



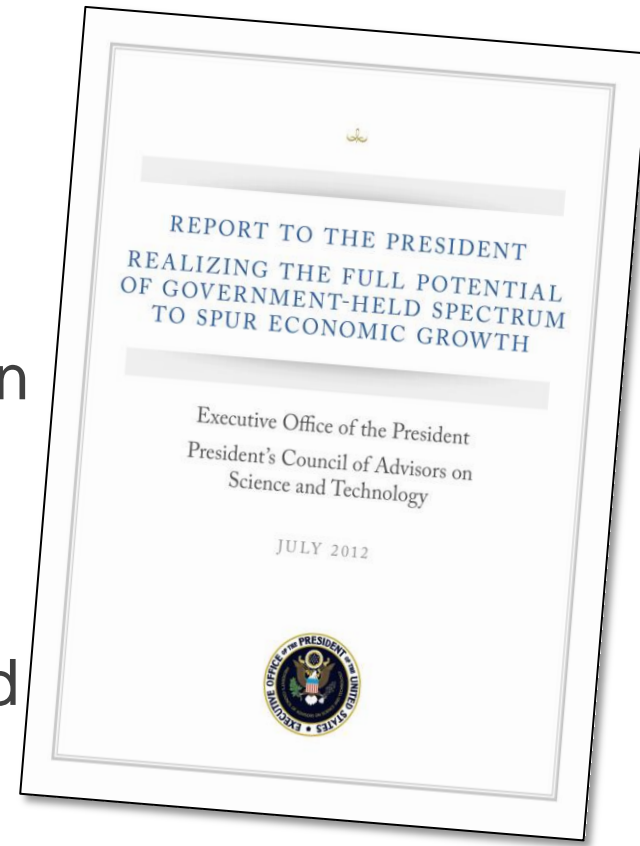
# **Wireless Abundance through Spectrum Sharing: Implementing the PCAST Vision**

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# 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 spectrum as an instrument for innovation in technology, services, and architectures, as well as traditional concerns
- Proposed fundamentally new concepts in spectrum sharing, spectrum markets, and architectures
- Enable emergence of wider range of wireless solutions than can be supported by today's spectrum policy



# PCAST Concepts



- Flexible Spectrum Sharing has Been Present for a Long Time, but PCAST Proposed to Extend this Model
  - Use Federal Spectrum as a “Green Field”
  - Provide Secondary Users the right to Acquire Protection from other Secondary/Tertiary Users – “Commercial Quality”
  - Support Innovators with Shorter-term, Limited Licenses for Scalable Deployments and Spectrum Liquidity
  - Common Band for Protected and non-Protected Users for Economy of Scale and Technology Availability
- Spectrum Access System Extended the TVWS Model
  - Manage Aggregation, rather than Reduce Power based on Worst Case Density Predications/Fears/Imagination
  - Relocate or terminate secondary operations to protect Primaries
  - Protects some Secondary Users from others
  - Reflected actual Out of Band Emissions and Receiver Responses to Encourage Device Improvements – No Fixed Exclusion Zones
  - Support Technology specific Co-Existence Techniques as they Emerge

# Progress to Date



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



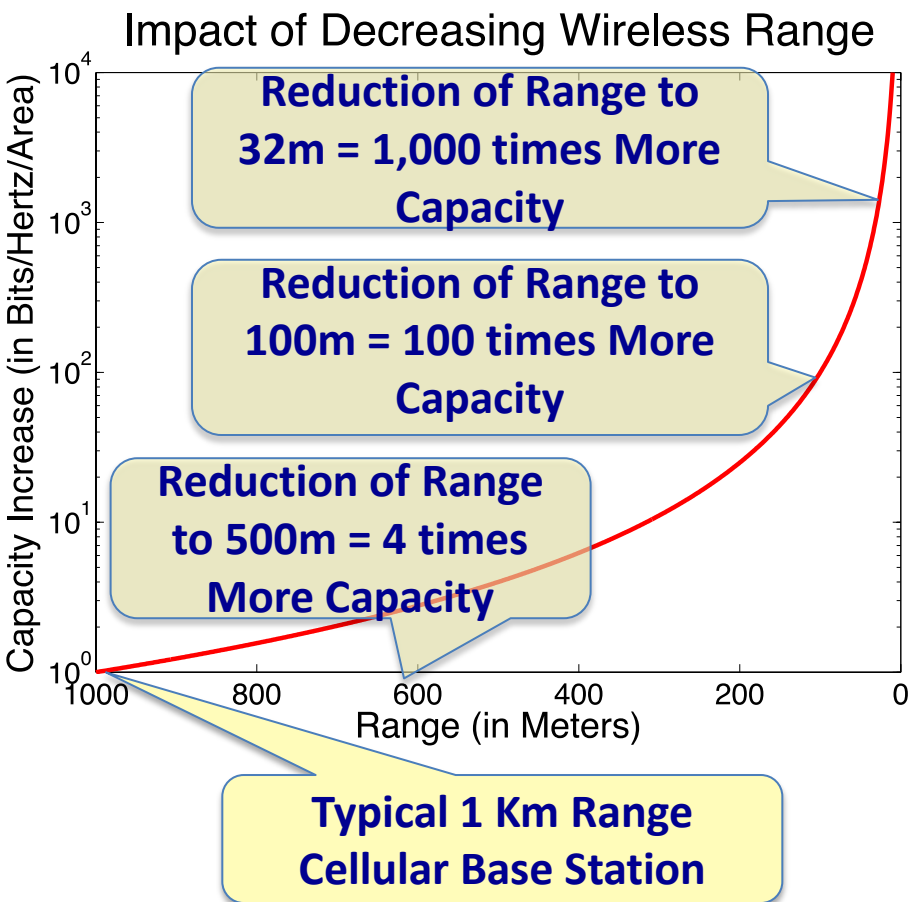
- Generally assumed that administration supports the PCAST concepts
  - Support (in principle) expressed by OSTP, FCC chairman, DoC director of NTIA, NEC, and DoD
- PCAST proposals initially met severe resistance from the cellular industry
  - Concerned that it will divert focus from clearing and auctioning exclusive use spectrum
- House Energy and Commerce Subcommittee on Communications and Technology held hearing on recommendations
- FCC has initiated proceeding to share Government 3.55 to 3.70 GHz band along principles of the PCAST report for femtocell and similar usage
- Presidential Memorandum established many of the PCAST principles on June 14, 2013
- Joint AT&T & Google letter of support for spectrum sharing efforts in the FCC 3.55 GHz NPRM
  - 3 Tiers, with Broad eligibility
  - Spectrum Access database
  - Small cell exclusion sizes protecting incumbents only
  - Lightweight auctions to resolve mutual exclusivity

**We look forward to Unlocking the Potential of Spectrum Sharing to Create Wireless Abundance**

# How do you Create Abundance in Wireless Capacity?



Qualcomm: 1000 times More Bandwidth in One Decade



- Latest air interface is very efficient, with little improvement likely
- Reduction in wireless range provides massive increase in wireless capacity
- Solution to wireless capacity is dense, short range infrastructure
- The future – towers provide coverage, but local devices will provide aggregate capacity
- Requires transition from high cost, low density cellular, to high density, low cost wireless infrastructure
- In the limit, wireless is going to look similar to Wi-Fi deployments

**Challenge: Conceive and Enable Architectures that Seamlessly Operate Across this Wide Range of Deployments**

# PCAST Concepts – Protection without Exclusion



- Previously – Assured non-Interference to Privileged users by Excluding any other Users/Usages
  - Primary User “Controlled” Devices entering the band
  - Managed all of the Interference in the Band
  - Result - Much spectrum left fallow
- PCAST Proposed: “Protection without Exclusion”
  - Use registration data base to provide protection to multiple tiers
  - Tier 1 -- In-band Primaries and Adjacent Band Users
  - Tier 2 -- Exclusive Protected/Priority Access (PA) User
  - Tier 3 -- Unprotected General Authorized Access (GAA)
- Each Tier Assured Protection via Database Registration
  - Spectrum Available to Lower Tiers if no Higher Tier Device would be Interfered with
  - Tier 1 Membership via FCC and NTIA Assignments
  - Tier 2 Established through dynamic, shorter term marketplace
  - Tier 3 Can use Tier 3 dedicated spectrum, and any non-interfering spectrum throughout the shared segment

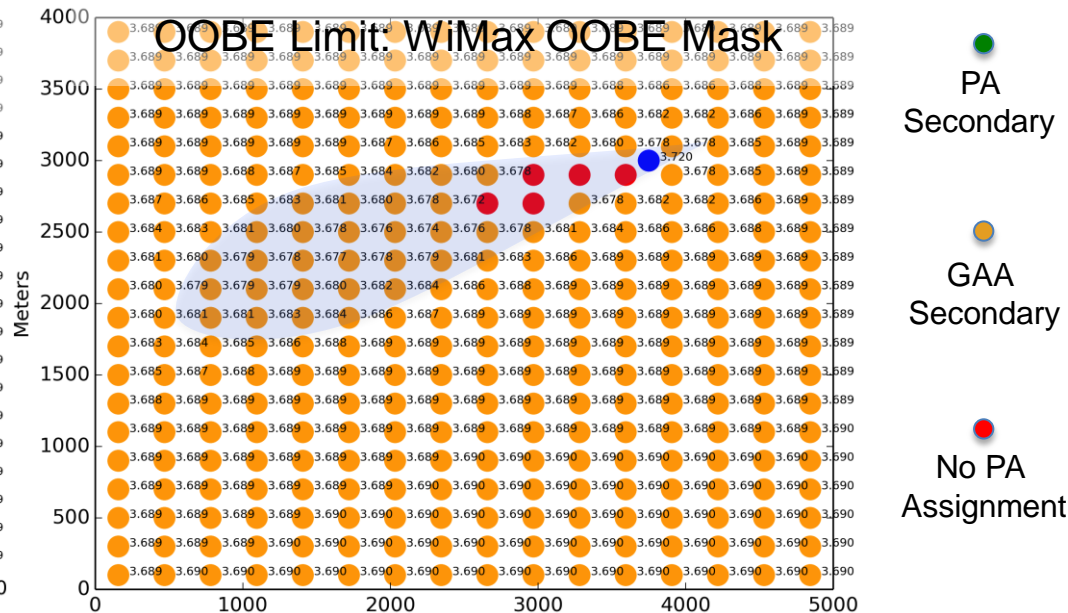
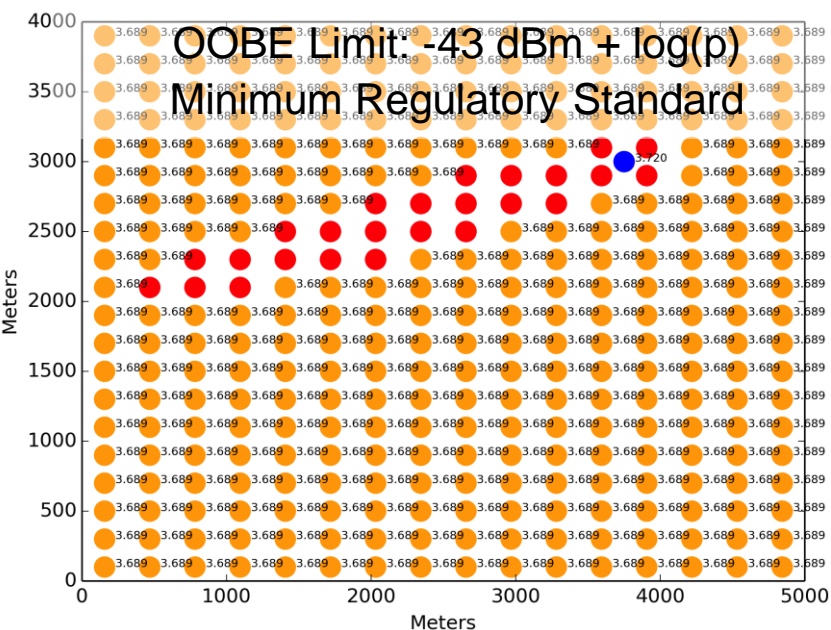
# PCAST Concepts – Let Marketplace Dictate



- Allocation between Licensed and Unlicensed (GAA)
  - Provide Bands with both modes Permitted
  - Market will determine balance of “Free” and “Paid” spectrum
  - Symmetric rights for protected and unprotected users
- Receiver Performance and Out of Band Emissions
  - Spectrum Payments Based on Spectrum Precluded for use by other devices
  - “Externalities” increase spectrum cost/reduce sharing opportunities
- Repurposing of Spectrum Usage and Control
  - Provide for Periodic “Re-Auction” of Protected Spectrum, without perpetual right of renewal
  - Small blocks of spectrum (time and space) available through market to enable scalable development/experimentation and deployment
- Support user choice, wholesale providers, and low cost ecosystem
  - Require Coverage of Shared and Protected Segments of Band



# SAS Reflects and Incentivizes Improved Device Performance: Transmit Side



## Exclusion area around C-Band dish with 5 degree elevation angle in 3.55 to 3.7 GHz

- Using actual out-of-band emissions shape reduces rejected nodes by factor of five
- Shaded area represents assignments that become possible when SAS uses actual WiMAX mask
- Maximum frequency is adjusted based on secondary users filter skirts
  - Automatic and locally dependent guard band creation



# Types of Services



- Wireless has been through a fundamental shift -- No longer entirely CMRS focused
  - WiFi Offload Now Handles over Half of Phones
  - New “Providers” Entered Wireless Space
    - Coffee Shops, Hotels, Venues, Malls, ISPs, Airports, WiFi Aggregators
- Regulation has Partitioned Technologies, Services, Reliability ... along Licensed/Unlicensed lines
  - Different regulatory limits resulted in different technologies
  - Different technologies and volumes resulted in different services, cost and price points, expectations
- PCAST could change that
  - Protected or Unprotected have same service opportunity
  - Technical decision to “buy” protection or not
  - Situation Driven (Congestion, Revenue Opportunity, QOS needs, ...)

# How do We Exploit this?



- Shared access by both licensed and unlicensed communities has significant impact
  - LTE advantages available to wider range of users, due to carrier presence in band
  - High volume of unlicensed devices reduces costs for more advanced technologies, such as LTE, benefiting everyone
  - Opportunity for seamless integration of wide area and local services
- Regardless of technology choice, opportunity for a range of new network types, such as:
  - Community LTE
    - Enabled by high volume carrier devices plus LTE management in the cloud
  - Private LTE networks (premises, M to M, medical, ...)
  - High QoS Wi-Fi networks
    - Option to protect high QoS service offerings
  - Premises-based, wholesale LTE services
    - Low marginal cost equipment, GAA spectrum, revenue sharing with premises owner

# Opportunity for Innovation



- In Past, Regulation Has Provided few Benefits Based on Improved Performance and Innovation
  - Typically Based on Worst Case Performance
- PCAST (and maybe 3.55 R&O) Sharing Framework provide incentives for better coexistence
  - Less likelihood to go to auction and pay more
  - Reduced Exclusion Areas
  - Better operation in congestion without the need to get protection at all
- Licensed Protection Available to Any Device, at any location
- Common Ecosystem for Protected and Unprotected Technology, Components, and Devices accessible to all

# PCAST – Spectrum Policy Can Enable New Technology, Industries, and Services



- Make Federal spectrum available for sharing
  - Obtaining new spectrum through clearing is increasingly difficult, costly, lengthy, and disruptive – not long-term, sustainable policy
  - Low power technologies, such as femtocells make sharing spectrum with Federal users viable
  - Support innovation and new services, without disruption and cost of relocating existing federal or commercial users
  - Massively increase the quantity of spectrum that is available for innovation and new technology (> 1 GHz of sharable spectrum)
  - Provides “spectrum liquidity” on a local level
- Three tiers of users in shared spectrum (FCC NPRM terms)
  1. Federal Primaries (as Now)
  2. Priority – Assured no interference, but no exclusivity to warehouse or tie up spectrum, or preclude new entrants
  3. General Authorized Access – Like current unlicensed, but can obtain protection through micro-auction process

# PCAST – Spectrum Policy Enables New Technology, Industries, and Services



- Provide new, shorter term, licensing models
  - Allow entrepreneurs and innovators to “rent” spectrum to experiment and validate business concepts and technologies, and scale up
  - Reduce the billions of dollars of investment, and decade long process of current clearing and auction process for “perpetual” rights
  - Automated, real-time, mini-auctions triggered only when protection needs conflict and mutual exclusivity needed
- Provide certainty in incumbent user interference issues – Billions \$ Lost in LightSquared/GPS issue
- Provide Balance Between Competing Federal/Civil Usage at White House Level Operating Through the WH OSTP Chief Technology Officer

# Why 3 Tiers is Enabling of a New Wireless Future



- Protection without exclusive access to band
  - Protection right only exists for actually deployed usage
  - Interference sensitive services can deploy, but not warehouse spectrum/speculate/deny entry
  - Minimal commitment that is possible (small area, short time period)
- All spectrum can be used by someone: all spectrum is GAA (like unlicensed) unless use would interfere with protected users
- Wireless is wireless regardless of license status
  - Same equipment can be in both protected and GAA status
  - Why purchase protection if there is no congestion?
  - Market-based decision, not technology decision
- Allows premise owners, communities, new entrants, ... to deploy carrier quality (handover, UE interoperable, QoS, stable IP addr., Protected (if needed))!
  - You could buy protection for a Wi-Fi network, or have a private LTE network, or make an LTE network public, or wholesale bandwidth, or ...



# A More Converged Wireless Future



- Current Licensed and Unlicensed Technologies Both Have Strong Points
  - Unlicensed – High Volume, Inherently Self-Organizing, Simple Deployment Model, Interference Tolerant, ...
  - Licensed – Network Management Focused, Extensive Coexistence Management (RRM), QOS Management, Spectrally Flexible, Carrier Aggregation, Authentication ...
- Both are Looking to Adopt Aspects of the Other
  - Unlicensed – Enterprise Management, Hotspot 2.0, Authentication
  - Licensed – Self Organizing Networks, LTE-A,
- Some Wireless Services Have Already Been Very Converged
  - Devices transition from Wi-Fi to CMRS and back very Flexibly
- Common Band where all Services can Operate Should Accelerate this Opportunity and “De-partition” Wireless Services

# Defense View of Each Technology Partition



## **Defense Tech:** + In Protected Military/Federal Allocations

- C4I based on Threats, doctrines, TTPs irrelevant before systems achieve IOC, much less FOC
- Lack of a component ecosystem forces DoD to absorb non-recurring costs deep into the supply chain, and poor integration
- High cost, DoD unique industrial partners

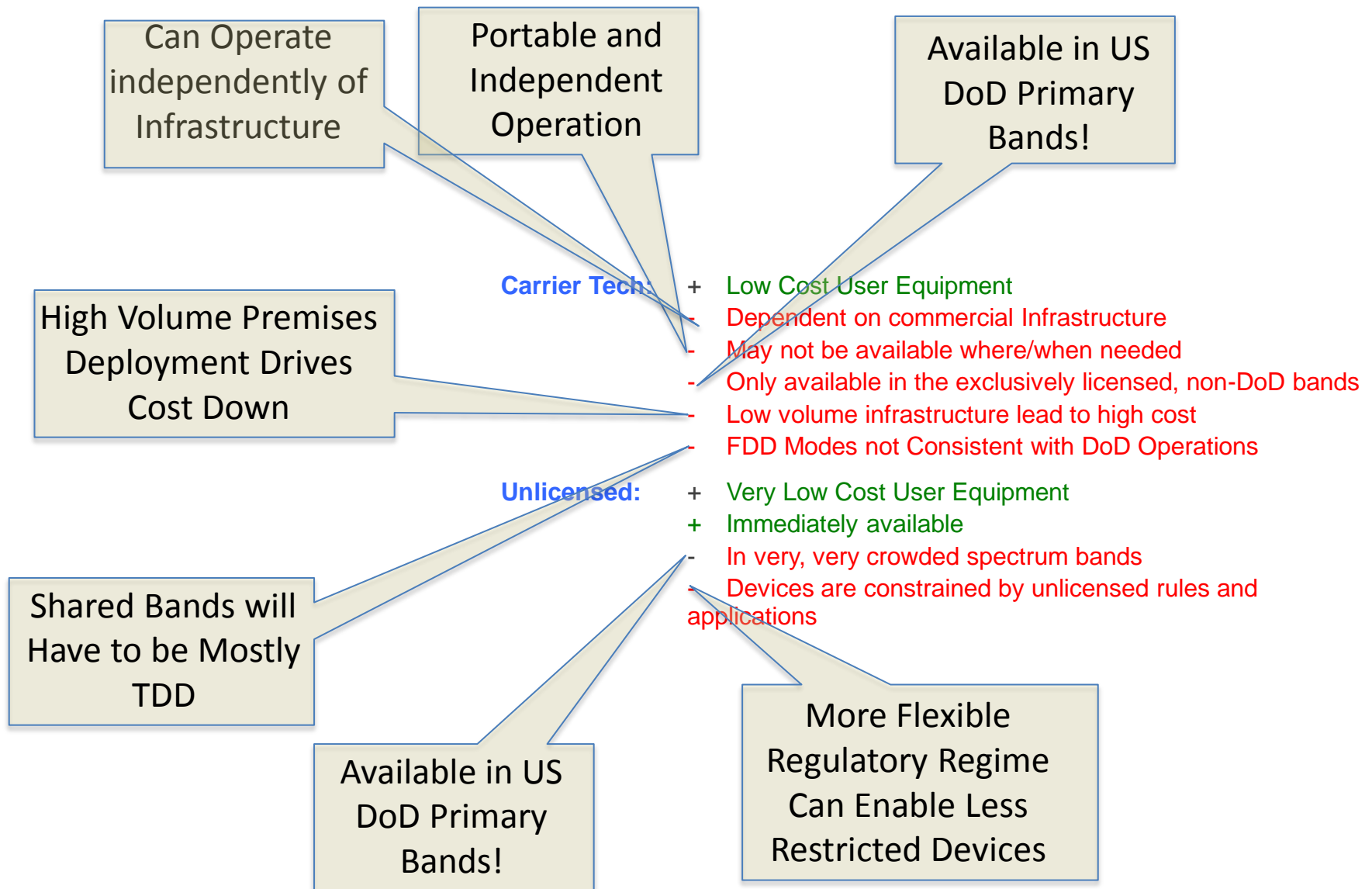
## **Carrier Tech:** + Low Cost User Equipment

- Dependent on commercial Infrastructure
- May not be available where/when needed
- Only available in the exclusively licensed, non-DoD bands
- Low volume infrastructure lead to high cost
- FDD Modes not Consistent with DoD Operations

## **Unlicensed:** + Very Low Cost User Equipment

- + Immediately available
- In very, very crowded spectrum bands
- Devices are constrained by unlicensed rules and

# Many of COTS Shortcomings Will Be Resolved





Questions?