

Realizing the Full Potential of Government-Held Spectrum to Spur Economic Growth

President's Council of Advisors on Science and
Technology (PCAST)

Jan 9, 2013

Key PCAST Members and Spectrum Experts

PCAST Members

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- **John Leibovitz**, Federal Communications Commission
- **Douglas Sicker**, National Telecommunications and Information Association
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Invited Experts

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- **Vanu Bose**, Vanu Inc.
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- **Michael Katz**, University of California, Berkeley
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- **William Lehr**, Massachusetts Institute of Technology
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- **Preston Marshall**, University of Southern California
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- **Mark McHenry**, Shared Spectrum
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- **Jeff Reed**, Virginia Tech
- **Dennis Roberson**, Illinois Institute of Technology
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- **Pierre de Vries**, University of Colorado, Boulder
- **Kathleen Wallman**, Wallman Consulting, LLC.
- **Tom Wheeler**, Core Capital

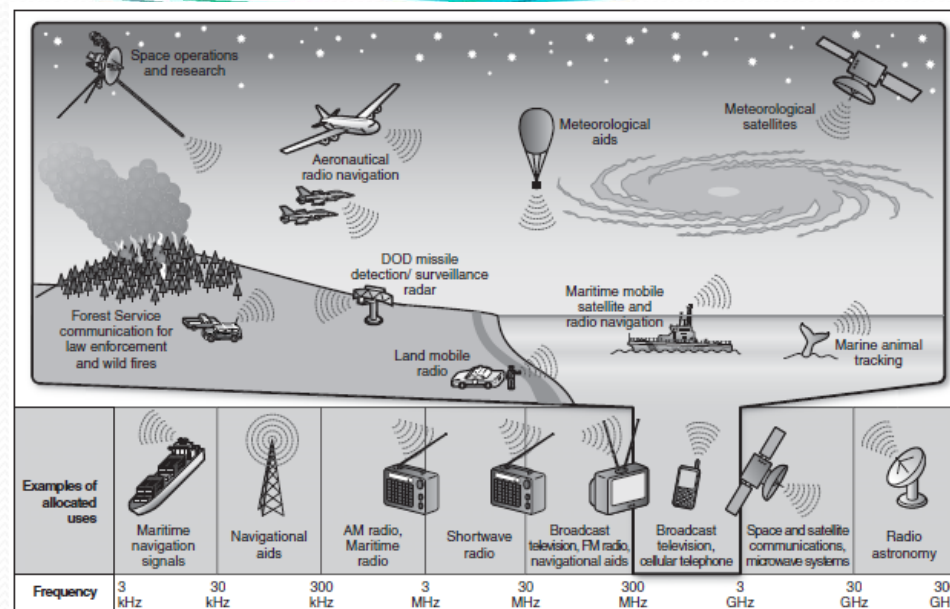
Why Do We Need to Repurpose Spectrum?

- **Presidential Memorandum of June 2010 requires 500 MHz of spectrum to be made available for commercial use within 10 years**
- **Huge WW Mobile Device Growth Opportunity (2020)**
 - \$4.5T Global Value
 - M2M Wave next
 - 50B devices
 - Zetta-bytes of Data
- **Enhanced Mobile Devices are Already Leading to a US Bandwidth Deficit**
 - Data more than doubled 4 years in a row
 - Smartphones generate 24X data of basic-feature cell phones
 - Tablets create 5X more traffic than smartphones
- **Federal Agencies also need more Spectrum**
 - DOD unmanned aerial systems increased 45X in 8 years

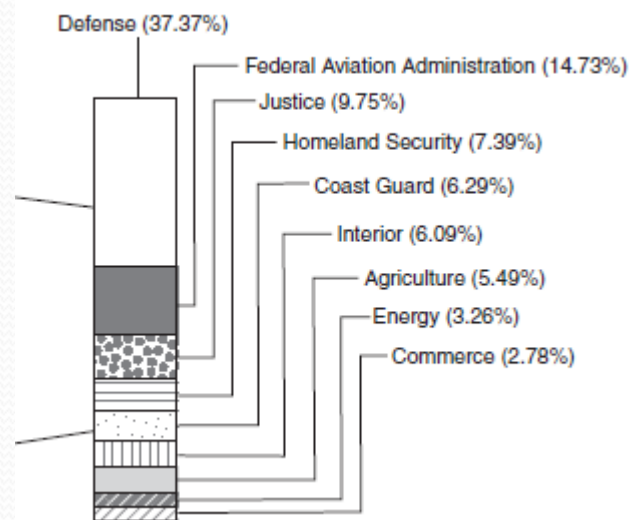


PCAST Study Concentrated on Federal Spectrum

- **Clearing and Reallocation of Federal Spectrum is Not Sustainable.**
 - Recent NTIA Study - Clearing of just one 95 MHz band will take 10 years, **cost \$18 billion**, and cause significant disruption.
 - Net revenue from last successful auction of 45 MHz realized a **net income of just a few hundred million a year** for the government. (\$5.3 billion total)
- **More Efficient and Immediate Use of Federal Spectrum will be Obtained through Sharing**



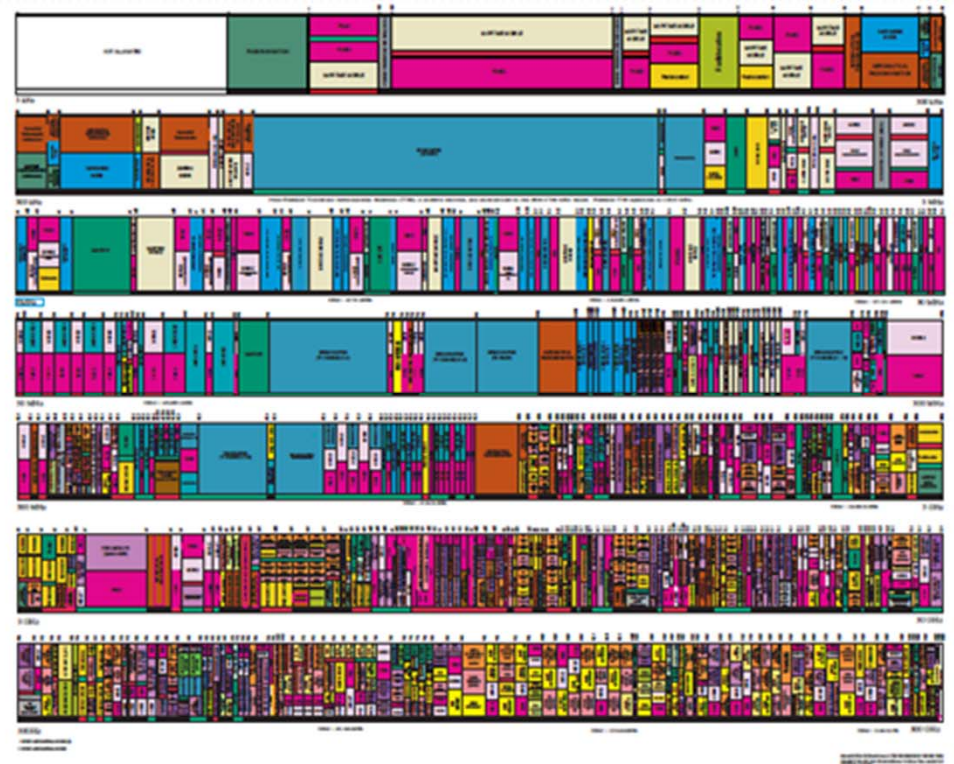
Source: GAO analysis of NTIA, federal agencies, and industry information.



Today: Wireless Spectrum Master Zoning Plan

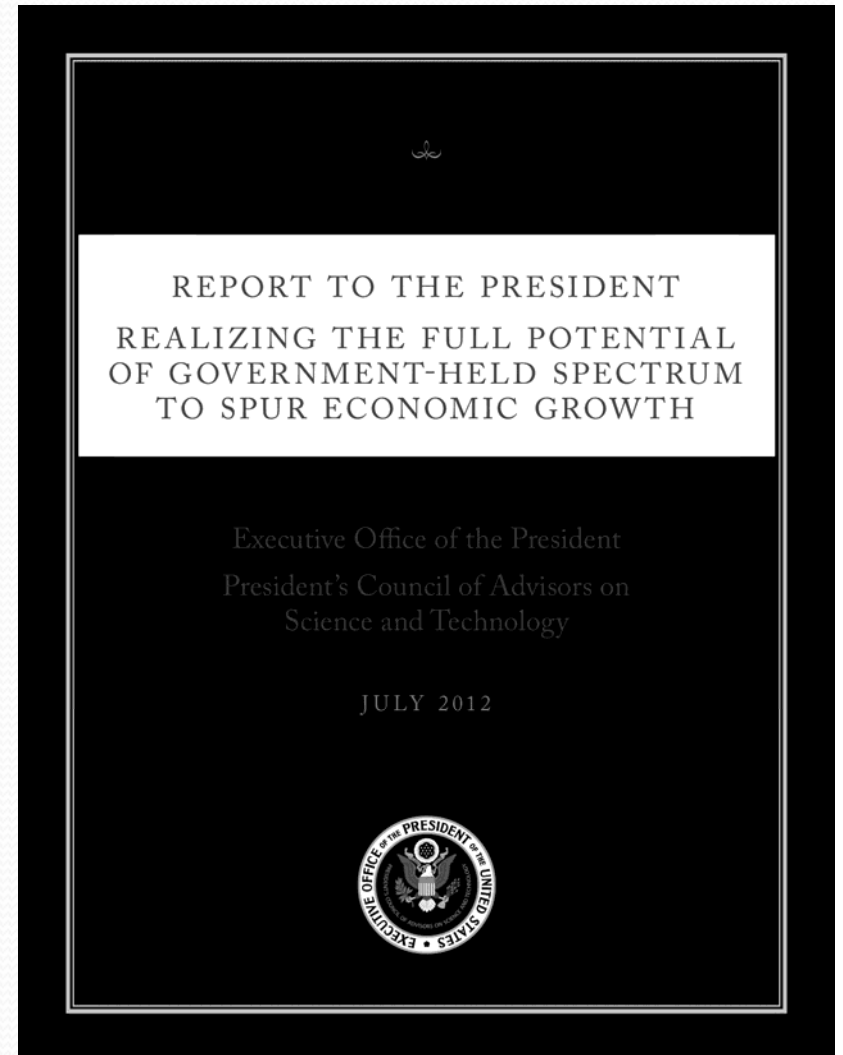
Fragmentation of spectrum for exclusive Federal use leads to artificial scarcity and constraints on current and future users.

UNITED STATES FREQUENCY ALLOCATIONS THE RADIO SPECTRUM



PCAST Recommendations and the Opportunity for Innovation in Wireless

- **Presidents Council of Advisors on Science and Technology (PCAST) Report Looks at Spectrum Policy from a New Perspective**
 - **Addressed Not Just Traditional Spectrum Policy, but also Spectrum as an Instrument for Innovation in Technology, Services, and Architectures**
- **Proposed Fundamentally New Concepts in Spectrum Sharing, Spectrum Markets, and Architectures**
- **Enable Emergence of a Wider Range of Wireless Solutions than can be Supported by Today's Spectrum Policy**

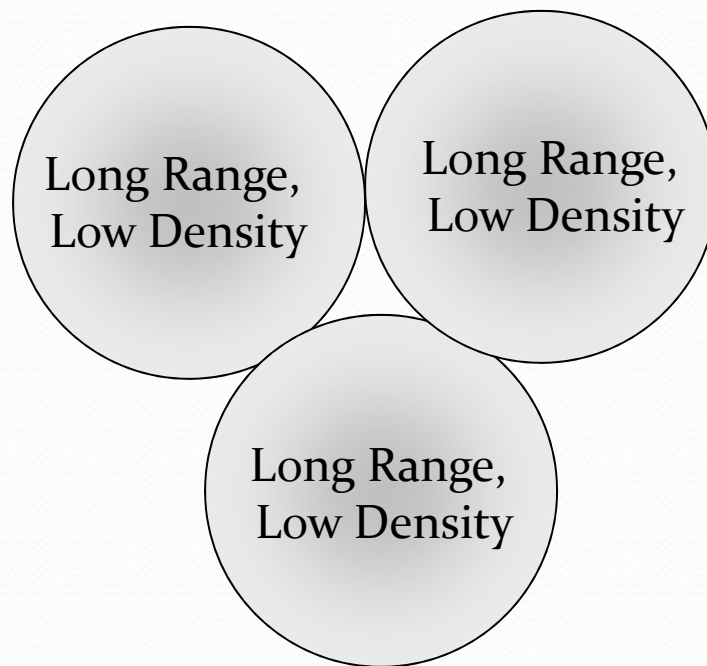


Why Architecture and Spectrum Policy is Critical for Wireless Capacity

- **Internet (Wired) Growth Based on Scalable Bandwidth**
 - Doubling Bandwidth is less than double the cost
 - One Fiber carries 3,800 GHz of Bandwidth (in Optical C-Band)
 - Each Wired Path is independent – No Interaction or Trades
 - Example – Ethernet has gone from 1 to 10 to 100 MHz to 1 GHZ, and now 10 GHZ+ in just several decades
- **Wireless Fundamentally Different**
 - Spatial Bandwidth Available is Finite, Fixed, and Shared
 - Adding Bits to Spectrum Comes at Increasing Energy/Bit (Shannon's Capacity Bound)
 - Most Wireless Usage is within a total of 5.3 GHz (.7 to 6 GHz) Extent! (1/750th of one C-Band Fiber)
- **Yet, We want to “mimic” what we do on a scalable media to one that is fundamentally un-scalable**

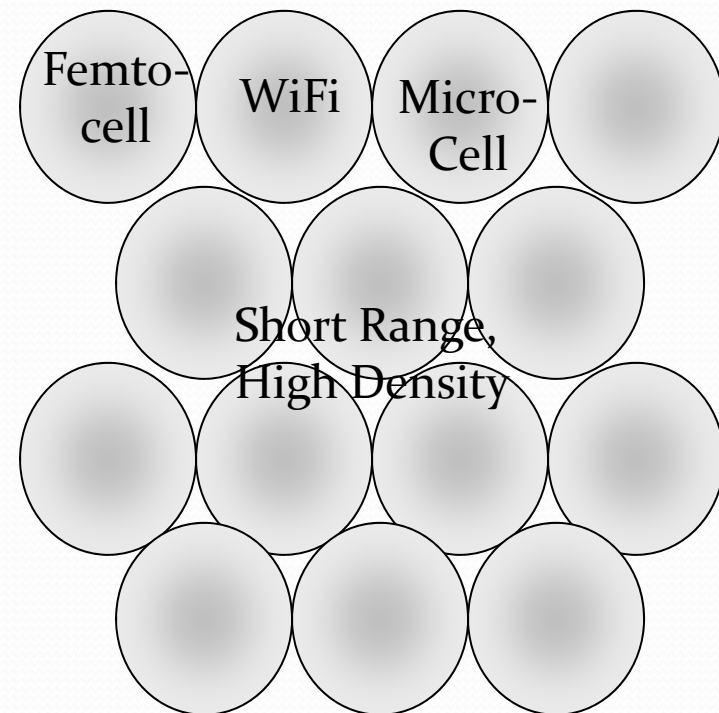
The Architecture Transition Needed for Wireless Equivalency

Today's Wireless Infrastructure



Optimized for Coverage

Emerging Wireless Infrastructure



Optimized for Aggregate Capacity

Opportunity or Inevitability?

Three Drivers –

- 1. Spectrum Sharing is the Only “Untapped” Resource Capable of Providing 100’s of MHz of Spectrum for New Innovation**
 - Process for this is not Clear, but we should Assume the Eventual Outcome
- 2. Dense, Heterogeneous Spectrum Usage will drive the need for, and development of, New technology**
 - Manual Deconfliction of Spectrum through Existing Policy Structures to Ensure Absolute Protection too Slow, Unpredictable, Ineffective, and Wasteful of Spectrum Resources
- 3. Cellular is Transitioning from “Building Out” for Coverage to “In-Building” for Capacity**
 - Higher Frequencies, Lower Antennas, Lower Power all Advantageous for Maximizing Capacity (More Like WiFi than AMPS towers!)

Profound Impacts on the Technology Needed to Build Systems

Operation in Dense Spectrum Reverses Many of the Dominant Design and Technology Concepts from Less-Dense Spectrum

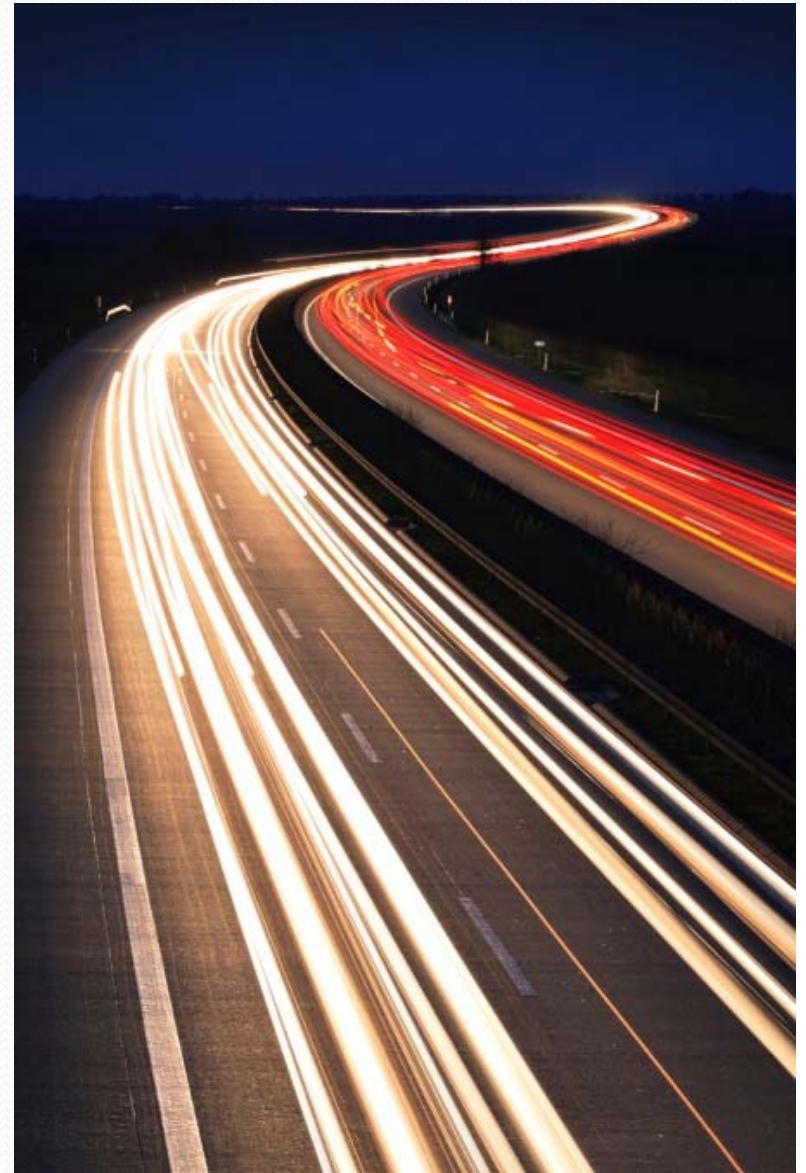
Tomorrow: Shared-Use Spectrum Superhighways

PCAST recommends the President issue a new memorandum that:

- states the policy of the U.S. government is to share underutilized Federal spectrum; and
- identifies immediately 1,000 MHz of Federal spectrum for sharing with the private sector; and

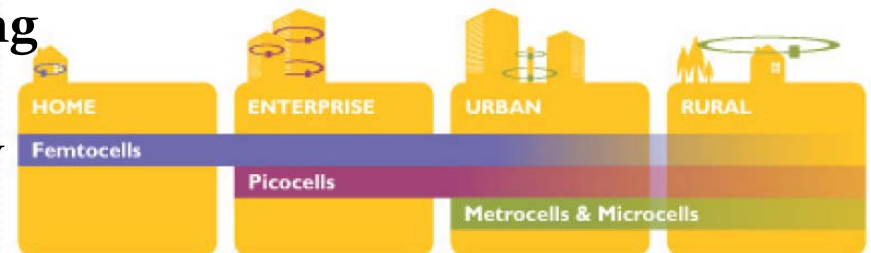
The New Spectrum Superhighway:

- Divides spectrum into substantial blocks with common characteristics
- Makes sharing by Federal users with commercial users the norm
- Measures spectrum effectiveness using a new metric
- Increases capacity by 1,000's of times.



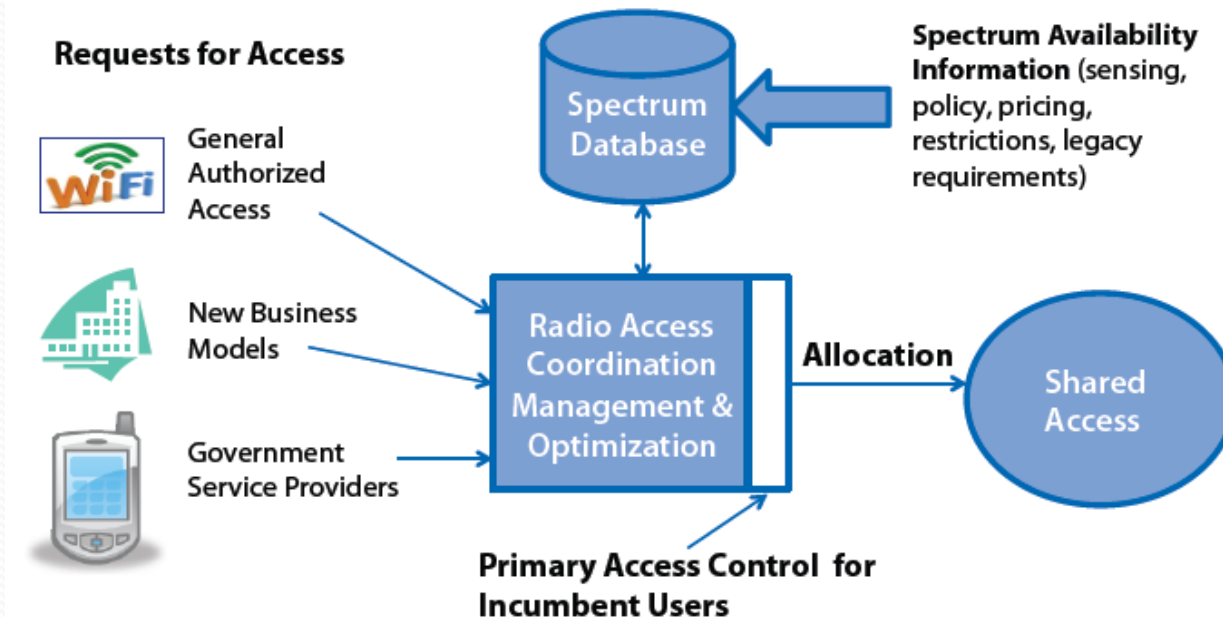
Start Now: Use Existing Technologies

- **Database Management Technology**
 - Geo-location Database Management is already being implemented by FCC in TV Band
- **Policy Immediately Enables Existing Technologies such as Small Cell**
 - Optimized for Aggregate Capacity
 - Lower power technologies make sharing with Federal users more viable
 - Can exploit spectrum unsuitable for high power uses
- **PCAST report Not Dependent on new device technologies like Cognitive Radio, Smart Antenna, DSA**
 - a sharing architecture will accelerate innovation cycles and investments
 - they will further increase effectiveness



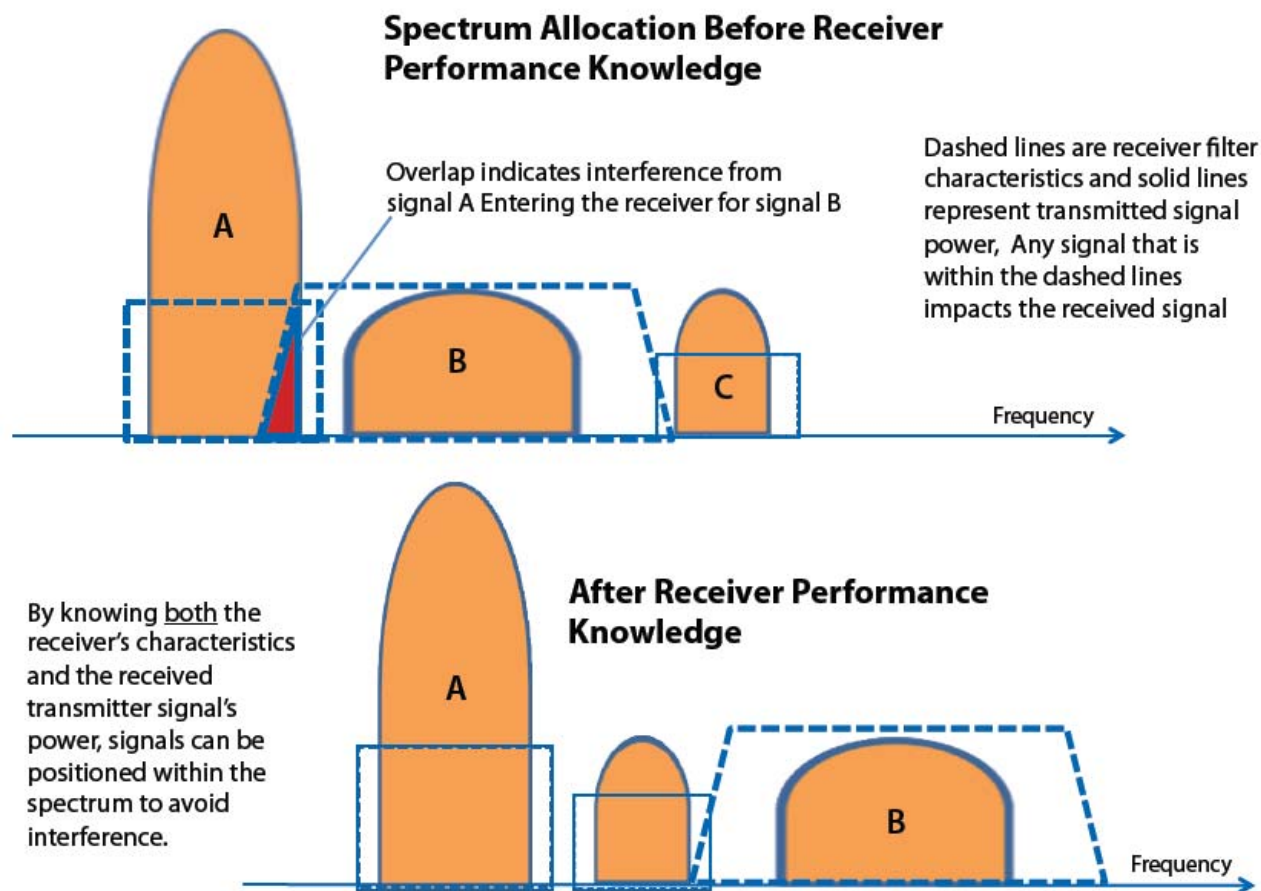
Recommended: New Federal Spectrum Access System

- **Implement a Federal Spectrum Access System**
 - **Hierarchy of Users**
 - **Federal Primary Access (Incumbent)**
 - **Secondary Exclusive Access (Accommodates non-shared access technologies like LTE or Quality of Service Applications)**
 - **General Authorized Access**
 - **Geo-location Database with policy information**
 - **Sensing option for Federal Systems**
- **Allow Access to Unused Spectrum**



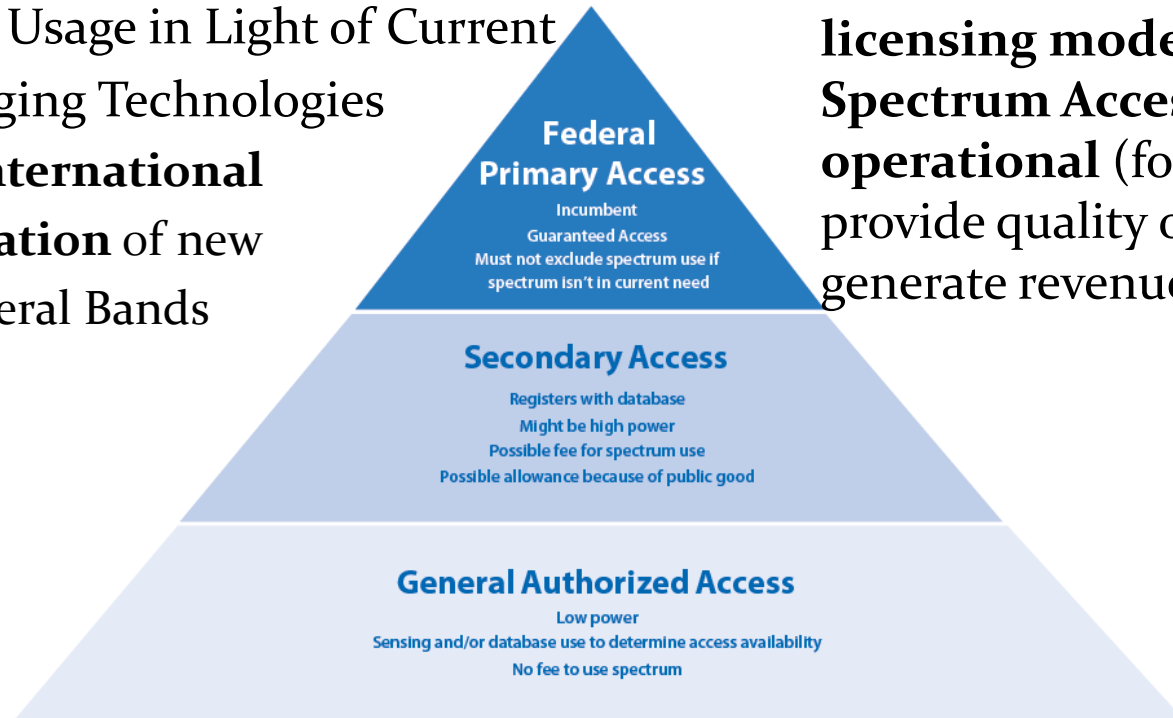
Recommended: Receiver Management Framework

- **Receiver not just Transmitter Focus**
 - Establish minimum technical standards for coexistence of transmitters and receivers to enable flexible sharing. Many ways to consider it.



Recommended: Federal Spectrum Management Mechanisms

- **Formalize a White House-based Spectrum Management Team (SMT)** of the U.S. Chief Technology Officer, National Security Staff, Office of Management and Budget, and National Economic Council to work with the National Telecommunications and Information Administration.
- **Reexamine Partitioning of Federal Spectrum Usage in Light of Current and Emerging Technologies**
- **Support International Harmonization of new Shared Federal Bands**
- **Implement a Mechanism that gives Federal Agencies Incentives to Share Spectrum** (e.g., Spectrum Currency)
- **Redefine Existing Spectrum Relocation Fund to Revolving “Spectrum Efficiency Fund”**
- **Experiment with new shorter-term license economic licensing models once a Spectrum Access System is operational** (foster innovation, provide quality of service, generate revenue)

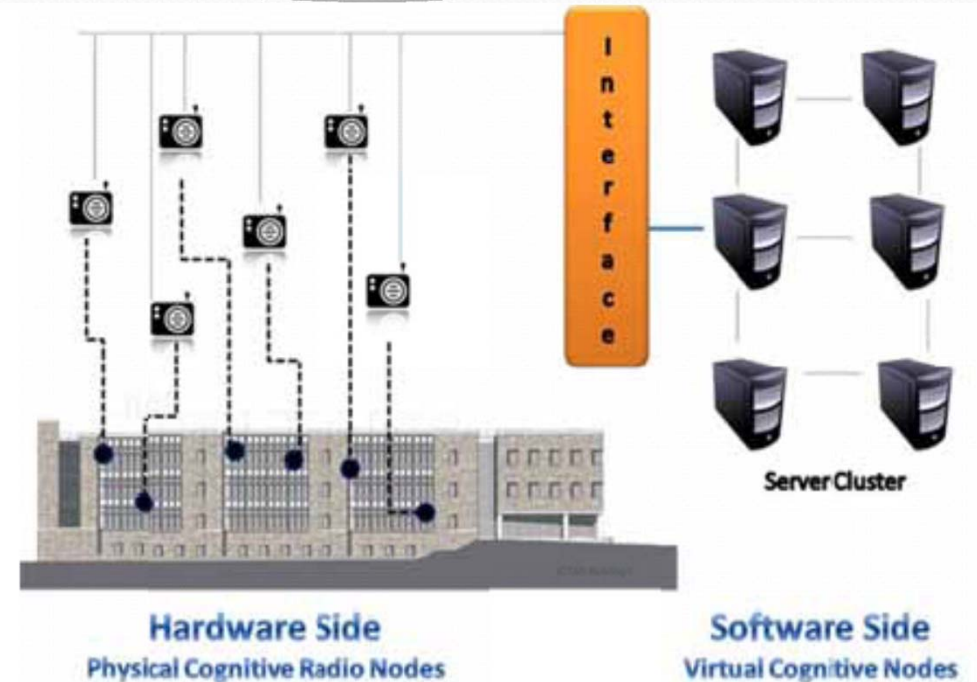


Benefits and Barriers in Getting Started

- **Benefits to Federal Agencies, especially DoD**
 - Eliminate the need for future clearing of spectrum by DoD, ensuring continuity of mission and avoiding major costs associated with the change;
 - Enable military spectrum agile systems to leveraging commercial production;
 - Simplify stateside training by providing access to a wide range of frequencies on a shared basis; and
 - Increase US military effectiveness in deployed environments by offering more flexible equipment that can both leverage and better “hide” within local spectrum.
- **The key barrier to progress remains the trust gap between the commercial and federal user communities.**
 - Federal users must be comfortable that spectrum sharing will not cause harmful interference and that they will have assured access to their spectrum when and where they need it.
 - Commercial users need to gain confidence that the shared spectrum can lead to a viable business model.
 - Neither side has been satisfied with the data generated from simulation or field trial in remote locations.

Recommended: Immediate Pilot Actions

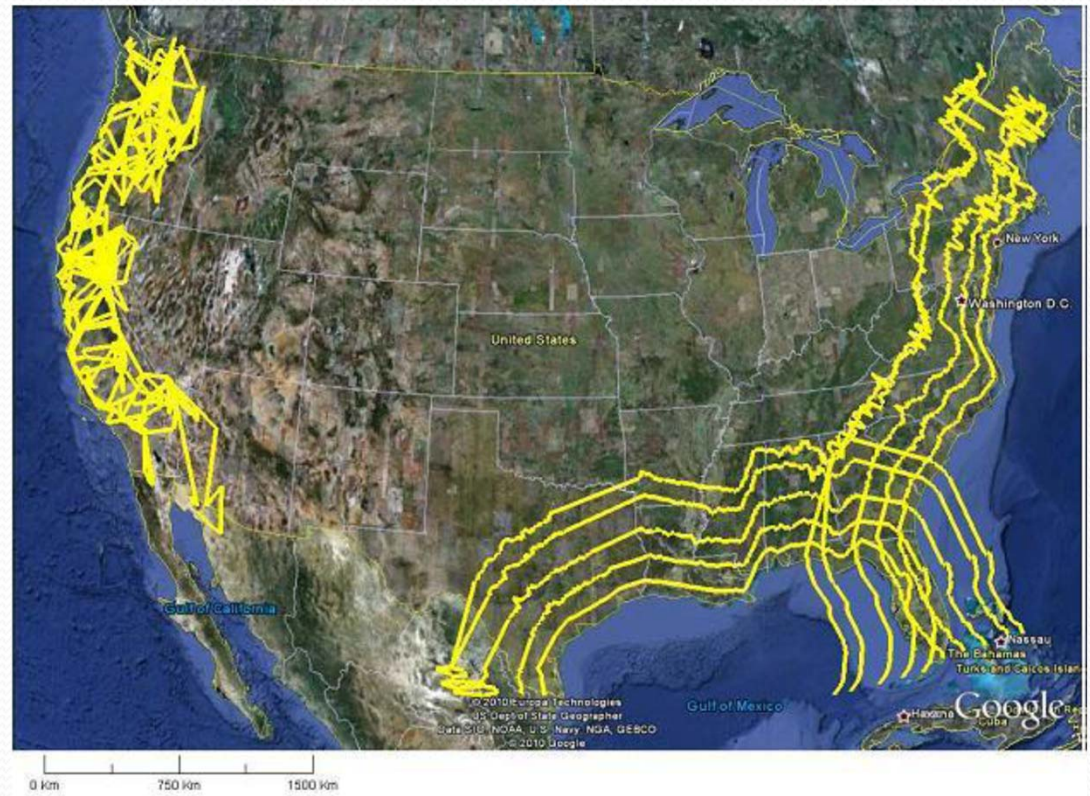
- **Establish Spectrum Sharing Partnership Steering Committee** - an Advisory Committee of C-level Industry Representatives – to Advise on Federal Spectrum Sharing System Implementation
- **Specify and fund the ongoing Scalable Real-World Test Services needed** (a Test City and Mobile Test Service) to test sharing of Federal Bands and Public Safety with industry



Recommended: Immediate Pilot Actions

3550-3650 MHz NTIA Exclusion Zones*

- **Modify Rules to Allow to Operate in two bands in the NTIA Fast Track List – specifically the 3550-3650 MHz (radar bands) and a second band to be determined by FCC and NTIA**



NTIA Fast-Track Report, Figure 5-3. Composite Depiction of Exclusion Zone Distances, Shipborne Radar Systems

Subsequent Activity



CTIA-The Wireless Association® Statement on PCAST Government Spectrum Report

July 20, 2012

WASHINGTON, D.C. – After the President's Council of Advisors on Science and Technology (PCAST) released its report "Realizing the Full Potential of Government-Held Spectrum to Spur Economic Growth,"



- Generally Assumed that Administration Supports the PCAST Concepts
 - Support (In Principle) Expressed by FCC Chairman, Director NTIA, and DoD
- PCAST Proposals Have Met Resistance from some in the Cellular Industry
 - State that Concerned that it will Divert Focus from Clearing and Auctioning Exclusive Use Spectrum
- House Energy and Commerce Subcommittee on Communications and Technology Held hearing on Recommendations, Sept 13, 2012
- FCC Initiated Proceeding to Share 3550 – 3700 MHz Band along Principles of the PCAST Report for Small Cell usage, Dec 12, 2012

FCC Progress – Rule Making in 3550-3700 MHz

- The FCC Commissioners voted 5-0 to begin the NPRM (Notice of Proposal of Rule Making) on Wednesday, December 12, 2012
 - Process to implement the PCAST recommendations of a Spectrum Access System working with small cells in the 3550 to 3650 or 3700 MHz range.
 - Would unlock 100-150 MHz of Federal Spectrum as outlined in the PCAST report. released on July 20th, 2012 and create the first shared Spectrum Superhighway.
- The documents of the NPRM, FCC press release, and commissioner statements are all found at: <https://www.fcc.gov/events/open-commission-meeting-december-2012> .
- The statements of Commissioner Rosenworcel was particularly moving
 - “Today we are taking a peek into the future of wireless topology, technology, and policy.... for some time, the outlook for commercial opportunity in the 3.5 GHz band was not good. But now, based on recommendations from the President’s Council of Advisors on Science and Technology, rather than discarding this band as junk, we are staring at new opportunities for small cells. This is a big deal...”
- A Blog post was also written that day and released by Tom Power, Deputy Chief Technology Officer for Telecommunications at OSTP.
<http://www.whitehouse.gov/blog/2012/12/12/backing-pcast-commissioners-propose-spectrum-sharing>
- A PCAST Op-Ed applauding the FCC action appeared in GigaOm appeared January 5, 2013 <http://gigaom.com/2013/01/05/america-has-plenty-of-wireless-spectrum-we-just-need-a-new-way-to-allocate-it/>

FCC TAC Progress – Receiver Protection Limits Advanced

- The FCC Technology Advisory Council (TAC) formed a Receivers and Spectrum working group to look at receiver protection frameworks.
 - Chaired by Dennis Roberson, a member of the PCAST report technical advisory group.
 - Subgroup picked up where PCAST left off, delving into how to implement the PCAST work and recommendation on this topic in more detail.
 - Released their initial recommendations and a 50-page engineering whitepaper on Monday, December 10th, at the FCC TAC public meeting.
<http://transition.fcc.gov/bureaus/oet/tac/tacdocs/meeting121012/TAC12-10-12FinalPresentation.pdf> .

Other Key Activities of note

- **Industry Leaders accelerating sharing discussion**
 - Verizon CEO offered \$5M to DoD to explore sharing on May 9, 2012
 - T-Mobile granted FCC sharing license for 1755-1780 MHz band on Aug 14, 2012
 - ASA (Authorized Shared Access) / LSA (Licensed Shared Access) system proposed by Qualcomm, Nokia, Ericsson to European Commission (2011,2012)
- **European Commission recommended a plan on Sept 4, 2012 to move spectrum sharing forward in EU using a hierarchical access system**
- **Wireless Innovation Forum voted and announced broad support of PCAST recommendations on Sept 4, 2012**
- **NTIA CSMAC Spectrum Sharing subcommittee reviewing Federal bands (2012 quarterly public reports)**
- **NTIA FirstNet (Public Safety) Board of Directors met on Sept 25th to create shared public safety system**

What this Means for Innovation and Leadership

- **Licensed bands offer predictability, but...**
 - Innovators have been stifled by it being slowly planned and not disruptive
 - Cost of spectrum; Delays for clearing, or repacking; Regulatory Issues
 - Long Term Commitments and Planning cycles required
- **Unlicensed has met much of the innovator needs, but...**
 - While many new applications, such as M2M, have embraced unlicensed
 - It is congested and Its quality and availability is unpredictable
- **Sharing Federal Spectrum embraces the best of both worlds**
 - Flexibility between secondary licensed and unlicensed spectrum
 - Short term, regional licensing
 - Can iterate and experiment and “try before you buy”
 - It embraces short-range, more localized communications and small cells
- **Important dialog is ongoing about the future of wireless spectrum**
 - Continue to clear all possible spectrum while knowing that doubling of wireless demand every year cannot be met through doubling spectrum
 - Use sharable federal spectrum as an opportunity to leverage current licensed and unlicensed policies, support innovation, and motivate broad investment
- **They are not mutually exclusive**
 - A system for sharing will make Federal spectrum available for commercial use in 3 years, rather than 8-10 years
 - A system for sharing will improve Federal systems and make it easier to move equipment and produce “clearer” Federal spectrum over time



Summary and Conclusions

- **Move Spectrum Access from Scarcity to Abundance**
 - Access to spectrum is increasingly important to economic activity, growth and innovation, world-wide leadership, and national security.
 - The strategy to clear and reallocate spectrum over the next 10 years can not include significant Federal spectrum. We must accelerate sharing.
 - NTIA and FCC must work with industry to plan to implement a new spectrum management system that can start with Federal Spectrum
- **Pilot and Learn Now**
- **We can't wait**
 - We can have significant impact within the next 3 years
 - Dynamic sharing will lead to equipment improvements that will make it easier to move Federal systems over time and create “clearer” spectrum
 - A multiple decade innovation cycle will follow



Thank You

For More Information: www.whitehouse.gov/ostp/pcast

Result: Scarcity Amidst Abundance

- NSF studies of actual spectrum use show < 20% beachfront spectrum used in even most congested cities
- Status Quo can not meet demand
 - Seamless, high capacity mobile connectivity will require an enormous increase in overall “cleared” spectrum capacity that is not available
 - Even move to LTE may only increase supply by 5X compared to 50X demand in 5-10 years
- Spectrum licenses are scarce
- Increases in Capacity require:
 - More spectrum reuse
 - More effective use of wired backhaul

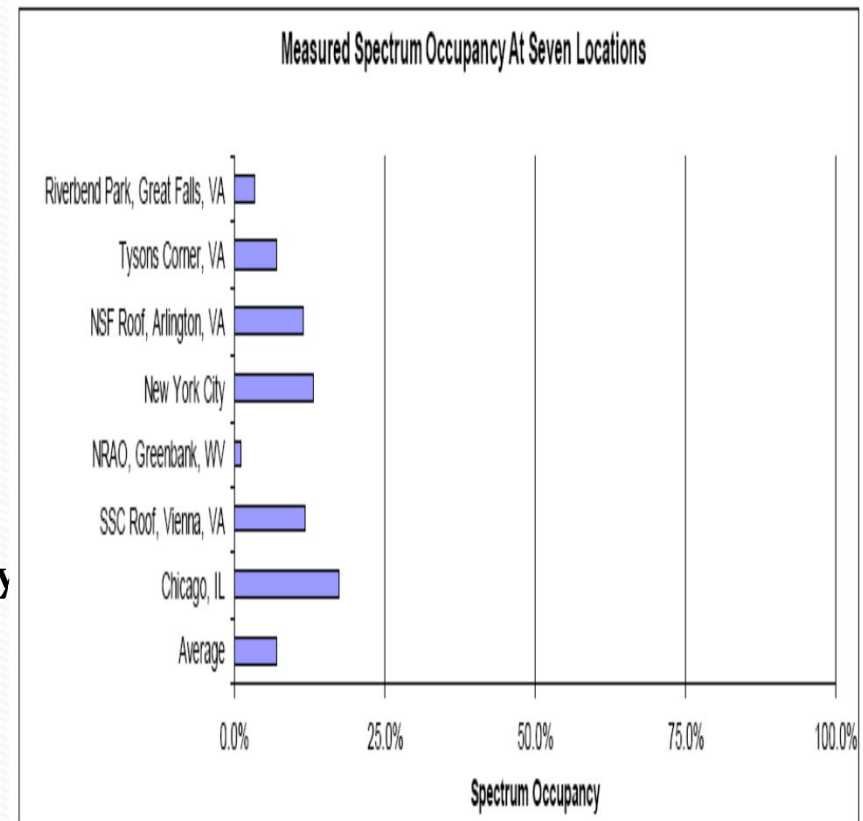
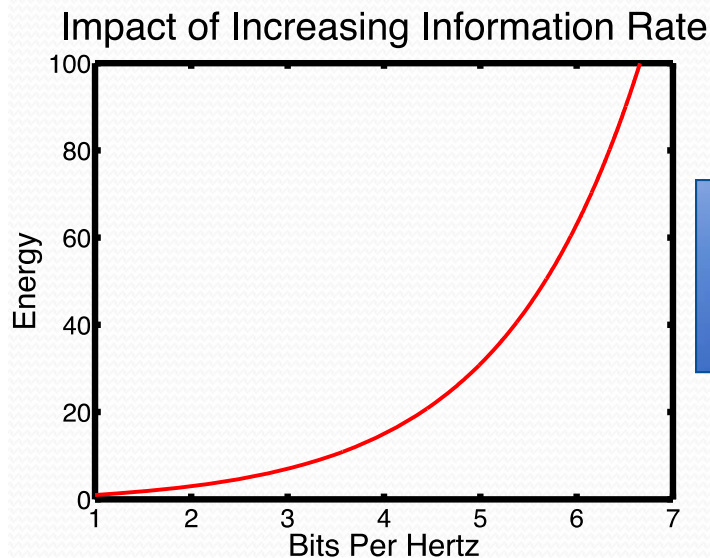


Figure 75 Overall Spectrum Occupancy Measured at Seven Locations

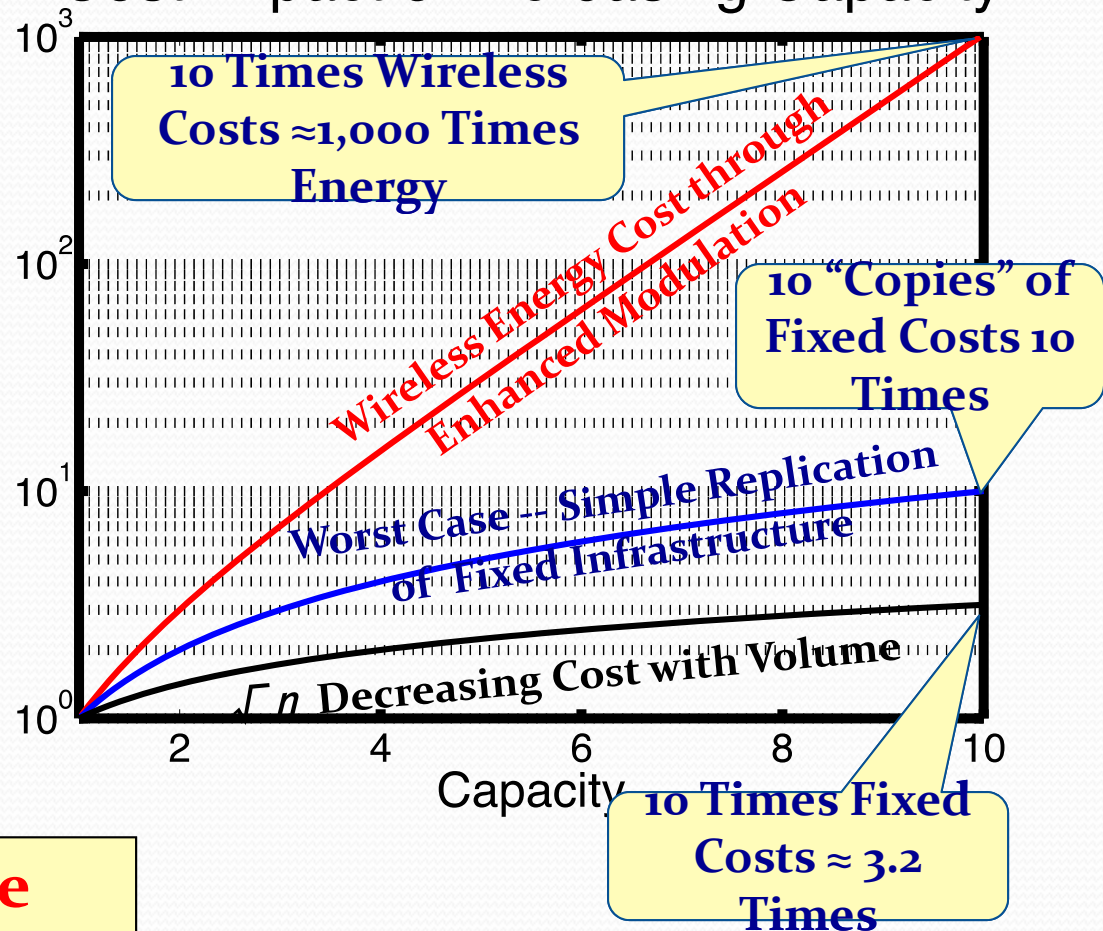
Another Way to Look at Wireless Scaling

- Shannon Teaches that Energy Increases Exponentially with Information Rate



Cost

Cost Impact of Increasing Capacity



Fixed Internet Can Scale Existing Architectures, but Wireless Can Not!

Typically, Electronics Cost often scales with Energy/Thermal load



What Kind of “Crunch” Is It?

How Do We Solve It?

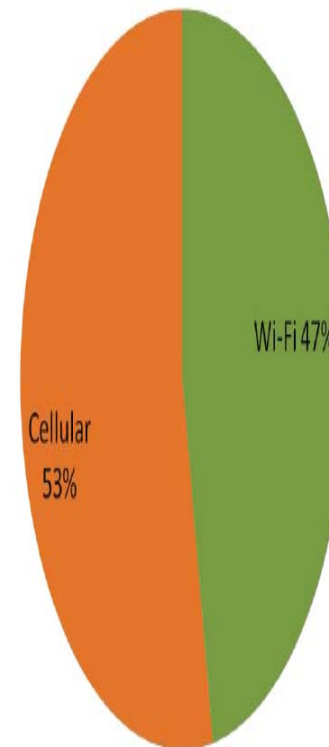
- **Shortfall is not in Spectrum -- it is in Infrastructure!**
 - More Infrastructure Means More Capacity
 - WiFi or LTE Both Offer Similar Capacity per “Unit” (Access Point or Cellular Sector)
- **Spectrum Policy Should be Driven by Need for Massive Infrastructure Deployment, and Innovative Technologies and Business Models**
 - Wide Range of Investment Options (and Participants)
 - Support New Business/Revenue Models
 - Provide “Liquidity” for New Entrant Technology/Service Models
- **Break down the Walls Between Premises and Wide Area Wireless (TELCO’s)**
 - One Ecosystem that Encompasses both Cellular and WiFi
 - Service Portability
 - Access to PSTN, or Equivalent Services

Impact of Spectrum on Emergence of New, Responsive Architectures

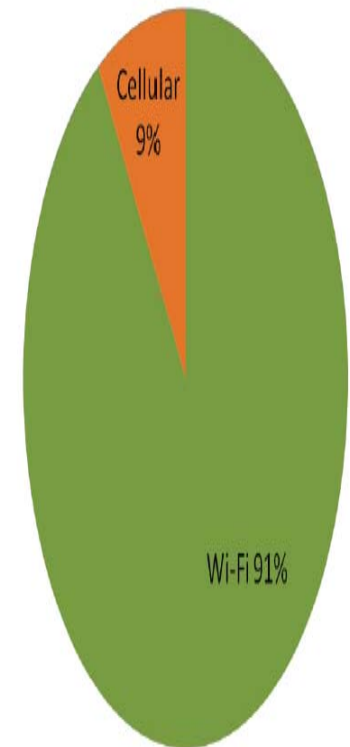
- **Wireless Capacity Dependent on very local, rich, distributed, and proliferated Infrastructures**
 - Opposite of Cellular Telephone Architecture
- **Expands the range of Infrastructure suppliers**
 - Non-traditional suppliers: Restaurants, Offices, Apartments, Municipalities all have infrastructure highly suited to these deployments
 - Very Different Problem than siting a 100 foot high tower, Kilowatt Cellular Base Station, dedicated backhaul, ...
- **Constraints:**
 - Only Spectrum Available has Been Unlicensed (WiFi)
 - No Service Guarantees, No predictable performance, technology partitioned from baseline 3G/4G (CDMA, HSPDA, LTE, ...)
 - Even so, carries more smartphone traffic than the Carrier Infrastructure

Sharing is not New and We Know How To Do It

- Over 50% of licensed spectrum is statically shared between Federal and Commercial users today in a controlled and planned fashion
- Unlicensed spectrum proves vendors will invest in shared spectrum and drive opportunities in innovation
- WiFi for enhanced cellular carrier offload, despite its shared and less predictable nature, carries over 40% of mobile data traffic and is fast growing as user experience improves



Share of iPhone data traffic



Share of iPad data traffic

Source: ComScore Digital Omnivores, Oct. 2011