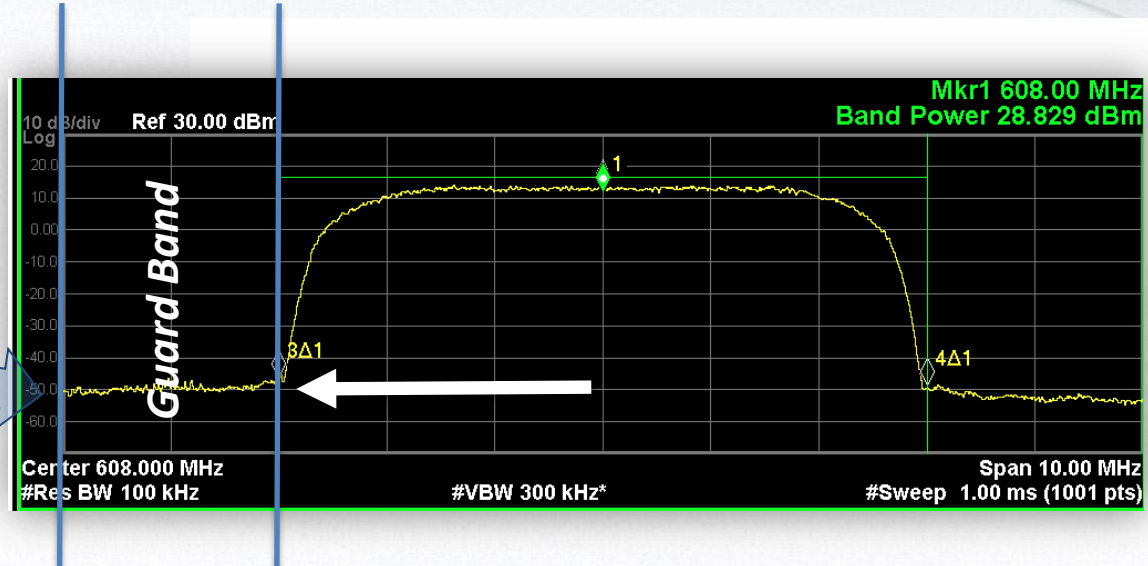


Receiver Regulation

Lightsquared <=> GPS Receiver Interference

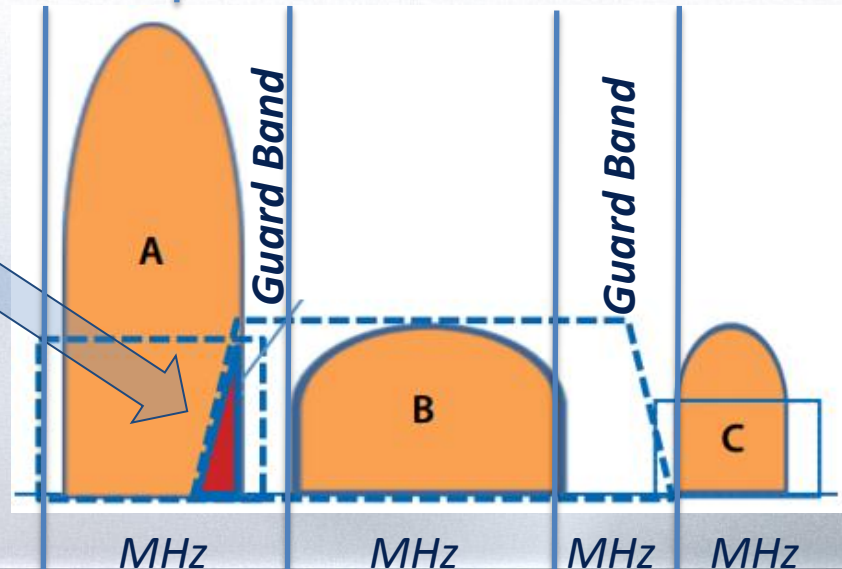
FCC 2008 Shared Spectrum

Order: "All unlicensed TV band devices will be required to limit their out-of-band emissions in the **first adjacent channel** to a level -55 dB below the power level in the channel they occupy, as measured in a 100 kHz bandwidth."



FCC 2010 Shared Spectrum

Order: "We recognize the petitioners' argument that tighter emission limits **could result in higher equipment costs.**"



Equipment Providers are Critical

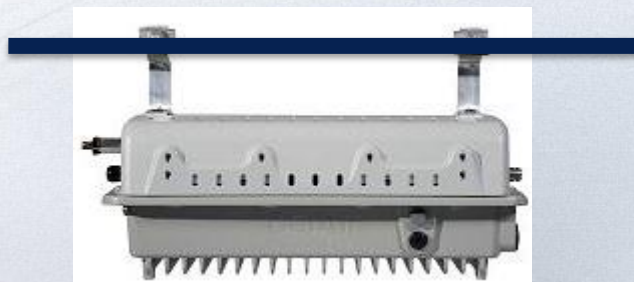
- Equipment providers have barriers to entry in the form of their proprietary technology.
- Seek vendor financing when possible
- In shared spectrum, equipment providers are smaller and often seeking their own financing
 - Possible two-step process
 - Equipment companies get financing
 - Equipment companies use part to finance customers
- Large telcos may pressure equipment providers to avoid supporting small shared spectrum startups

FCC 3.5 GHz Small Cell Docket

Evolution is from DAS to ➡ Small Cell

Option #1: 3rd Party Ownership ➡ DAS Networks Built & Managed

Option #2: Customers Own ➡ Wi-Fi – Femtocell/LTE



Some Solutions

- Separate infrastructure from service provision
 - One infrastructure company can serve many service providers
 - Tower companies are reasonably well positioned to do this
- European Model
 - Customers getting DSL/Cable modem get Wi-Fi routers with a public network
 - Wireless service would be at least partially done by wireline operators.
 - May result in spotty coverage

Sensing Opportunity

Sharing Federal Spectrum

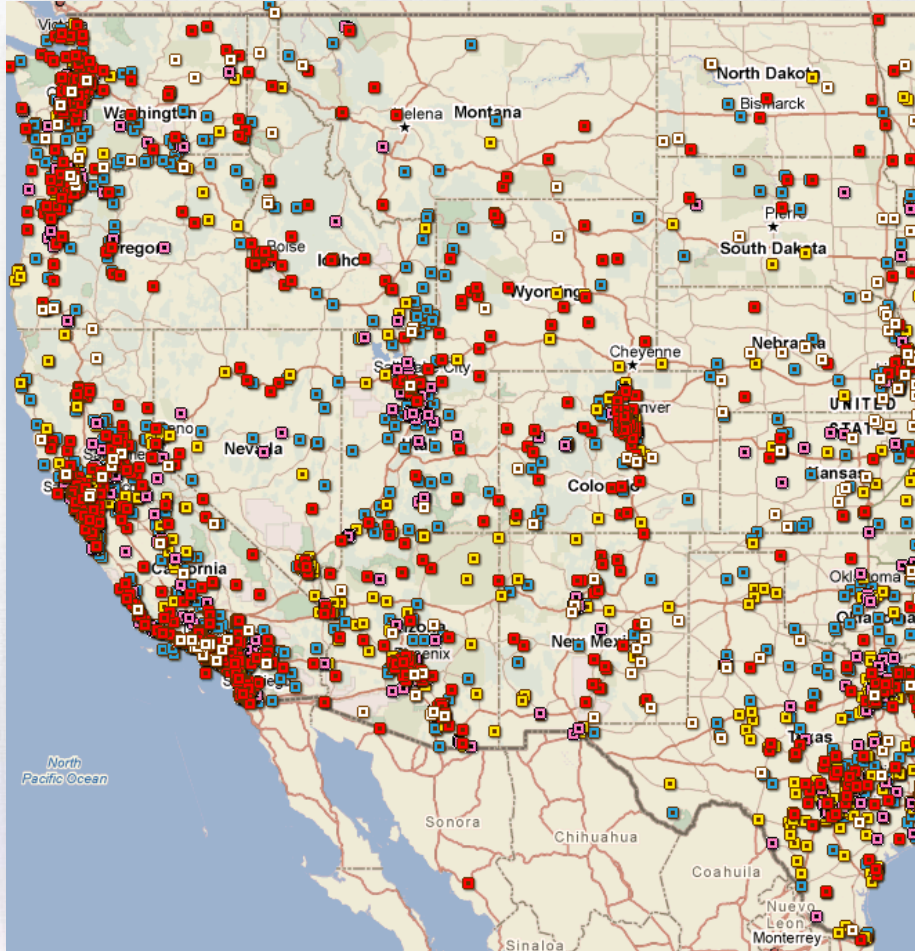
3550-3650 MHz



Fallow Spectrum

“Use it or Share It”

Regulators Require Use of Spectrum or, if Not Used, License



FCC / Regulators Create Investor Opportunity:

“Use it or Lose It” changes to....

“Use it or Share It”

Opening for Fallow Spectrum Carriers

Roaming Revenue or Lease Revenues

Similar to DAS

Database tracks Use

Must Create Other Entry Barriers

- Examples
 - Long-term customer contracts
 - “Lock-up” distribution channels
 - Exclusive alliances with valuable hardware providers
 - Proprietary hardware standards
 - Sub-contracts with existing service providers (backhaul, remote service provision etc.)
 - Others
- These can be fundamental business decisions – make with care

Thank you

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