

# Spectrum Assessment Project Webcast

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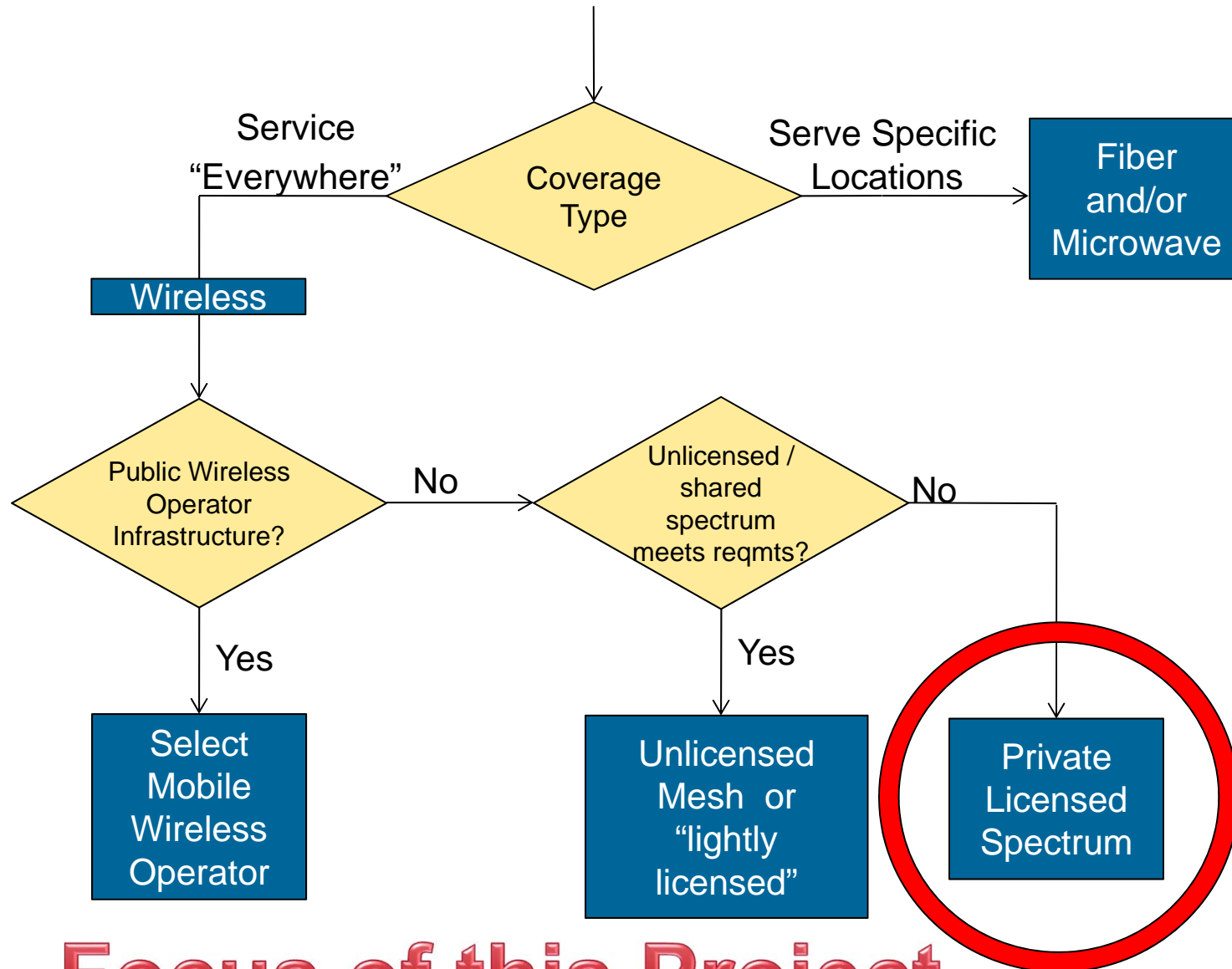


# Agenda



- Project Background and Scope
- Review of Requirements
- Overall range of spectrum search parameters
- Areas with highest potential
- Special Topics (longer timeframe)
  - FirstNet and other Public Safety Sharing
  - White Spaces
- Q&A

# Utility Communications Options



**Focus of this Project**

# Requirements Review



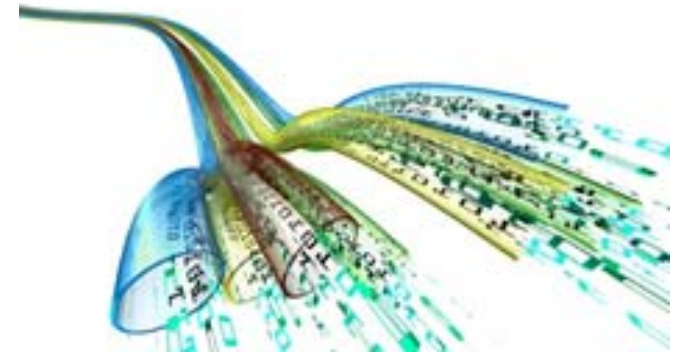
## Overview

- Project goal is to identify blocks of spectrum that meet current and future needs of utilities and critical infrastructure providers.
  - Spectrum suitable for Field Area Network
  - Not narrowband voice channels
- Target frequency blocks within bands of interest include:
  - Spectrum available on secondary markets under geographic licensing methods
  - Spectrum identified for auction by the FCC
  - Spectrum that can potentially be shared with federal entities

# Assumptions

- Spectrum will be acquired by utilities
- Spectrum will support fixed, machine to machine (M2M) communications
  - Enterprise voice communications and mobile field force voice are not a part of capacity requirement
  - Voice could be supported, but not included for capacity
- There is a strong preference towards spectrum capable of supporting standards-based technologies
- Generally, the network is coverage-limited rather than capacity limited

# Spectrum Requirements



- Critical system criteria driving spectrum requirements are:
  - Necessary data rate
  - Coverage and Network Engineering
  - Reliability
  - Round trip latency
  - Data security
  
- Proximity to other bands could create economies that reduce equipment costs.

# Spectrum Requirements

- Data capacity is the primary factor that determines how much spectrum is needed
- Application data requirements developed from:
  - *Estimating Smart Grid Communication Network Traffic*. UTC and EEI, March 17, 2014
- Other factors will influence amount of spectrum:
  - Frequency range
  - Air interface (e.g. LTE, WiMAX, or other)
  - Primary status (spectrum sharing)



# Standards Based Solutions



- The technologies used will play a role in the spectrum requirements.
- Predominant standards for FAN are WiMAX and LTE
- Lesser known technologies should not be ignored

# Requirements analysis: 450, 700, and 1800 MHz

Uplink only. Total for FDD pair is double	ENVIRONMENTAL MORPHOLOGY			
	Dense Urban	Urban	Suburban	Rural
Assumed 450 MHz Uplink Bandwidth. FDD (MHz)	3.00	3.00	3.00	3.00
Assumed 450 MHz Uplink Bandwidth. TDD (MHz)	5.00	5.00	5.00	5.00
Uplink Spectrum Requirement 700 MHz FDD (MHz)	2.4	2.5	0.2	2.1
Uplink Spectrum Requirement 700 MHz TDD (MHz)	4.1	4.2	0.3	3.6
Uplink Spectrum Requirement 1800 MHz FDD (MHz)	1.8	1.4	0.1	1.2
Uplink Spectrum Requirement 1800 MHz TDD (MHz)	2.9	2.3	0.2	2.1

\* Assumes maximum allowed use of uplink slots per frame

- For each spectrum range:
  - Minimum spectrum required for lowest-cost FAN supporting capacity and latency requirements of defined use cases
  - 2 kbps/sq km (rural) to 1700 kbps/sq km (dense urban)
- Above 700 MHz, BW to reduce total number of base stations
- At 450 MHz, the network could be capacity limited
- Include consideration of practicality of commercial equipment modification, which will inform assessment of available spectrum.

# Frequency Parameters



# Frequency Range

- The range of 400 MHz to 3 GHz was chosen as the focus of the analysis
  - Lower frequencies are currently allocated as narrowband, except for TV channels (which would require longer-term action to change rules)
  - Higher frequencies are challenging for full-coverage FAN architectures.
- There may be discrete bands both above and below this range that could support the requirements.

## Key points for Commercial Wireless

- Prime spectrum held by commercial wireless services
  - High demand, high cost, auctions
  - Channel Aggregation makes “odd bits” usable to the operator – less likely to sell
- Possibilities exist in rural areas to lease or buy
  - Commercial spectrum may be surplus in those areas
- As commercial wireless operators re-organize their spectrum portfolios, some bands may become less desirable
  - Operators may be more willing to sell/lease spectrum to a non-competitor

# 400 to 800 MHz Overview

Lower Limit (MHz)	Upper Limit (MHz)	Band Width (MHz)	Current Use in United States	Comments
406.1	420	13.9	Private Land Mobile (90)	
420	450	30.0	Private Land Mobile (90), Amateur (97)	
450	460	10.0	Private Land Mobile (90), others	
460	470	10.0	Private Land Mobile (90), others	
470	698	228.0	Broadcast television and "white space" devices	
698	746	48.0	Commercial wireless lower 700 MHz band	
746	758	12.0	Commercial wireless upper 700 MHz band	
758	775	17.0	700 MHz D-block and Public safety	paired with 788-805
775	788	13.0	Commercial wireless upper 700 MHz band	
788	805	17.0	700 MHz D-block and Public safety	paired with 758-775

## 406 to 420 MHz Government PLM

- Low frequency for good propagation; same frequency range as existing utility systems
- Possibility of spectrum sharing
  - PCAST identified as one of several “good candidates”
  - NIST says this band is lightly used by federal users
  - Currently used by TVA and other government utilities for land mobile (channels < 25 kHz, most 12.5 kHz)
  - Possibility of coordination or realignment to support utility broadband or wideband operations.
- Not currently a 3GPP LTE Band, but close to band class 31 at 450 MHz: LTE equipment exists for this band.

## 700 MHz Upper A Block

- 1X1 MHz block of nationwide spectrum (757-758/787-788 MHz)
- Licensed to three different entities currently (Access Spectrum, Beachpoint Capital, and Columbia Capital)
  - Licensees must meet build out requirements (i.e. substantial service) by 2019
  - Part 27 (flexible service rules)
  - Licensees are currently selling the spectrum to utilities.
- No standards-based products due to narrow channel width

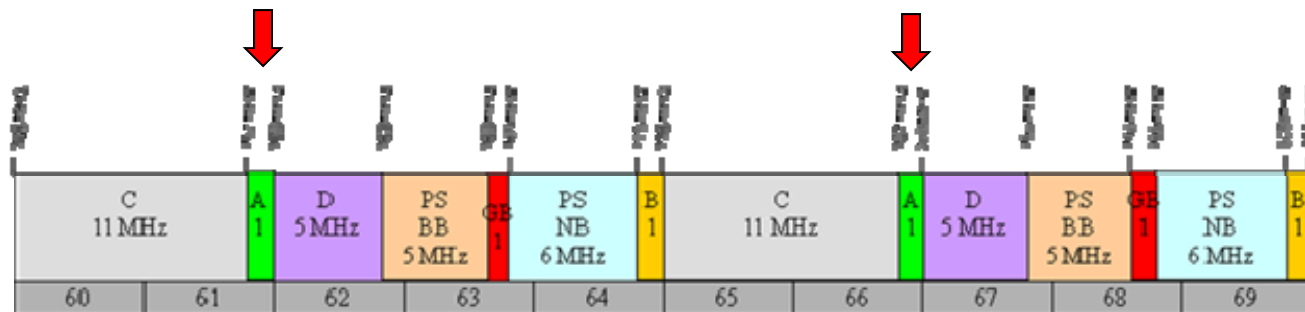


Figure 1: Current Upper 700 MHz Band Configuration



# 800 to 1000 MHz Overview

806	809	3.0	Public safety	
809	824	15.0	Public safety and SMR	
824	849	25.0	Cellular	
849	851	2.0	Commercial air-to-ground	
851	854	3.0	Public Safety	
854	869	15.0	Public safety and private land mobile	
869	894	25.0	Cellular	
894	896	2.0	Commercial air-to-ground	
896	901	5.0	Private land mobile	Previously Nextel/iDEN
901	902	1.0	Narrowband PCS	
902	928	26.0	Unlicensed (ISM)	
928	929	1.0	Multiple Address Service (101)	Widely used by utilities
929	930	1.0	Paging	
930	931	1.0	Narrowband PCS	
931	932	1.0	Paging	
932	935	3.0	Fixed microwave	
935	940	5.0	Private land mobile	Previously Nextel/iDEN
940	941	1.0	Narrowband PCS	
941	944	3.0	Various fixed link applications	
944	960	16.0	Various licensed services	

- Mostly narrowband - E.G. SpaceData 901-902 MHz
- Some re-packing and aggregating in 900 MHz (PDV petition)

# 1000 to 1400 MHz Overview

960	1164	204.0	Aeronautical navigation and radar	
1164	1215	51.0	Aeronatical nav and GPS	
1215	1240	25.0	Federal use for radar	
1240	1300	60.0	Federal use for radar, amateur	
1300	1350	50.0	Federal use for radar	
1350	1390	40.0	Fed. Radar, DoD point-to-point tactical communications	
1390	1392	2.0	Commercial telemetry	TerreStar
1392	1395	3.0	Commercial telemetry	paired with 1432-1435
1395	1400	5.0	Medical telemetry	
1400	1427	27.0	Radio Astronomy	With few exceptions, no transmission allowed

Terrastar is in bankruptcy.

50% buildout requirements in 2017

WiMAX profile is already defined

# 1400 to 1700 MHz Overview

1427	1429.5	2.5	Medical telemetry	
1429.5	1432	2.5	land mobile telemetry	
1432	1435	3.0	commercial telemetry	paired with 1392-1395
1435	1525	90.0	DoD, NASA, DoE flight test telemetry	
1525	1535	10.0	Commercial mobile satellite	
1535	1559	24.0	Commercial mobile satellite	
1559	1610	51.0	GNSS (GPS)	
1610	1610.6	0.6	Commercial mobile satellite	Globalstar
1610.6	1613.8	3.2	Commercial mobile satellite	Globalstar
1613.8	1626.5	12.7	Commercial mobile satellite	Iridium, Globalstar
1626.5	1660	33.5	Commercial mobile satellite	Inmarsat
1660	1660.5	0.5	Radio Astronomy	
1660.5	1668.4	7.9	Radio Astronomy	With few exceptions, no transmission allowed
1668.4	1670	1.6	Federal use for meteorology	
1670	1675	5.0	NOAA use for satellite data links and research	Lightsquared
1675	1695	20.0	NOAA use for satellite data links and meteorology	

## 1427-1432 MHz

- This spectrum comprises two smaller bands
  - 1427-1429.5 MHz and 1429.5-1432 MHz
  - Currently used primarily for licensed industrial telemetry
- Utilities are already users in these bands
  - Utilities could informally re-organize band – aggregation is allowed based on showing of need
  - Still site-by-site licensing
- The 1427-1432 MHz band is not designated as a TDD operating band in LTE standards

# 1700 to 2000 MHz Overview

1695	1710	15.0	AWS-3	
1710	1755	45.0	AWS	
1755	1780	25.0	AWS-3	
1780	1850	70.0	Military, but anticipated for future broadband mobile use	Transitioning from military communications
1850	2000	150.0	PCS and AWS-2	

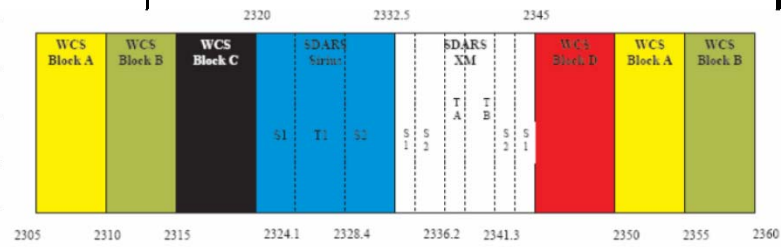
- AWS bands may be available for sale/lease in remote rural areas.

## 1780-1850 MHz

- Right above AWS-3 Band that was recently auctioned
- Currently federal allocation
  
- Possibilities
  - Federal users have spotty occupancy regionally
  - Of the 60 MHz, it is likely that a 5 MHz (for example) segment could be found to be unused
  - Possibly bear cost for moving an incumbent
  - This type of “Shared Use” is seen favorably by FCC
  
- Notes
  - Currently not standardized as TDD LTE spectrum.
  - Close enough to AWS-3 that some synergies may exist
  - Possible use of equipment designed for 1800 band in Canada

# 2000 to 2400 MHz Overview

2000	2020	20.0	Commercial mobile satellite	Held by Dish Networks
2020	2025	5.0	AWS-2	
2025	2110	85.0	NASA use for satellite and deep space data links	
2110	2120	10.0	NASA use for deep space communications	
2120	2180	60.0	AWS, AWS-3	
2180	2200	20.0	Commercial mobile satellite	Held by Dish Networks
2200	2290	90.0	NASA and other use for space communications	
2290	2300	10.0	NASA use for space research	
2300	2305	5.0	Amateur	
2305	2310	5.0	Amateur and some military use	
2310	2320	10.0	Broadcast satellite	
2320	2345	25.0	Broadcast satellite (Sirius/XM)	
2345	2360	15.0	Broadcast satellite	
2360	2390	30.0	Federal and non-federal flight test telemetry	
2390	2395	5.0	Federal and non-federal flight test telemetry, amateur	



- OOB and power limits due to SDARS (Satellite radio) reduce utility of 2360 MHz band

## 2000 – 2200 Dish Networks



- Paired FDD spectrum: 2000-2020 and 2180-2200 MHz
- Rule changes in process from satellite to commercial broadband.
- Nationwide availability
- Dish is facing buildout requirements: 40% pop by end 2016
- Some analysts think Dish will wholesale or lease spectrum



# 2400 to 2700 Mhz Overview

2395	2400	5.0	Amateur	Incompatible with current use
2400	2417	17.0	Amateur, limited federal use for air to ground communications	
2417	2450	33.0	ISM: Primarily used for unlicensed applications (e.g. 802.11)	Incompatible with current use; see "Licensed vs. Unlicensed Spectrum" discussion
2450	2483.5	33.5	ISM: Primarily used for unlicensed applications (e.g. 802.11)	
2483.5	2495	11.5	Commercial mobile satellite	Incompatible with current use
2495	2496	1.0	Commercial mobile satellite and others	
2496	2690	194.0	Commercial Mobile Educational Broadband Service (EBS)	Held by Sprint nationwide (Band 7, 38, 41)
2690	2700	10.0	Radio Astronomy	With few exceptions, no transmission allowed

## 2496-2690 MHz Sprint Holdings

- Nationwide, TDD spectrum
- Already standardized for LTE in 3GPP
  - Chipset and equipment availability
  
- Reasons Sprint might sell or lease:
  - More spectrum than they can build out (194 MHz)
  - They may utilize “small cells” rather than deploying macro network at 2.5 GHz
  - A 5 MHz segment is only 2.5% of their holdings
  - They might prefer giving access to non-competitors
  - Utilities could barter right of way, fiber, sites/towers
  
- Downsides
  - Cost may be high
  - Relatively high frequency raises deployment cost

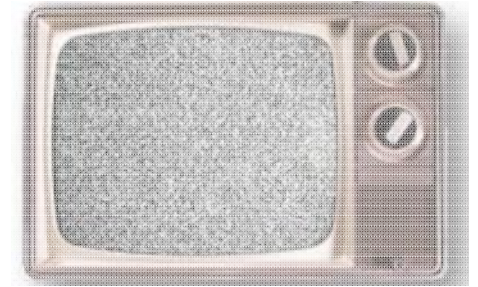
# Summary of bands with potential

Band	Pros	Cons
Sprint 2496-2690 MHz	<ul style="list-style-type: none"> <li>Nationwide, TDD, large allocation, LTE band</li> <li>May be easier to build relationship as non-competitors</li> </ul>	<ul style="list-style-type: none"> <li>Likely expensive</li> <li>Relatively high frequency</li> </ul>
Dish Networks: 2000-2020 and 2180-2200 MHz	<ul style="list-style-type: none"> <li>Nationwide, 20x20, LTE bands</li> <li>Current owner motivated (buildout requirements)</li> </ul>	<ul style="list-style-type: none"> <li>Likely expensive</li> </ul>
406 to 420 MHz Govt Sharing	<ul style="list-style-type: none"> <li>Low Frequency</li> <li>Possibility of creating equipment ecosystem in the band with many utilities</li> </ul>	<ul style="list-style-type: none"> <li>Would require time to negotiate and aggregate</li> <li>Close to LTE, but not in band</li> </ul>
1427-1432 MHz Telemetry Band	<ul style="list-style-type: none"> <li>Relatively Low Frequency</li> <li>Already used by utilities</li> </ul>	<ul style="list-style-type: none"> <li>Licensing has been problematic</li> </ul>
1780-1850 MHz Govt Sharing	<ul style="list-style-type: none"> <li>Right above AWS-3 band</li> <li>Lightly used – some portion could be shared</li> <li>FCC is favorable toward sharing</li> <li>Overlaps Canadian 1800 MHz band</li> </ul>	<ul style="list-style-type: none"> <li>Would require time to negotiate</li> <li>Close to LTE, but not in band</li> <li>Uncertain future of band</li> </ul>

## Longer Term – Public Safety

- Public Safety Sharing
  - Currently the “secondary” status of utilities is under review by FirstNet.
  - A favorable decision (considering utilities as co-primary first responders) would likely enable reasonable sharing scenarios in 700 MHz public safety broadband spectrum
  
- The 4940-4990 public safety band is underutilized
  - Another candidate for sharing
  - A favorable ruling on utility use is expected soon
  - High frequency limits application for full coverage FAN

## Longer Term – TV White Spaces



- Current rules make use of TVWS for FAN problematic
  - 4 W EIRP power limit
  - Antenna: Lower of 30 M AGL and 250 M HAAT
  - Adjacent channel vacancy requirement for fixed stations
  - 600 MHz auctions will further reduce available channels
  
- Opportunities (longer term)
  - Unused High VHF channels 174-216 MHz?
  - Less likely to be auctioned, but broadcasters may be forced back into VHF as UHF is auctioned.

# Conclusions

- Five possibilities identified for consideration
  - For fast access but higher cost, Sprint or Dish
  - For lower cost but higher time & risk, govt shared bands
  
- This study indicates that the availability of appropriate licensed spectrum for utility networks is quite limited
  
- Final Report is published:
  - [Assessment of Licensed Communication Spectrum for Electric Utility Applications](#)
  - [Product ID: 3002005851](#)

# Questions?



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