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Challenges with the Current Spectrum Approach

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Todays Topics

- What is Multi-Tier Spectrum, and Specifically Three Tiers
  - Show it addresses the weakness in the exclusive licensing model
  - Common to some of Regulator's Workshop
- Discuss the US implementation in Citizens Broadband Radio Service
  - Regulatory and industry considerations and progress
- How multi-tier enables innovation
  - The Sweet Spot" from 3.1 to 4.2 GHz
- Implications for 5G spectrum policy
  - Show multi-tier even more essential for 5G

What Should We Achieve in Wireless?

- Goals of Wireless Policy:
  1. Provide sufficient bandwidth for unencumbered, non-compromised use of all network services and products
  2. Cost should not be an obstacle or impediment to its use
  3. The ecosystem should be open, competitive, and encourage innovation in services, technology and business models
- Todays Discussion
  - Single tier, exclusive licensing precludes achieving all of these objectives
  - Multi-tier spectrum management enables achieving these objectives
  - Even more essential as we move from 4G to 5G wireless ecosystems

Why Exclusive Spectrum Actually Blocks these Key Goals

Sufficient Bandwidth

- Much of the Spectrum is Wasted if the single "owner" does not deploy in a given place
- Potentially usable spectrum has incumbents, could not be licensed exclusively, but where additional uses would not cause interference
- Emphasis on larger area coverage, rather than denser, small cell

Cost not an Obstacle

- Spectrum scarcity leads to 'scarcity premium" on spectrum and service
- Carrier can not leverage existing enterprise/building/conduit … infrastructure to lower cost (like in WiFi)
- Owners of infrastructure have low marginal cost to deploy, and could drive down cost, but can not get spectrum

Competitive, Innovative Ecosystem

- No "scalable" entry path to market
- Large area, and longer term licenses preclude any specialized, localized or trial services

What Does a Three Tier Regime Look Like

The Three Tiers

- Protected tier: Assured protection from interference
  - Operates with no impact on incumbent, except informing about frequency, location, receive antenna gain/pattern and protection details
- Protected Access(PA) Tier: Provides protection from lower level and other PAs
  - Assumed some competitive, auction-like process to assign
  - Provides no right to exclude, only protection from interference
- General Access (GA): Any spectrum that would not cause interference to higher levels
  - Significant spectrum guarantee to assure devices are not orphaned, and operation is possible for all users
  - Users will perceive it similar to unlicensed

Why Two New Tiers in the Same Band?

- Same technology/equipment can be used by carriers and traditionally unlicensed users (typical case)
- Eliminates spectrum as a partition among service models, technologies, license classes, …
- Can enter a market without cost/delay of obtaining perpetual, exclusive use licenses, and then scale that deployment
- Equipment is not orphaned when it "looses" an auction, it just becomes GAA, so price for spectrum is capped; based on interference impact
- One band, accessible to all carriers and non-carriers, with protection rights

Scalable, Experimental, and Incremental Concepts Enabled – Has been Key to the Venture-Driven Internet Ecosystem

Implications for Spectrum Access

- Spectrum is not forced to be idle if the "Owner" does not deploy locally
  - All spectrum can be used at all times, at all locations
  - If the higher tier is not using spectrum, any lower tier can access and use
- In large venues, or with no PAs, GA users may often have access to all Tiers
  - With clutter losses, interior spaces may be isolated from outdoor PA usage, and may have all PA and GA spectrum available
  - Worst case, all non-PA spectrum available inside or outside

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The US Citizens Broadband Radio Service (CBRS)

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Citizens Broadband Radio Service - First Three Tier Band. (CBRS)

- Access to 150 MHz of Spectrum
- Choice to either acquire protection, or to operate unprotected with no spectrum costs
- Spectrum management and assignment performed automatically by a “Cloud” service
- Coexistence services to minimize conflicts with adjoining spectrum users
- Nano-transactions to share spectrum, with no legal and engineering costs or delays
- Carrier technology and interoperability available at high volume cost points

Implications of the Changes in Wireless Roles on CBRS

Dense, indoor bandwidth growth is the most expanding segment of usage, not outdoor

- Indoor is not well suited to macro-cell service due to density of users, building loss at higher frequencies, …
- Traditional small cells deployment is expensive per site, and difficult to scale; impractical for dense, multiple MNO indoor deployments
  - Dedicated siting, backhaul, management, power replicated for each MNO at a site
- DAS adds coverage, not capacity, has poor revenue model, and RF side is MNO specific

Industry Collaborations

Venue for establishing standards for CBRS spectrum operations

- 58 members represent all 3.5 GHz interests, including incumbents and different user technologies/communities
- Focus on technology independent interoperability of the unique control structure in Part 96

Venue for Establishing Standards for TD-LTE

- Now over 85 members, including Google, Qualcomm, Nokia, Intel, Ruckus, AT&T, Federated
- Promotes and advocates TD LTE CBRS technology
- Developing neutral host, CBRS LTE coexistence, and RAN standards

Innovation, Venture Friendly Spectrum

Spectrum as Innovation Enabler

- The Argument for multi-tier is really about innovation, not spectrum
- Focus is to create opportunity for new technologies, and non-carrier deployment of wireless capacity
  - Neutral Host emerging as one of these
- Spectrum shared by all carriers and by non-carriers is an enabling feature, with or without spectrum protection
- Can solve issues in spectrum access for other bands in US, and world-wide
- Innovations not just in technology, but in business models, applications, industrial structure, …

The Innovation Impact

- Belief: Current spectrum policies hinder/preclude spectrum dependent innovation
  - Long (Presumption of Renewal) licenses deny new applications access to spectrum due to availability and cost
  - Large regional auctions preclude localized uses
  - Lack of scalable entry to spectrum (like office space rental) preclude the venture ecosystem that has fostered technology innovation elsewhere
- Spectrum policy has resulted in a low-risk, monolithic usage model to emerge in exclusive bands
  - Limited technology and business model competition

Making Spectrum "Venture Friendly", as Well as Useful, is a Key Goal

"Venture Friendly" Spectrum Policies

- Support the scaled market entry, "Fail Fast" and failure tolerant, philosophy, evolutionary products, … Concepts that have made the startup ecology so successful
- Be able to enter small and scale up in:
  - Geography (Do trials, then expand business in national scope)
  - Spectrum Extent (Expand depth in customers and services)
- Pay only for what you need
  - Not forced to buy national, perpetual rights, or all resources eventually needed for full scaling

Need Not be "Free" Spectrum, Just Requires a Flexible Marketplace, and/or a level of Assured Access

First CBRS Innovation – Massive Neutral Host Deployment

- Many different interpretations, but common elements include:
  - A single network that can support a number of MNOs, as well as "*Private Network*" use of same network
  - Common backhaul, network management, and eNodeB deployments serving multiple MNO/MVNO offerings
  - Revenue model to encourage venue deployments at a level advantageous both carriers and venues
- Unlike DAS:
  - A CBRS-based neutral host network adds capacity with each access point, while DAS adds coverage, but not capacity
  - No complex "Hetnet" macrocell interactions, no unique carrier arrangements or licensing, , no unique RF heads, …

Why is Neutral Host Attractive?

- Cost of deployment could be much less
  - Venue owner has access to power, siting, and backhaul at marginal cost
  - Deployment can be integrated with IT infrastructure build out
  - Marginal cost to add to Wi-Fi Access Point is likely less than $50-100/access point
  - Enterprise and multiple MNO and MVNO's effectively share cost
- Provides venue/enterprise benefits from LTE
  - Improved WLAN security, reliability, manageability over Wi-Fi
  - Carrier-grade scaling/coexistence of network
  - Chargeback of excess \capacity to carriers for offload
- Provides MNO/MVNO Benefits
  - No CAPEX, no spectrum cost, and potentially less marginal cost/bit
  - Provides indoor capacity that otherwise would be impractical/impossible to deploy at necessary density

What About 5G?

Is Three Tier Relevant to 5G?

Does it Solve any 5G Problems or Obstacles?

5G Implications

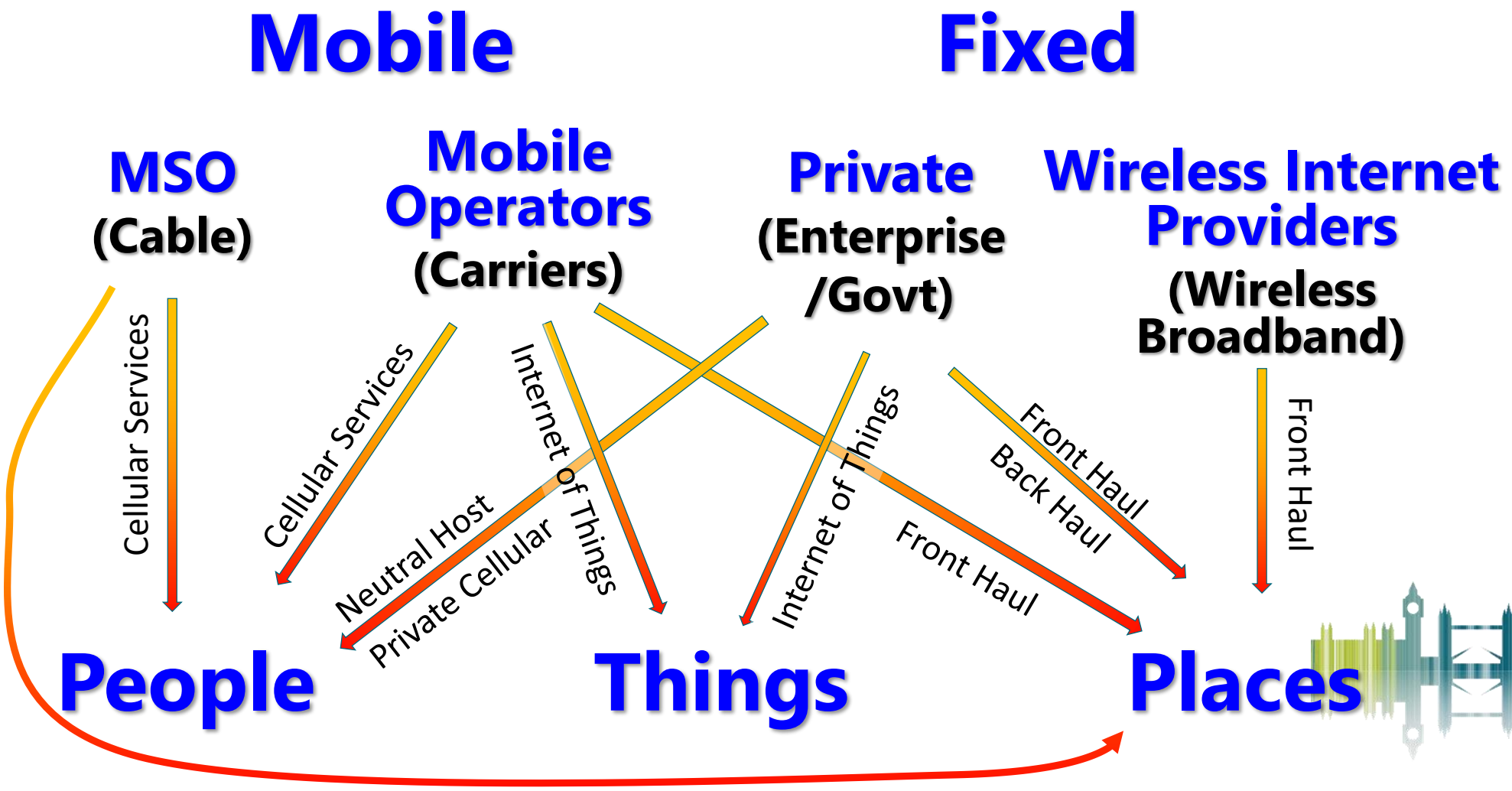
- Aren't these "4G" considerations even more true for 5G?
  - Building penetration losses 30-80 dB at MM Wave
  - Tens of millions of access points, not tens of thousands
  - Indoor services as major market
- US CBRS band offers insights into 5G network architecture
- Extension of current trend to virtualize wireless and TELCO networking
- Why assume that 5G deployment is just like 4G?
  - First 4 generations of cellular were coverage/service type driven
  - 5G is first generation that is primarily driven by capacity

The (Mobile) Licensed Service World

Type of Service	**Mobile**
Deployer	**Mobile Operator**
Technology	Cellular Services
User Community	**People**

May not be the intent, but auction or allocation rules favor this sole application via geographic extent, duration, pairing, …

The Future 5G World is More than Mobile Operators



Fully Populating this Model Takes More than Carriers

- Physics: 5G deployment and service is inherently going to be localized, above or below 6 GHz
  - More like Wi-Fi, than traditional area coverage
- Cost effectiveness driven by opportunities to provide/obtain backhaul, power, placement, access,…
  - Impact clear in differences between Wi-Fi AP vs. small cell deployment densities
  - In the Internet, opportunistic fiber dominated over traditional, vertically integrated TELCO longlines; same may be true for wireless
- Dense 5G deployments will take more than traditional carriers to get into dense areas, such as venues, buildings, enterprises, …
  - Have access to buildings, can leverage power, backhaul, access and can serve all MNO's/MVNO's/unique enterprise needs

Spectrum Policy is Key to this Evolution

- Spectrum policy has forced individual service communities and providers into technology and business model stovepipes
  - Cellular, fixed wireless, WiFi, ...
  - Unique monetization models
  - Limited volume raises cost, constrains interoperability
- Spectrum that is common to all categories of suppliers enables technology and infrastructure sharing, as well as spectrum sharing
  - Neutral host, where a hotel offers cellular services through the same deployment as for Wi-Fi
  - Common band makes networks accessible to all carriers, enterprises, MVNOs, …
  - Avoids carrier-specific systems, such as DAS

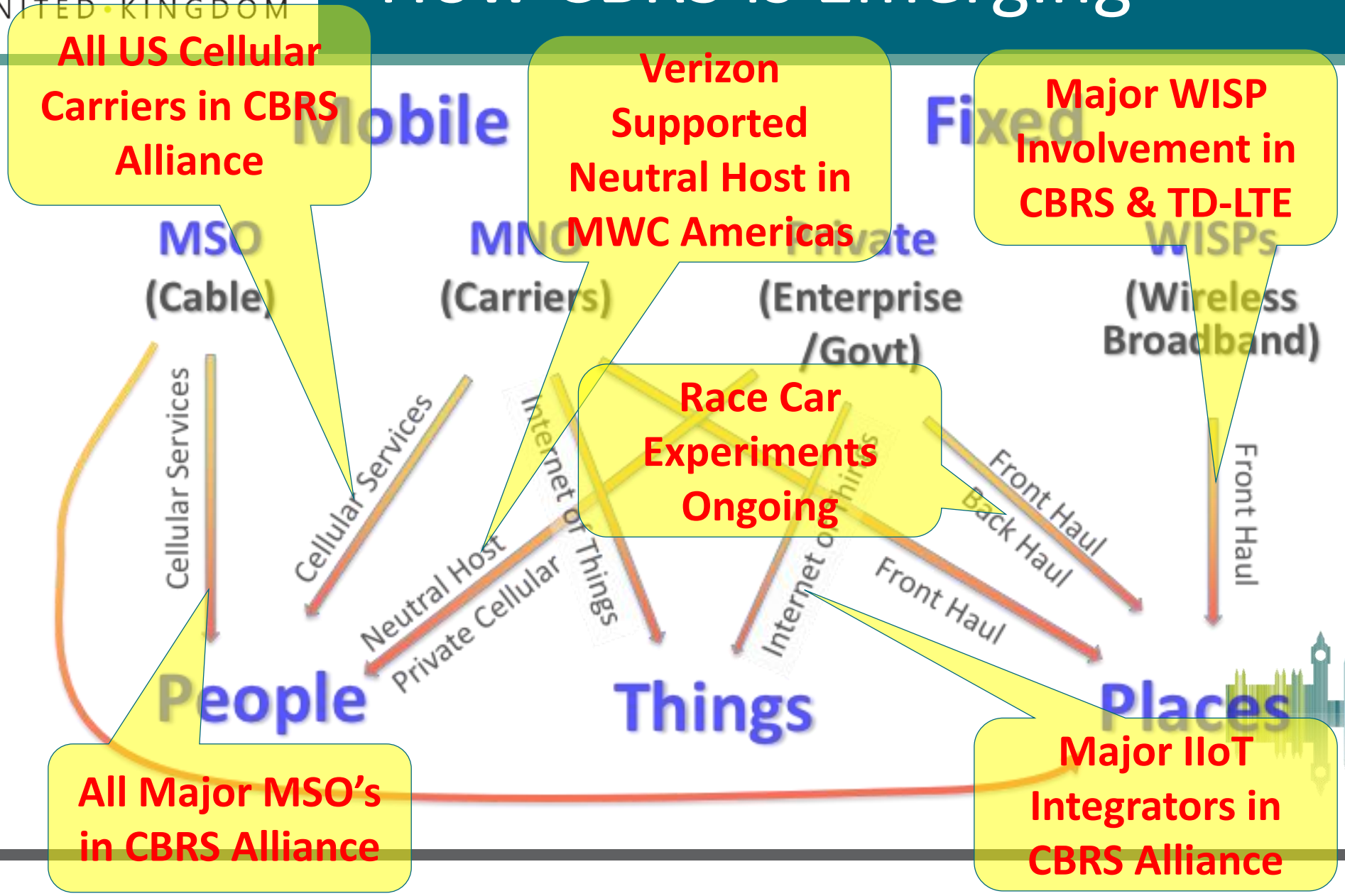
Common Spectrum Enables Shared Infrastructure

- Shared Infrastructure is a win for all parties:
  - Carriers: Reduce CAPEX, and get capacity inside of buildings/venues where traffic growth is most severe
  - Venues: Monetize low marginal cost augmentation to existing infrastructure/cabling/power/IoT nets
  - Users: Capacity where they need it most
- Follows the Internet Model
  - Few Internet paths are over single provider's Infrastructure
  - Opportunistic, lowest cost providers have emerged in each segment of the network
  - Internet: power utilities, cities, public-private partnerships, railroads, cable operators, TELCOs, and new entities all provide portions of the end-to-end path

Evolving Use of CBRS in the 5G Model

- Citizens Broadband Radio Service (CBRS, FCC Part 96) is the laboratory for many of these concepts
- Band Offers:
  - Available to any entity (carrier, enterprise, individual)
  - Some of Band Available with protection, some without
  - Unused spectrum made available to anyone
- New Models Emerging:
  - Neutral host: enterprises/buildings/venues supply MNO-services within their spaces at lower CAPEX than dedicated deployments
  - Private LTE: Standalone services to conventional handsets and other cellular products
  - IIoT: Use security and low cost points of LTE to deploy the next generation of IIoT Systems
- Breaks the old Model: *LTE is for Carriers; Wi-Fi for everyone else*
  - Why would 5G be any Different?

How CBRS is Emerging



5G Final Thoughts

- 5G claimed by many to be disruptive in its impact
  - Abundance disrupts ecosystems that are based on scarcity
- Technical disruption is generally not possible without fundamental changes in the business, regulatory, and monetization models, as well
- Many 5G deployment attributes appearing in CBRS
  - Large, non-traditional community embracing the traditional carrier technology, with unique deployment, monetization, and usage plans
  - For maximum impact, 5G will need to have similar adoption
- Common spectrum, available to all network deployers, with practical licensing terms (cost, duration, extent, …) is key to the full vision of 5G

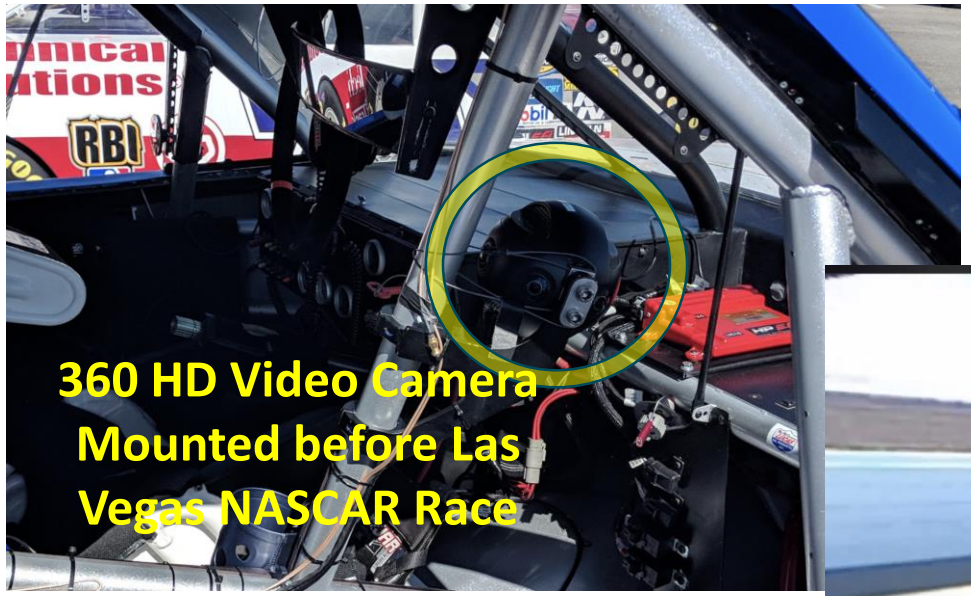
Summary

We have a new model for managing spectrum that has numerous attractive features

- Market-driven and dynamic to changes in the business and technology
- Assures all spectrum resources are productive
- Opens up participation and investment to a much wider range of participants
- Not only has corporate competition, but enables technology, business model and infrastructure competition
- Seamlessly supports the current ecosystem, while extensible into the new ones that are emerging

My Favorite CBRS Application!

360° Real-time Virtual Reality Video from NASCAR Stock Race Cars Using a Private LTE Network



360 HD Video Camera Mounted before Las Vegas NASCAR Race

360 View, with head turned towards outside rear window to see car overtaking along the wall

"The King" Richard Petty Viewing Las Vegas Race in 360 VR

LTE Modem Installed in Race Car at Las Vegas Speedway

Joint Project with Google, Nokia, and Bosch

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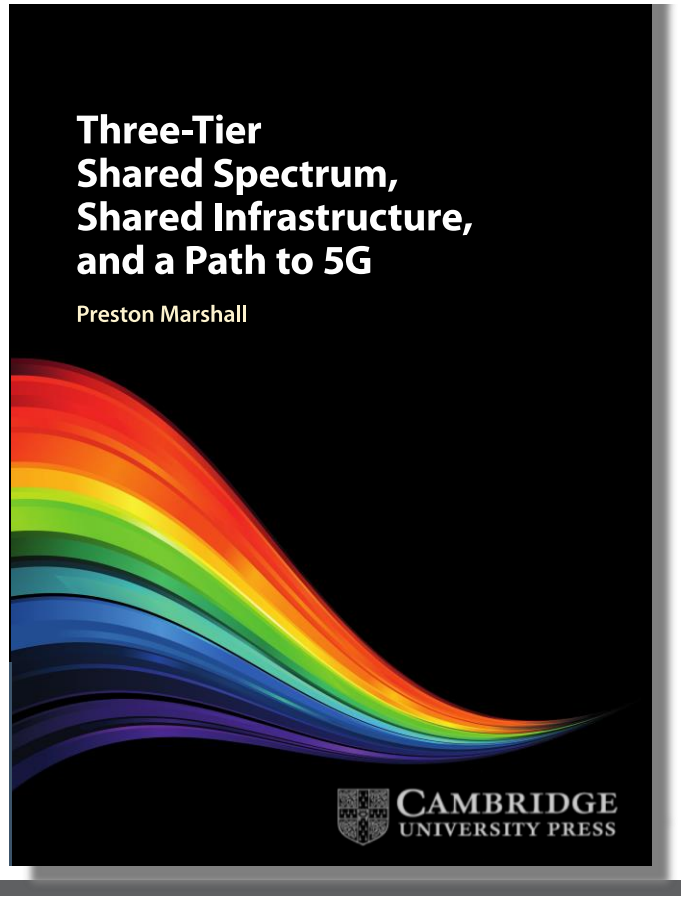
For More Detail on Three Tier Spectrum & CBRS

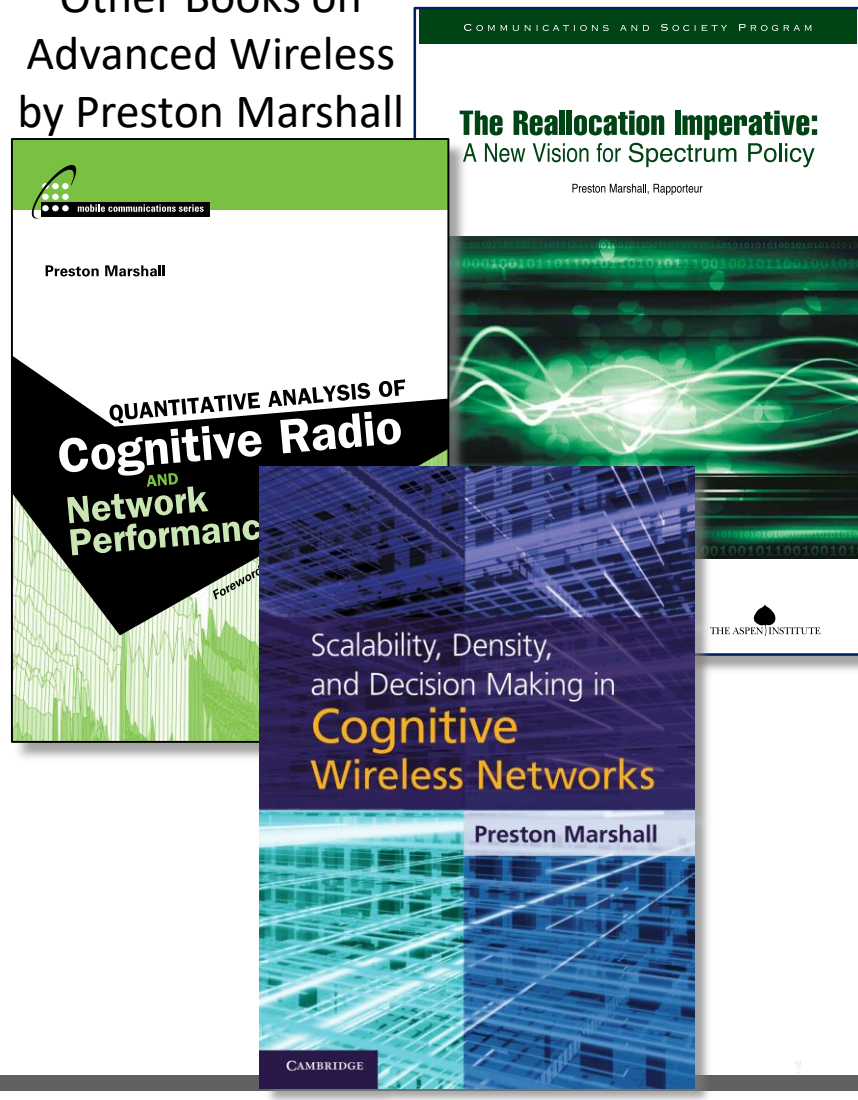
Three-Tier Shared Spectrum, Shared Infrastructure, and a Path to 5G (2017)



CAMBRIDGE UNIVERSITY PRESS

Covers the general concept of multi-tier spectrum, from both a policy and technical perspective, and describes the first implementation of this concept in the US. This book traces these concepts from early spectrum sharing, the US PCAST Report, the CBRS Band, future expansions of tiered shared spectrum, and new markets. Includes analysis of the opportunities band by band worldwide, and descr*ibes* the highly innovative wireless ecosystems that can emerge from these policies.

Other Books on Advanced Wireless by Preston Marshall



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