INTERNATIONAL SYMPOSIUM ON ADVANCED RADIO TECHNOLOGIES
CENTER FOR ADVANCED COMMUNICATIONS

Commerce Spectrum Management Advisory Committee (CSMAC) Spectrum Sharing Studies
A Tutorial

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Goals

- Provide an overview of the methodologies and processes used throughout the CSMAC deliberations to develop the spectrum sharing analyses.
- Outline analysis methodologies and areas for more study.
- Discuss the motivations behind the various assumptions adopted by the industry and government stakeholders.
- Provide essential background for ISART conference participants who are unfamiliar with the CSMAC deliberations.

Agenda

- What is CSMAC
- Background of the Work
- AWS-3 Working Groups
  - WG1 1695-1710 MHz Meteorological-Satellite
  - WG2 1755-1850 MHz Law Enforcement Surveillance, EOD, and other short distance links
  - WG3 1755-1850 MHz Satellite Control and Electronic Warfare
  - WG4 1755-1850 MHz Tactical Radio Relay, SDR and Fixed Microwave
  - WG5 1755-1850 MHz Airborne Operations (Air Combat Trainings System, Unmanned Aerial Vehicles, Precision-Guided Munitions, Aeronautical Telemetry)
- Summary

What is CSMAC?

Commerce Spectrum Management Advisory Committee

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CSMAC

- Established in accordance with the Federal Advisory Committee Act (FACA)
- Members of the committee are Special Government Employees (SGEs) and shall be subject to the ethical standards applicable to SGEs.
- Chartered under the President's Memorandum on Improving Spectrum Management for the 21st Century (November 29, 2004)
- Advises the Assistant Secretary for Communications and Information at NTIA on a broad range of spectrum policy issues.
- May also provide advice and recommendations on needed reforms to domestic spectrum policies and management in order to:
  - (1) authorize radio systems and frequencies in a way that maximizes their public benefits;
  - (2) keep wireless technologies and networks as open to innovation as possible; and
  - (3) make wireless services available to all Americans.

CSMAC

- Scope of activities may include:
  - Expediting the introduction of wireless broadband services, especially in rural areas;
  - Addressing governmental and commercial concerns regarding public safety spectrum management issues;
  - Assisting in efforts to encourage the establishment of long-range spectrum planning processes;
  - Identifying international opportunities to advance U.S. Economic interests;
  - Gathering input on the latest technology and market trends;
  - Examining the latest radio-frequency research and development outputs;
  - Exploring ways to foster more efficient and more imaginative uses of electromagnetic spectrum resources across the federal government, subject to and consistent with the needs and mission of federal agencies; and
  - Promoting the interoperability and transparency of federal and non-federal spectrum databases.
- NTIA may create subcommittees, working groups, standing committees, ad hoc groups, task groups or other subgroups as it considers necessary for the performance of its functions (subject to FACA provisions).

Background for AWS-3 CSMAC Activities

- Goal:
  - To explore ways to lower the repurposing costs and/or improve or facilitate industry access to spectrum while protecting federal operations from adverse impact.

- Approach:
  - Create five CSMAC Working Groups (WGs) to consider ways to facilitate the implementation of commercial wireless broadband in the 1695-1710 MHz and 1755-1850 MHz bands.
  - NTIA created these WGs corresponding to the Federal systems in the bands:
    - WG1: Meteorological Satellite (1695-1710 MHz)
    - WG2: Law Enforcement Surveillance, EOD, and other short distance links
    - WG3: Satellite Control and Electronic Warfare (1755-1850 MHz)
    - WG4: Tactical Radio Relay, SDR and Fixed Microwave (1755-1850 MHz)
    - WG5: Airborne Operations (1755-1850 MHz)

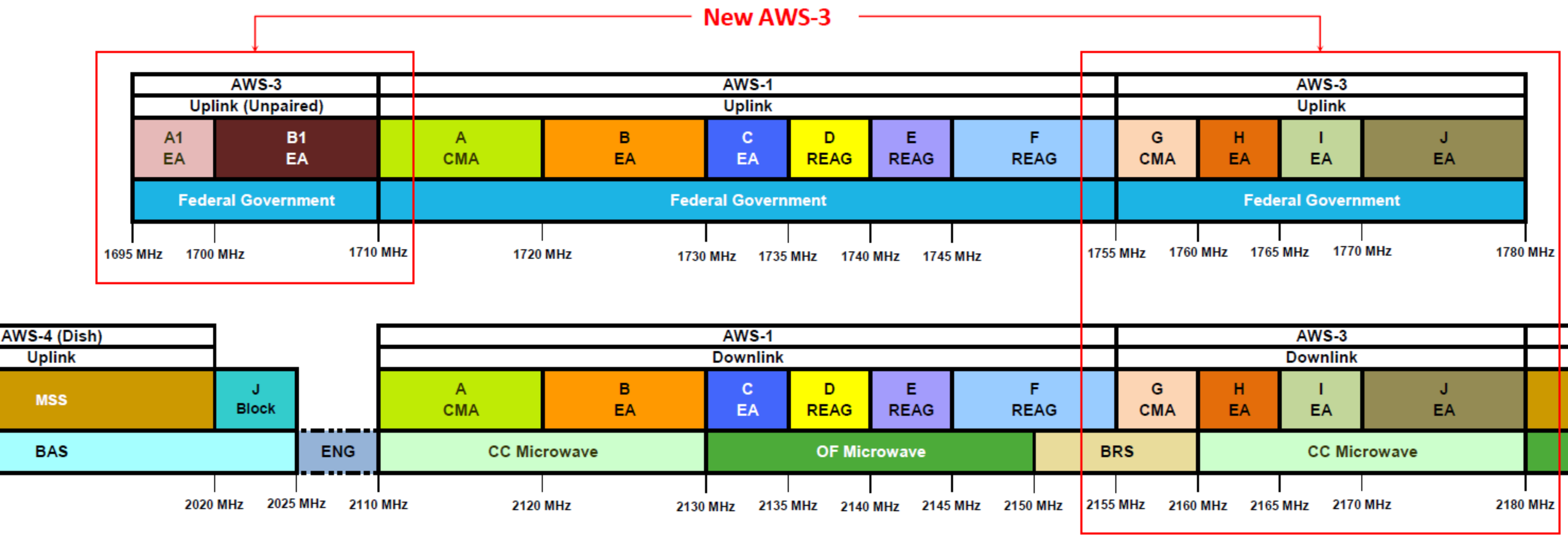
Background for AWS-3 CSMAC Activities

- Each WG had:
  - Industry and Government co-chairs
  - FCC and NTIA points of contact
  - CSMAC Liaisons
- Participation in WGs was open to anyone.
- WGs first studied approaches to sharing feasibility (i.e., Do the agencies actually have to move?), or as the means to facilitate access during relocation transition (i.e., Transitional Sharing).
- WGs worked to determine:
  - What is the potential real impact from or to the government operations,
  - Whether that impact is acceptable, and
  - What restrictions would have to be placed on the commercial operations.

Background for AWS-3 CSMAC Activities

- Where WGs concluded that sharing was not possible, they tried to identify transition approaches and critical information to support transition.
- Early recognition of possible classified discussions
- Work took place from June 2012 – July 2013
- Reference Documents:
  - NTIA Fast Track Report, “ An Assessment of the Near-Term Viability of Accommodating Wireless Broadband Systems in the 1675-1710 MHz, 1755-1780 MHz, 3500-3650 MHz, and 4200-4220 MHz, 4380-4400 MHz Bands”, (NTIA, October, 2010)
  - President’s Spectrum Plan Report, “Plan and Timetable to Make Available 500 Megahertz of Spectrum for Wireless Broadband”, (NTIA, October, 2010)

AWS-3 Band Plan



CSMAC AWS-3 Working Groups

WG1: 1695-1710 MHz Meteorological-Satellite

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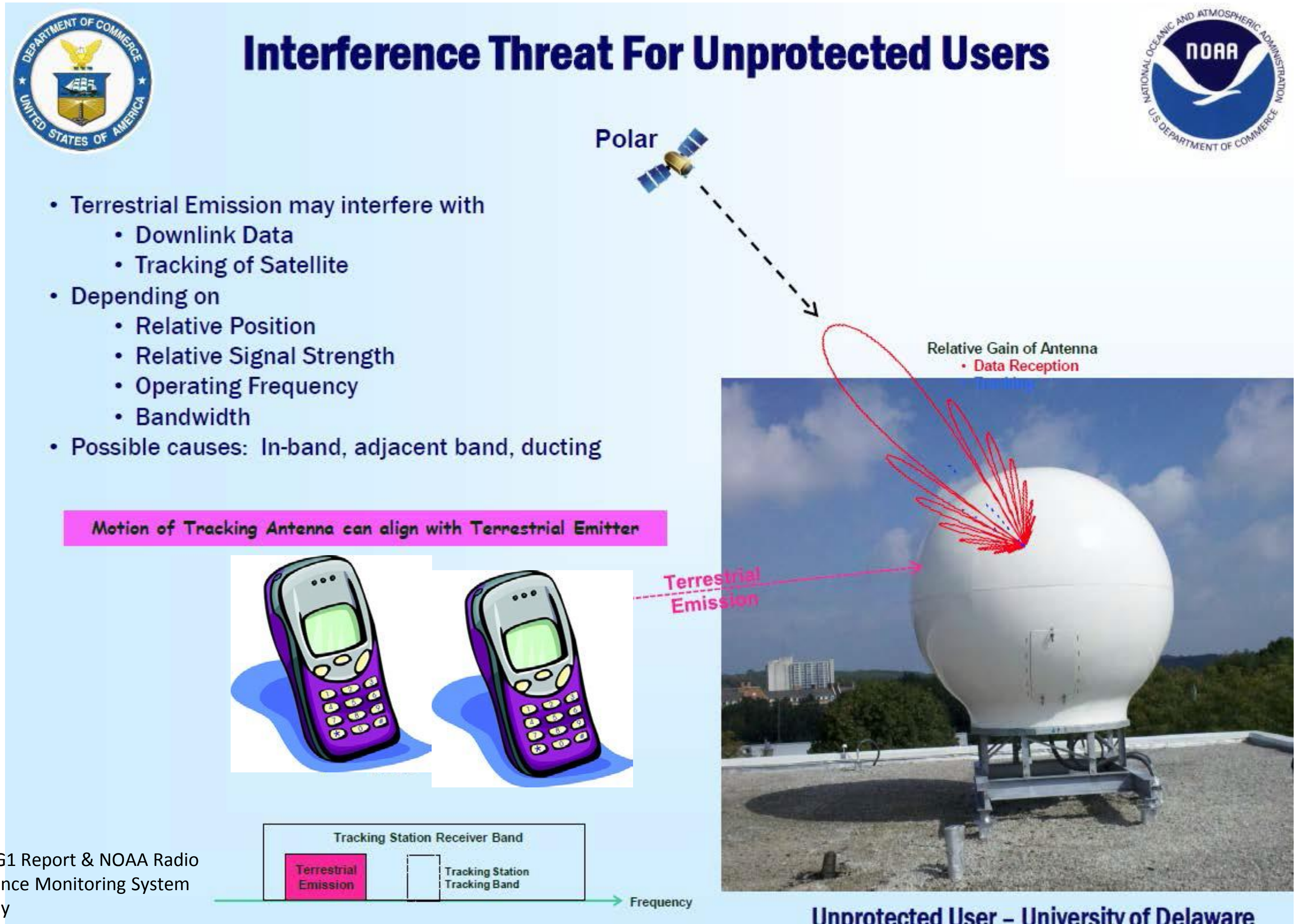
WG1: 1695-1710 MHz Meteorological-Satellite

- Focus of Work
  - Improved modeling of commercial wireless networks and possible reduction of exclusion zones

- Study Areas:
  - Refine interference analysis (from Fast Track Report)
    - LTE System Parameters (used by the rest of the WGs)
    - Propagation Models
    - Government System Parameters
  - Protection Zone vs. Exclusion Zone
  - Impact of GOES-R and JPSS on Continued Need for POES Receivers in the 1695-1710 MHz Band.
  - Prioritization of relocation

Interference Threat For Unprotected Users



Sources: CSMAC WG1 Report & NOAA Radio Frequency Interference Monitoring System (RFIMS) Industry Day

Method of Work – Interference Analysis

- Based on revised LTE inputs, NTIA revised interference analysis
  - Separation distances in the Fast Track Report were reduced by 21 – 89%
  - Each site's analysis included at least 500 Monte Carlo trials to minimize the variance in the interference model results
  - Analysis results include Minimum Distance, Mean Distance and Maximum Distance reflecting variation in scenarios
    - Analysis results will require validation through field testing prior to rulemaking for general implementation.

- LTE is highly configurable and dynamic
  - Interference protection rules should leverage LTE's configurability and dynamic capabilities, where implementable
  - Numerous system and operator controls, including wide range of dynamic power control, can be applied to protect federal operations and mitigate potential for interference
  - Deployment specific conditions create challenges in precisely modeling potential for interference in a general discussion, further testing will be required on a case-by-case basis

Method of Work – Interference Analysis

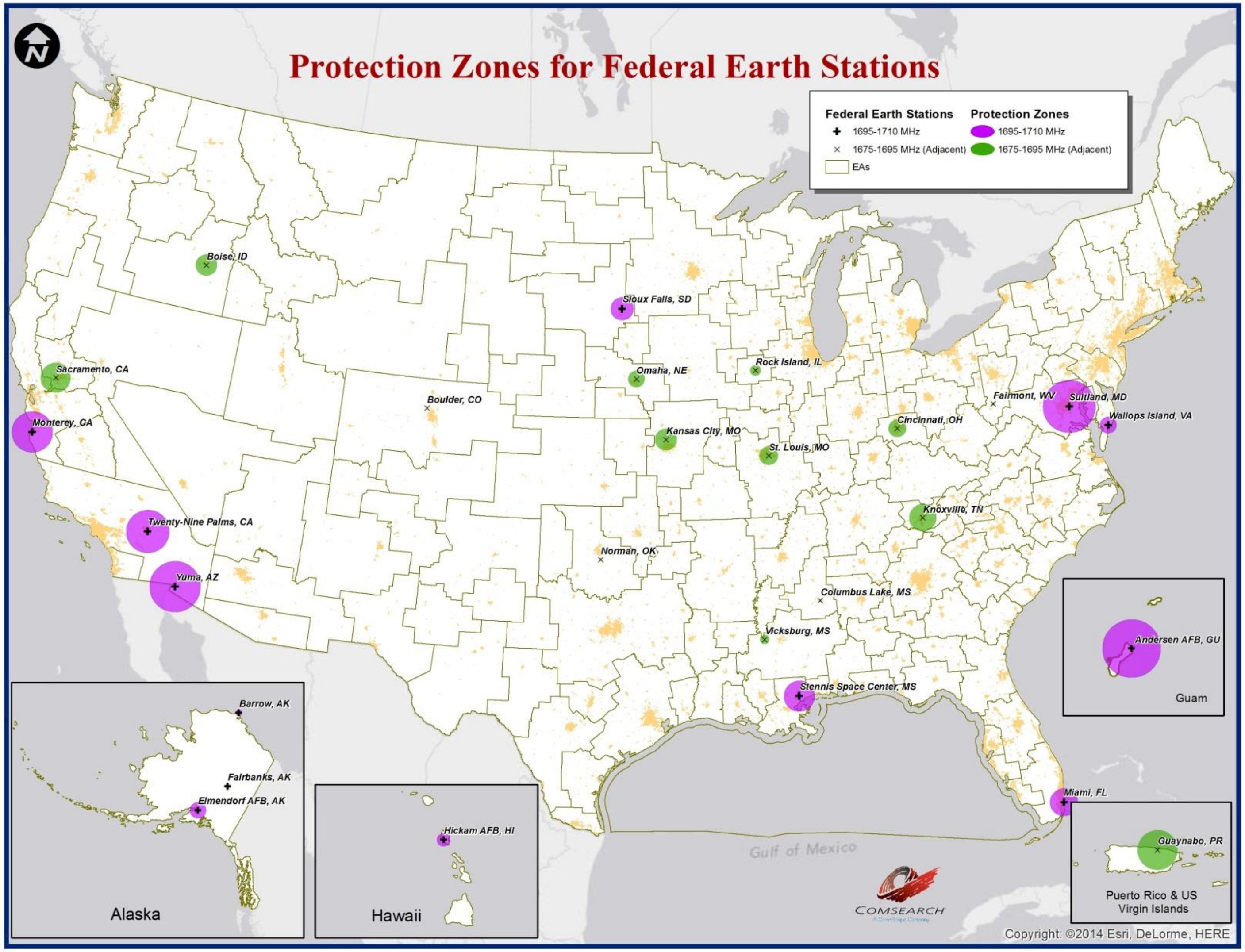
- Protection Zones vs. Exclusion Zones
  - Ability to coordinate industry operation with the protection zones as long as certain conditions can be met
  - Continues to fully protect Government Operations since operation within Protection Zones is only permitted following coordination and agreement

- Propagation
  - WG conducted extensive discussions about the most appropriate propagation model.
  - Concluded that the ITM model was appropriate and should be used in NTIA's updated analysis.
  - No final conclusion was reached regarding use of clutter as part of the model.
  - However, it was determined that the analysis results would be accurate enough for the intended purpose of recommending Protection Zones and that further refinement of the interference analysis was not necessary at this time.

Protection Zones for the Meteorological Receive Sites

Protection zones for the meteorological receive sites. Fast Track Report sites are shown in red and the new sites are shown in blue. (from WG1 Report)

Protection Zones for Federal Earth Stations



WG1 Recommendations

- Adopt the proposed framework structure for sharing the band and establish the FCC and NTIA-led Working Group to begin developing the coordination, testing, monitoring, and compliance processes, roles, and responsibilities.

- Spectrum reallocated to commercial use in the 1695-1710 MHz band should be limited to mobile uplink use only.

- Consider the option of assessing the feasibility of relocating federal government receive locations or other methods to maximize commercial use of the top 100 markets by population.

Framework for Sharing

- Protects satellite downlink receivers in the 1695-1710 MHz band and the adjacent 1675-1695 MHz band based on Protection Zones
  - Commercial licensee operations within the Protection zone will be permitted following a successful coordination process concluding that such commercial operations will not cause any loss of capability at the federal site, and meeting certain other conditions
  - If coordination for commercial licensee operation within the Protection Zone is unsuccessful, commercial licensee operations within the Protection Zone will not be permitted
  - Requirement to not cause harmful interference (loss of capability) to identified federal sites still applies to operations in either circumstance
- Presumed protection based on coexistence criteria, including aggregate Interference Power Spectral Density (IPSD) Limits, to be determined for each receiver location

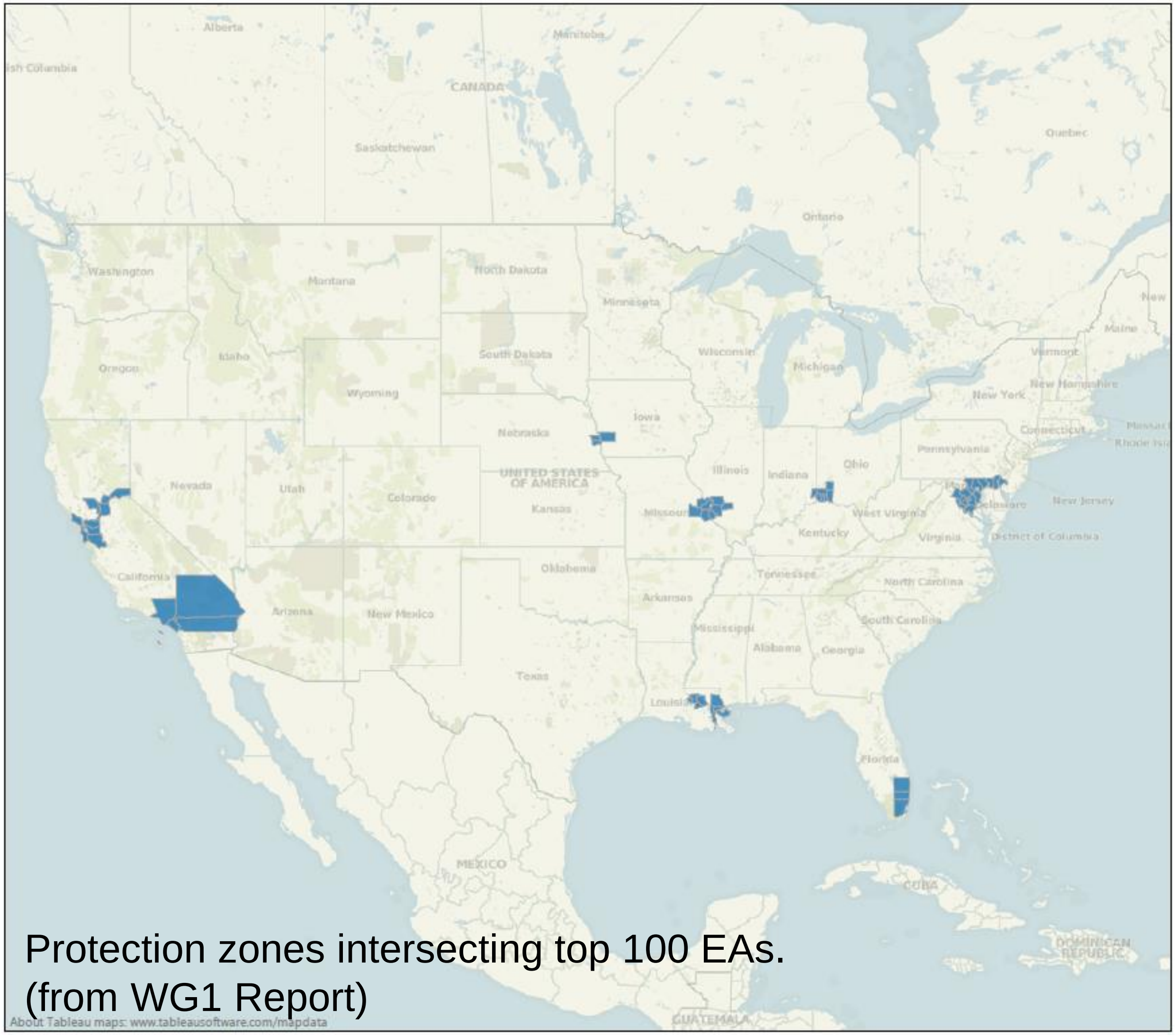
Framework for Sharing

- Coordination Process - NTIA and FCC, in coordination with the affected federal agencies, will establish:
  - A nationally-approved interference prediction model, associated input parameters, and distribution of the aggregate IPSD Limit among commercial licensees
  - Coordination procedures, including an automated process, to the extent possible, to assess if the proposed commercial network will meet the IPSD limits, to facilitate coordination allowing commercial licensee operations within the protection area
  - Procedures for implementing an on-going real-time monitoring to ensure the IPSD Limits are not being exceeded and that commercial operations can be adjusted immediately if they are
- Criteria and procedures for coordination and operation within the protected zones, as well as enforcement mechanisms, must still be clearly defined and subsequently codified in the FCC rules and the NTIA manual, as appropriate

Testing Program

- The framework for sharing the 1695-1710 MHz band endorsed by WG-1 contained a provision for a testing program to demonstrate the viability and effectiveness of proposed protection/mitigation methods before wireless service providers begin operations within Protected Zones.
- The testing program envisioned by WG-1 will:
  - validate co-channel and adjacent channel sharing assumptions and model prior to the development of final service rules, and validate interference mitigation methods prior to commencing operations;
  - establish mutual agreement on proposed validation and verification methods;
  - clearly define coordination and approval responsibilities for verification test plans and schedules; and
  - be adaptable for future or potentially changing satellite and commercial configurations.
- Compliance and enforcement – An agreed upon mechanism must be established to ensure that wireless operators cease operations in the band until interference sources are identified and resolved

Protection Zones Intersecting Top 100 EAs



Protection zones intersecting top 100 EAs.
(from WG1 Report)

List of Protected Earth Stations – From Fast Track Report

Fast Track Report Sites				
Earth Station Location	**Latitude**	**Longitude**	**Maximum Protection Distance (km)**	**Population Impacted (%)**
Wallops Island, Virginia	375645 N	752745 W	30	0.0088
Fairbanks, Alaska	645822 N	1473002 W	20	0.0329
Suitland, Maryland	385107 N	765612 W	98	3.129
Miami, Florida	254405 N	800945 W	51	1.5114
Hickam AFB, Hawaii	211918 N	1575730 W	28	0.3866
Sioux Falls, South Dakota	434409 N	963733 W	42	0.0874
Cincinnati, Ohio	390610 N	843035 W	32	0.5041
Rock Island, Illinois	413104 N	903346 W	19	0.1180
St. Louis, Missouri	383526 N	901225 W	34	0.6650
Vicksburg, Mississippi	322047 N	905010 W	16	0.0119
Omaha, Nebraska	412056 N	955734 W	30	0.2596
Sacramento, California	383550 N	1213234 W	55	0.9022
Elmendorf AFB, Alaska	611408 N	1495531 W	98	0.1664
Andersen AFB, Guam	133452 N	1445528 E	42	0.0683
Monterey, California	363534 N	1215120 W	76	0.3294
Stennis Space Center, Mississippi	302123 N	893641 W	57	0.2465
Twenty-Nine-Palms, California	341746 N	1160944 W	80	0.2191
Yuma, Arizona	323924 N	1143622 W	95	0.1321
				8.78 (7.36)

List of Protected Earth Stations – New Sites

New Sites				
Earth Station Location	**Latitude**	**Longitude**	**Maximum Protection Distance (km)**	**Population Impacted (%)**
Barrow, Alaska	711922 N	1563641 W	35	0.00183
Boise, Idaho	433542 N	1161349 W	39	0.20683
Boulder, Colorado	395926 N	1051551W	2	0.0001
Columbus Lake, Mississippi	333204 N	883006 W	3	0.0001
Fairmont, West Virginia	392602 N	801133 W	4	0.00210
Guaynabo, Puerto Rico	182526 N	660650 W	48	0.6169
Kansas City, Missouri	391640 N	943944 W	40	0.4799
Knoxville, Tennessee	355758 N	835513 W	50	0.1679
Norman, Oklahoma	351052 N	972621 W	3	0.0001
				1.48 (0.65)
			Total	**10.26 (8.01)**

Updates since CSMAC Work

- Current work on Radio Frequency Coordination Portal
  - Should accommodate analysis methodologies recommended by WG
- RFI issued for monitoring capability

CSMAC AWS-3 Working Groups

WG2: 1755-1850 MHz Law Enforcement Surveillance,
Explosive Ordnance Disposal, and other short distance links

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WG2: 1755-1850 MHz Law Enforcement Surveillance, Explosive Ordnance Disposal, and other short distance links

- Focus of Work
  - Based on sharing analyses done during the Federal relocation of the 1710-1755 MHz spectrum, did not believe that sharing between video surveillance and other short range links was feasible.
  - Develop a prioritized list of geographic areas according to industry implementation priorities, first considering 1755-1780 MHz and second 1780-1850 MHz for the potential transition of video surveillance systems

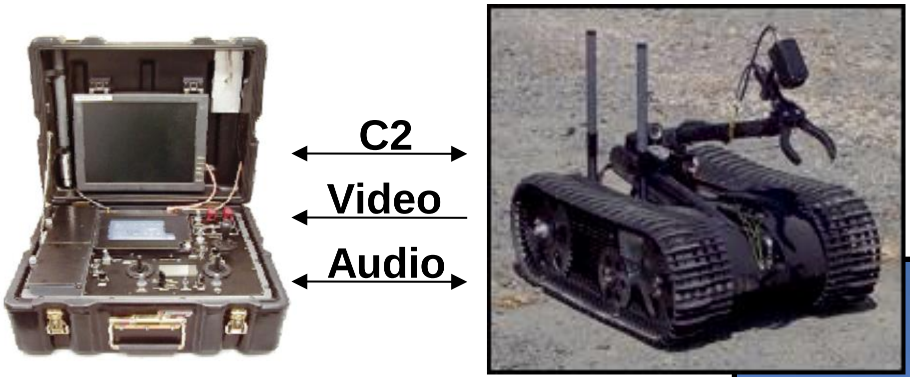
- Study Areas:
  - Focused on two primary types of video surveillance systems:
    - Video surveillance used by Federal law enforcement agencies that are operated in all portions of the spectrum at any time and location; and
    - Land robotic systems used by Federal agencies that reduce personnel “risk to life” during explosive ordnance demolition, disposal and other uses.
    - Video surveillance operations are conducted by DHS, DOD, DOE, DOJ, DOI, HHS, HUD, OPM, Treasury, USAID, USCP and the USPS.

WG2 Recommendations

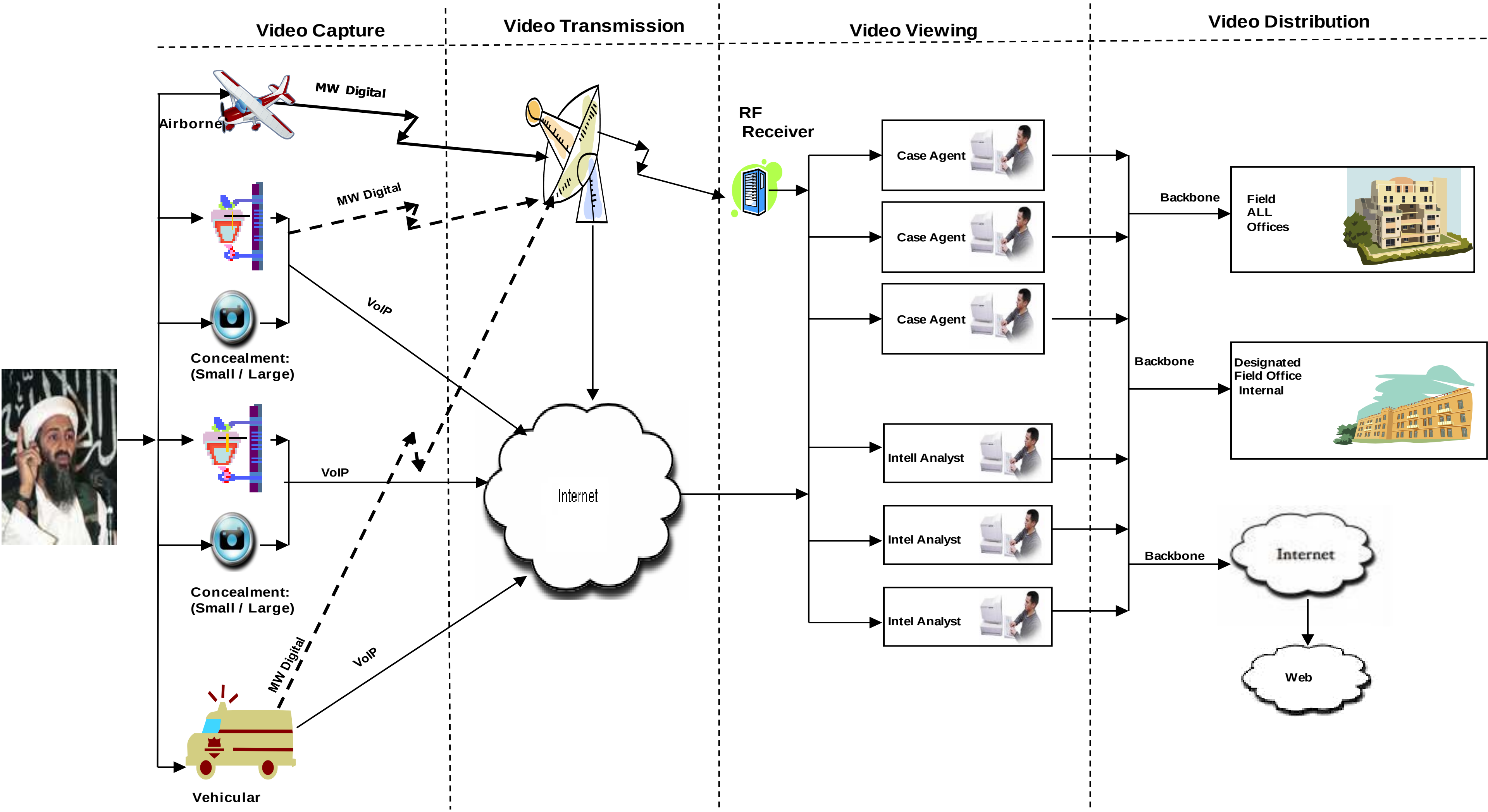
- Federal agencies should consider in developing their transition plans the list of 176 industry-defined Economic Areas (EAs) according to industry's geographic implementation priorities.
  - This list should be used by other WGs
  - The geographic unit chosen, Economic Areas, was based on its probability of alignment with likely FCC licensed areas for the 1755-1850 MHz band.
  - While geographic areas based on license areas makes sense and have defined geographic boundaries, there will be instances where agencies will clear larger areas.

- While industry would prefer that federal relocation be based on these EAs, the WG2 participants acknowledged that the exact order in which agencies will be able to clear the EAs will be based on the federal agencies' operational requirements and may vary from the industry priority.

Applications: DoD Land Mobile Robotic Video Functions



Applications: DOJ Surveillance Operations



Top 31 EA Rankings

Economic Areas		Major Economic Area	REAGs	Median Ranking
10	(NYC-Long Is. NY-NJ-CT-PA-MA-VT)	2 (New York City)	1 (Northeast)	1
160	(LA-Riverside-Orange Cnty CA-AZ)	44 (Los Angeles-San Diego)	6 (West)	2
64	(Chicago-Gary-Kenosha IL-IN-WI)	18 (Chicago)	3 (Great Lakes)	3
131	(Houston-Galveston-Brazoria TX)	31 (Houston)	5 (Central)	4
31	(Miami-Fort Lauderdale FL)	11 (Miami)	2 (Southeast)	5
163	(San Fran.-Oakland-San Jose CA)	43 (San Francisco-Oakland-San Jose)	6 (West)	6
158	(Phoenix-Mesa AZ-NM)	40 (Phoenix)	5 (Central)	7
127	(Dallas-Fort Worth TX-AR-OK)	32 (Dallas-Fort Worth)	5 (Central)	8
12	(Phil.-Atl. City PA-NJ-DE-MD)	4 (Philadelphia)	1 (Northeast)	9
161	(San Diego CA)	44 (Los Angeles-San Diego)	6 (West)	10
57	(Detroit-Ann Arbor-Flint MI)	16 (Detroit)	3 (Great Lakes)	11
3	(Boston-Worcester MA-NH-RI-VT)	1 (Northeast)	1 (Northeast)	12
55	(Cleveland-Akron OH-PA)	15 (Cleveland)	3 (Great Lakes)	13
30	(Orlando FL)	10 (Tampa-St. Petersburg-Orlando)	2 (Southeast)	14
13	(Wash.-Balt. DC-MD-VA-WV-PA)	5 (Washington)	2 (Southeast)	15
170	(Seattle-Tacoma-Bremerton WA)	46 (Seattle)	6 (West)	16
34	(Tampa-St. Petersburg FL)	10 (Tampa-St. Petersburg-Orlando)	2 (Southeast)	17
49	(Cincinnati-Hamilton OH-KY-IN)	13 (Cincinnati-Dayton)	3 (Great Lakes)	18
40	(Atlanta GA-AL-NC)	8 (Atlanta)	2 (Southeast)	19
53	(Pittsburgh PA-WV)	12 (Pittsburgh)	3 (Great Lakes)	20
134	(San Antonio TX)	38 (San Antonio)	5 (Central)	21
96	(St. Louis MO-IL)	30 (St. Louis)	4 (Mississippi Valley)	22
67	(Indianapolis IN-IL)	19 (Indianapolis)	3 (Great Lakes)	23
23	(Charlotte-Gastonia NC-SC)	7 (Charlotte-Greensboro-Greenville-Raleigh)	2 (Southeast)	24
63	(Milwaukee-Racine WI)	17 (Milwaukee)	3 (Great Lakes)	25
152	(Salt Lake City-Ogden UT-ID)	42 (Salt Lake City)	6 (West)	26
107	(Minneapolis-St. Paul MN-WI-IA)	20 (Minneapolis-St. Paul)	3 (Great Lakes)	27
130	(Austin-San Marcos TX)	32 (Dallas-Fort Worth)	5 (Central)	28
83	(New Orleans LA-MS)	27 (New Orleans-Baton Rouge)	4 (Mississippi Valley)	29
19	(Raleigh-Durham-Chapel Hill NC)	7 (Charlotte-Greensboro-Greenville-Raleigh)	2 (Southeast)	30
141	(Denver-Boulder CO-KS-NE)	33 (Denver)	5 (Central)	31

CSMAC AWS-3 Working Groups

WG3: 1755-1850 MHz Satellite Control and Electronic Warfare

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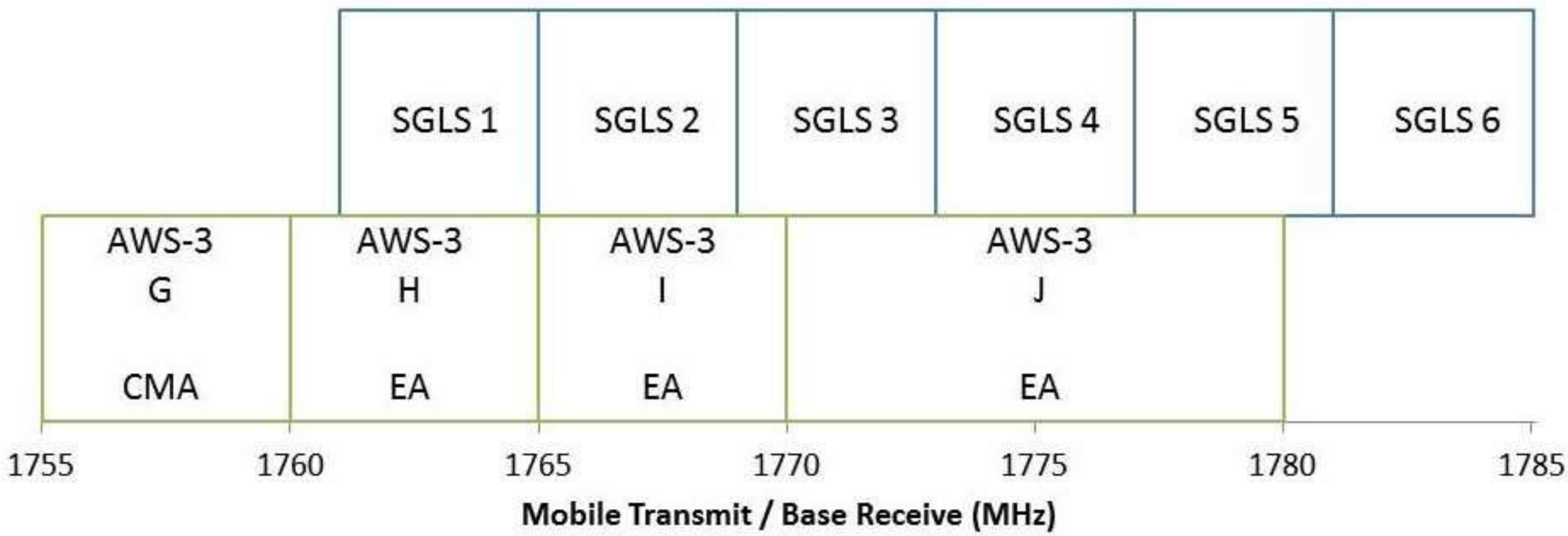
WG3: 1755-1850 MHz Satellite Control and Electronic Warfare

- Focus of Work
  - Recommendations to optimize industry access to the 1755-1850 MHz band while protecting federal operations.
  - Consider the entire 1755-1850 MHz band while taking into account the industry priority to access to 1755-1780 MHz first.
  - Deliverables include recommendations regarding definition and specification for sharing techniques with satellite operations (including any interference acceptance rules and coordination zones) and improved coordination rules and procedures for electronic warfare.
- Study Areas:
  - Analysis of Interference into LTE Base Station Receivers
  - Analysis of Potential Aggregate LTE Interference to Space-Borne Satellite Operations
  - Sharing of the band by LTE with Electronic Warfare activities
- Concluded that satellite control systems and Electronic Warfare operation can co-exist with LTE operations in the 1755-1850 MHz band
  - Requires coordination at 25 sites

Interference to Satellite Control Systems



AWS-3 blocks impacted by Federal earth station transmissions

Interference to Satellite Control Systems

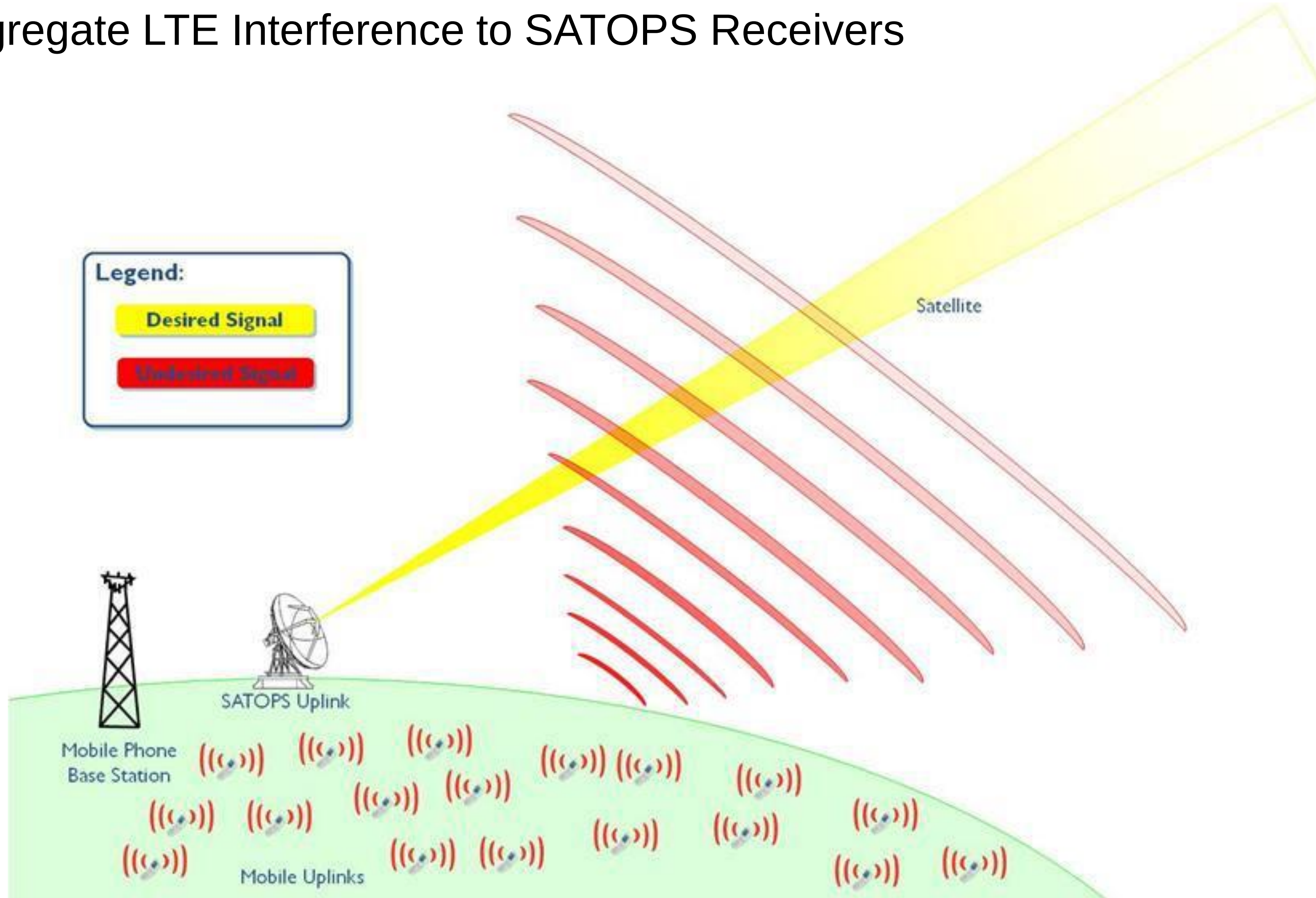
- Examined aggregate LTE interference to satellite operations (SATOPS) on-board orbiting spacecraft
- Analysis was based on WG1 assumptions about LTE parameters
- An interference level of -205 dBW/Hz into a SATOPS receiver, assuming a 0 dBi antenna and no other losses, (equivalent to a power flux density of -179 dBW/Hz/m^2) was determined to be a safe interference level at geostationary orbit for most programs.
  - This level was derived from requirements documented for all programs.
  - It also ensures a safe level of RFI for most low earth orbit programs.
  - Satellite receiver designs/technology are not expected to change significantly in the future.

Interference to Satellite Control Systems

- Analysis Parameters:
  - Spacecraft sensitivity
  - Spacecraft position
  - LTE antenna gain
  - UEs/Base Station (18)
  - LTE channel bandwidth (10 MHz)
  - Rural/Urban cell radius (1.732 Km ISD / 7 Km ISD)
  - Rural/Urban UE power
  - Rural/Urban UE variance

Interference to Satellite Control Systems

Aggregate LTE Interference to SATOPS Receivers



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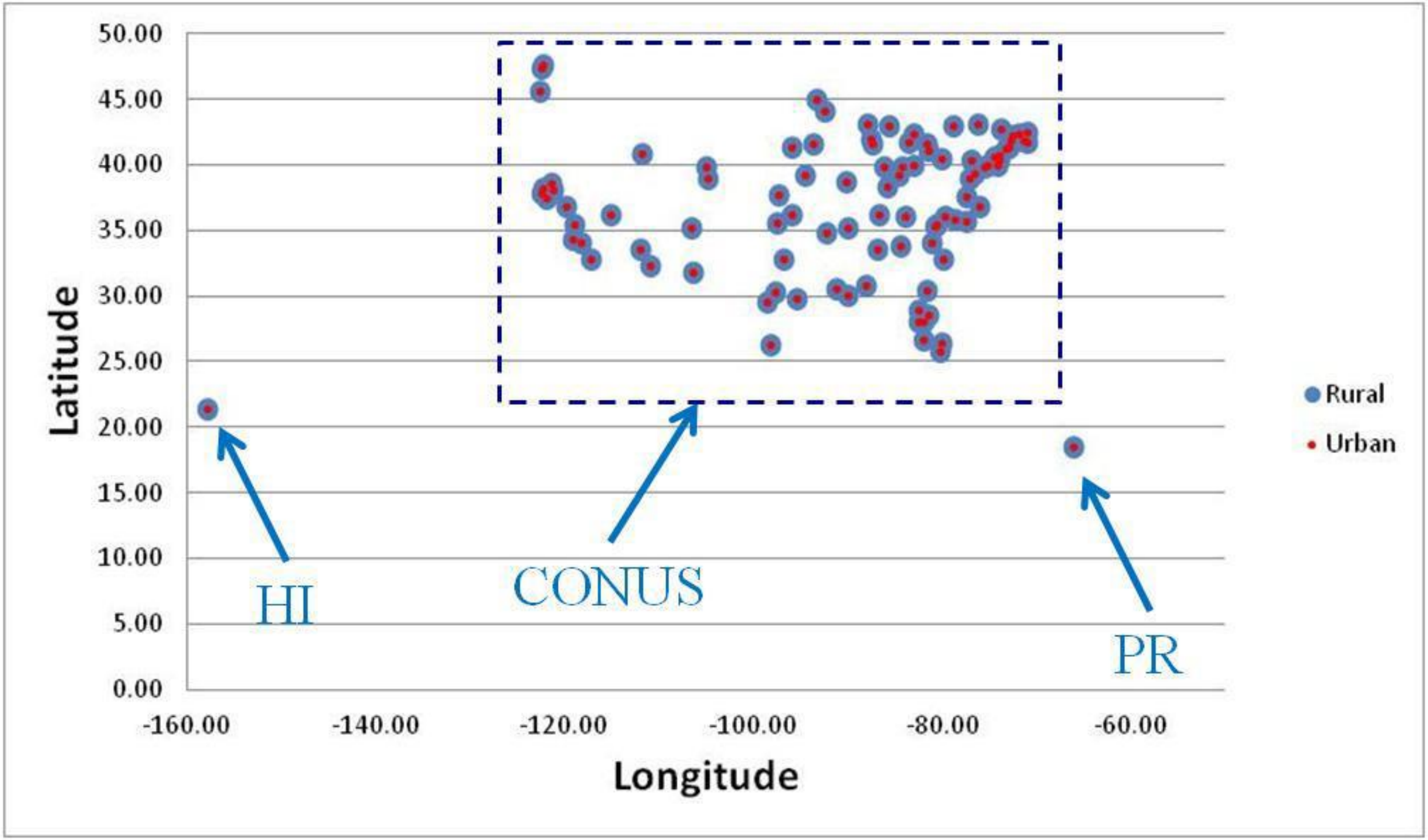
Interference to Satellite Control Systems

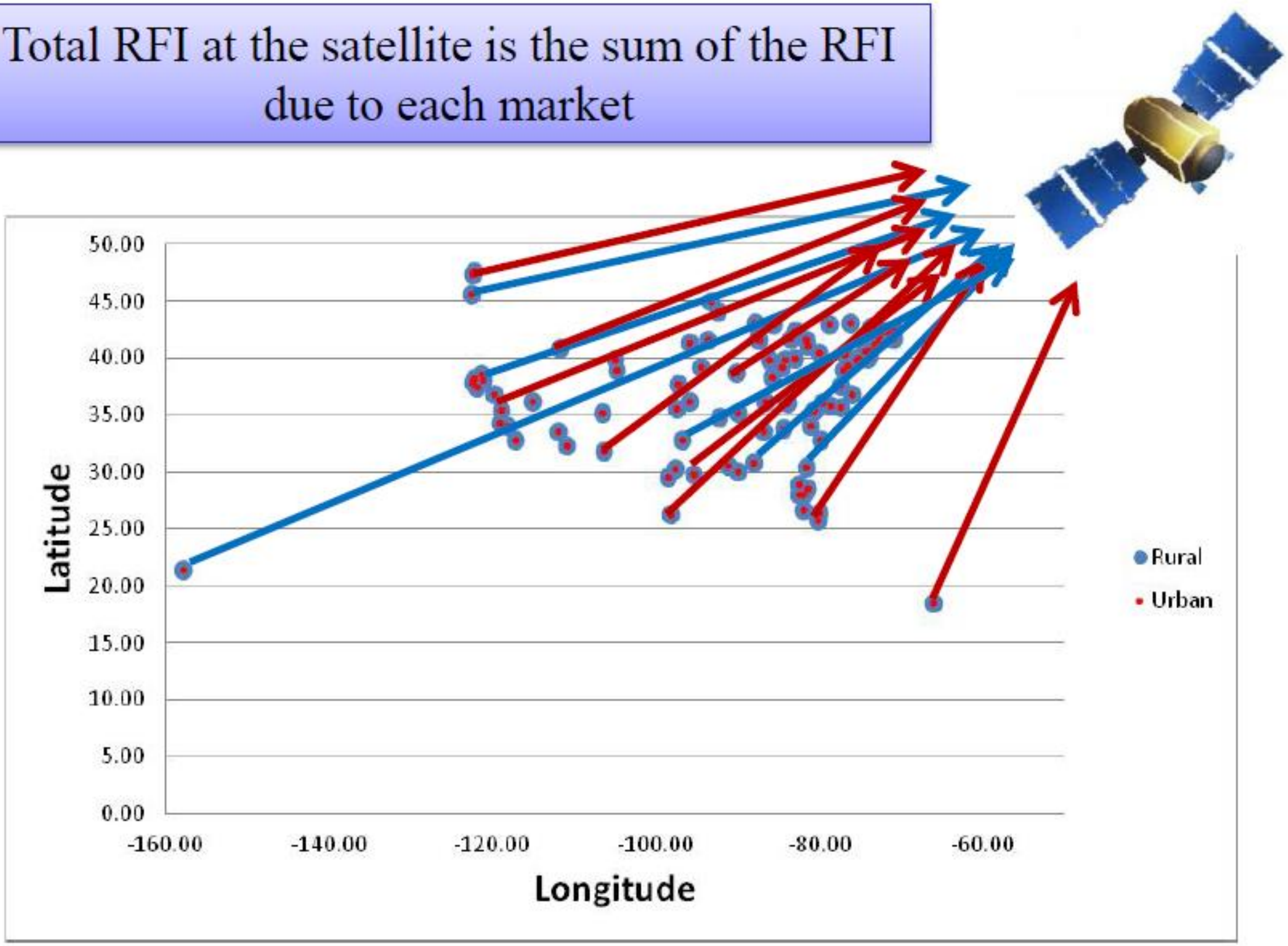


Modeled LTE Market Areas

~ 170,000 base stations and 3 million simultaneously transmitting UEs

Interference to Satellite Control Systems

Total RFI at the satellite is the sum of the RFI due to each market



Interference to Satellite Control Systems

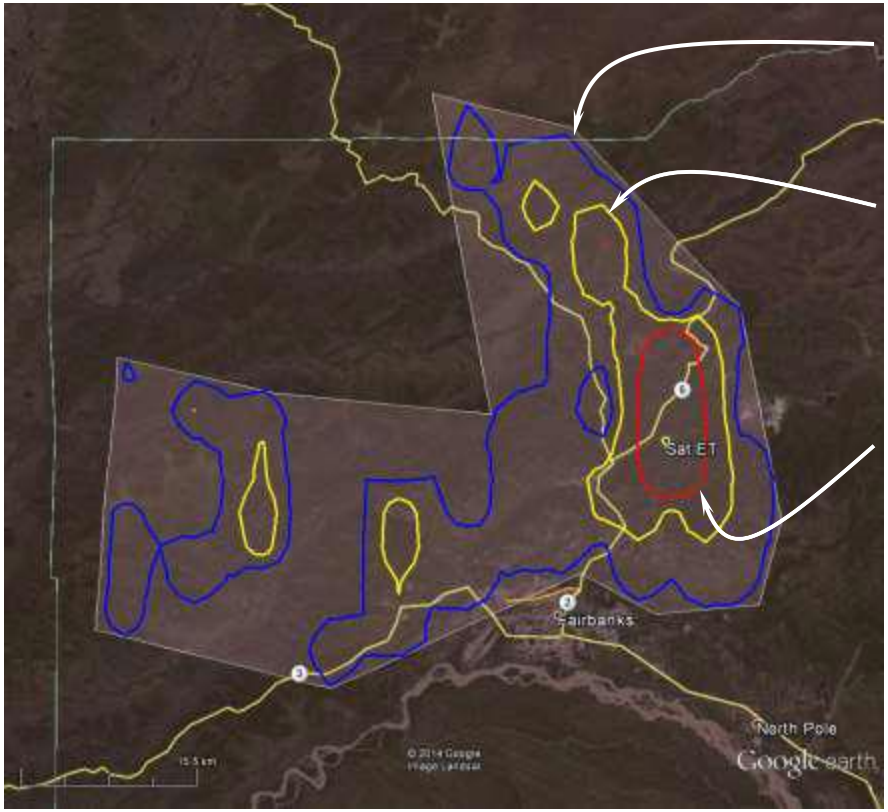
- Assumed free space path loss
- Analysis indicated that aggregate mean interference was estimated to be -212.6 dBW/Hz (7.6 dB below the safe level).
- However, a few experimental programs may not be protected by this level.
  - Therefore additional consideration is needed for the experimental programs, e.g., during transition planning.
- Analysis also found insignificant interference variation due to LTE power control (σ = 0.12 dB).

Interference to Mobile Broadband Systems

- SATOPS transmitting earth terminal interference into LTE base station receive operations.
  - Two studies were conducted based upon available data
  - Final results based on results from later study
- Used Satellite Orbit Analysis Program (SOAP) from The Aerospace Corporation
  - computes interference power received by a base station when a SATOPS antenna is pointed in each Azimuth/Elevation (Az/El) cell
  - driven by an input value of propagation path loss; used ITM for this analysis
- Resulted in protection zones around 25 sites
- Potential mitigation techniques were identified for further evaluation and implementation by licensees

Interference to Mobile Broadband Systems

Example of Protection Zone



3dB desense contour (baseline)

11.5 dB improvement contour using improved antenna (ITU-R F.1336-3 @60 deg off axis)

30.4 dB improvement contour using more improved antenna (Andrew HBX-9016DS-T0M @60 deg off axis)

Coordination zone for Fairbanks Alaska

WG3 Satellite Control Systems Recommendations

- Direct federal earth station operators to document in their transition plans publicly releasable information to allow prospective licensees to understand the potential impact to any base station receivers from SATOPS uplinks. Detailed information to be provided by the federal users should include:
  - Contours within which radiated power levels from federal earth stations is likely to exceed the -137.4 dBW LTE interference threshold (1 dB desense) assuming worst case conditions of maximum transmit power at minimum elevation angle.
  - Contours within which radiated power levels from federal earth stations is likely to remain below the -137.4 dBW LTE interference threshold (1 dB desense) as calculated at 100%, 99%, and 95% of the time assuming nominal operating conditions, based on recent historical use. Usage of federal earth stations can and will change with time, and is not limited by the information provided.

- NTIA should recommend that the FCC, in consultation with the NTIA, consider methods to allow government agencies to share with commercial licensees information relevant to spectrum sharing in the vicinity of federal earth stations, subject to appropriate non-disclosure or other agreements, consistent with US law and government policies.

WG3 Satellite Control Systems Recommendations

- NTIA should recommend the FCC require that commercial licensees accept interference from federal SATOPS earth stations operating in the 1761-1842 MHz band.

- Direct federal earth station operators to identify and document in their transition plans the cost and schedule required to accelerate and/or expand the transition of all federal earth stations to radiate a narrower bandwidth signal.

- NTIA should recommend establishment of rules/regulations with built in flexibility for future SATOPS growth and change, including satellite network and ground station locations/configurations. New federal earth station locations must be determined in coordination with commercial licensees. For existing federal earth stations, federal users must notify commercial licensees of significant changes such as additional antenna or extended anomaly support.

WG3 Satellite Control Systems Recommendations

- NTIA should recommend that the FCC, in consultation with NTIA and relevant federal agencies, develop methods for licensees in the 1761-1842 MHz band to demonstrate technologies or techniques that ensure commercial operations can accept interference from the satellite operations when operating within the zones where the nominal SATOPS power is expected to exceed the LTE interference threshold (a 1 dB desense), prior to deployment of base stations in the zones.

- The FCC propose in their rulemaking a requirement on licensees which overlap any of the 1761-1842 MHz band that specifies a technical showing of compatibility with satellite uplinks.

WG3 Satellite Control Systems Recommendations

- The FCC consider in its rulemaking methods to ensure that the following conditions be met to ensure the aggregate commercial wireless mobile broadband emissions will not exceed the acceptable threshold power level, including:
  - Method to aggregate the individual showings into a single value expected at the GSO arc from all licensees.
  - The actions to be taken by the FCC to reduce the projected aggregate emissions if it is projected to exceed the threshold.
  - The actions to be taken by the FCC to eliminate harmful interference if it does occur, to include potential cessation of operations by the commercial licensee(s) on the affected frequency until interference is resolved.
- Investigate measures that can be implemented in its NTIA manual to enhance future spectrum sharing with mobile broadband networks. One approach could be to specify power radiated at the horizon from new SATOPS terminals similar to that found in the NTIA manual at Section 8.2.35.

EW Systems Overview

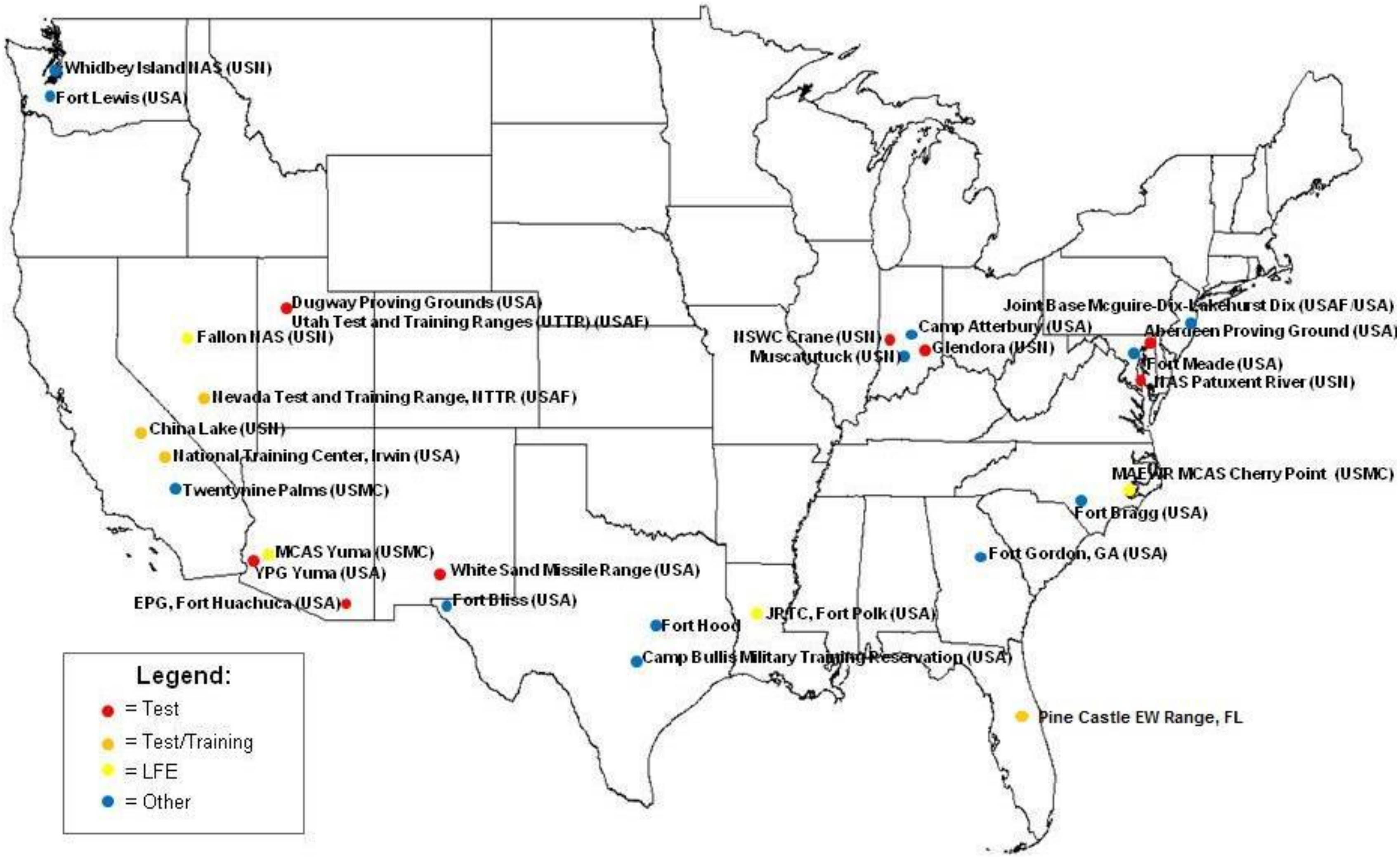
- **Electronic Warfare Mission:** US dominance of the EM spectrum, assuring US forces use of the spectrum to their full potential, while denying that use to our adversaries through the effect employment of EW Attack (EA), EW Protection (EP) and EW Support (ES)

- **Electronic Warfare Objective/Goal:** Enable the warfighting commanders to gain and maintain freedom of action across land, maritime, air, space and cyber domains through control of the EM spectrum.

- **Electronic Warfare Systems:** Airborne, maritime, and land mobile systems that detect, degrade, disrupt, deceive, deny and/or destroy enemy spectrum dependent operations across the battlefield.

- **Electronic Warfare Key Considerations, 1755-1850 MHz Band:**
  - Critical Counter-Improvised Explosive Device (C-IED) and Command, Control and Communications (C3) Exploitation capabilities for DoD
  - Operations driven by existing/emerging threat systems—commercial wireless systems employed in nontraditional ways against US Forces
  - Use pre-coordinated with civil and federal users (w/o frequency assignments)
  - US&P use for development, testing, and proficiency training

EW Test & Training Ranges



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WG3 EW Work

- Due to the sensitive nature of data on EW systems, no analysis was performed.
- WG focused on recommendations related to coordination.

WG3 EW Recommendations

- Allow the federal agencies to continue to conduct EW RDT&E, training and LFE operations on DoD ranges and within associated airspace on a NIB with commercial wireless operations, if introduced to the band.
- NTIA and FCC should evaluate current simulation and modeling tools, techniques and management processes used to coordinate EW RDT&E, training and LFE operations to ensure they are robust enough to allow timely and effective deconfliction with potential commercial wireless operations in the band.
- NTIA, FCC and DoD should assess the usefulness of establishing a formal coordination process between DoD and commercial wireless service providers to assist with spectrum sharing issues on a localized basis.
- Add additional information concerning the procedures for performing EA in the United States to section 7.14, Use of 302 Frequencies for the Performance of Electronic Attack Test, Training and Exercise Operations, of the NTIA Manual.

Updates since CSMAC Work

- Development of draft Framework coordination agreement between AWS-3 Licensees in 1755-1780 MHz and Federal Government SGLS Operations in 1761-1780 MHz.

- Establishment of National Spectrum Consortium to study spectrum sharing technologies.

Future Work

- Development of methods to share data on federal systems.
- Development of coordination processes and procedures (beyond joint FCC/NTIA PN).
- Development of improved sharing analysis capabilities.

CSMAC AWS-3 Working Groups

WG4: 1755-1850 MHz Tactical Radio Relay, SDR and Fixed Microwave

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WG4: Tactical Radio Relay, SDR and Fixed Microwave

- Focus of Work
  - Definition and specification (including any interference acceptance rules) of zones around DoD sites that require access
  - Relocation process of fixed microwave links starting from the 1755-1780 MHz
- Study Areas:
  - Refine interference analysis (from Fast Track Report)
    - LTE System Parameters (used by the rest of the WGs)
    - Improved analysis parameters
      - Propagation Models
      - IPC
      - Use of clutter
    - Government System Parameters
  - Protection Zone vs. Exclusion Zone

Microwave Systems

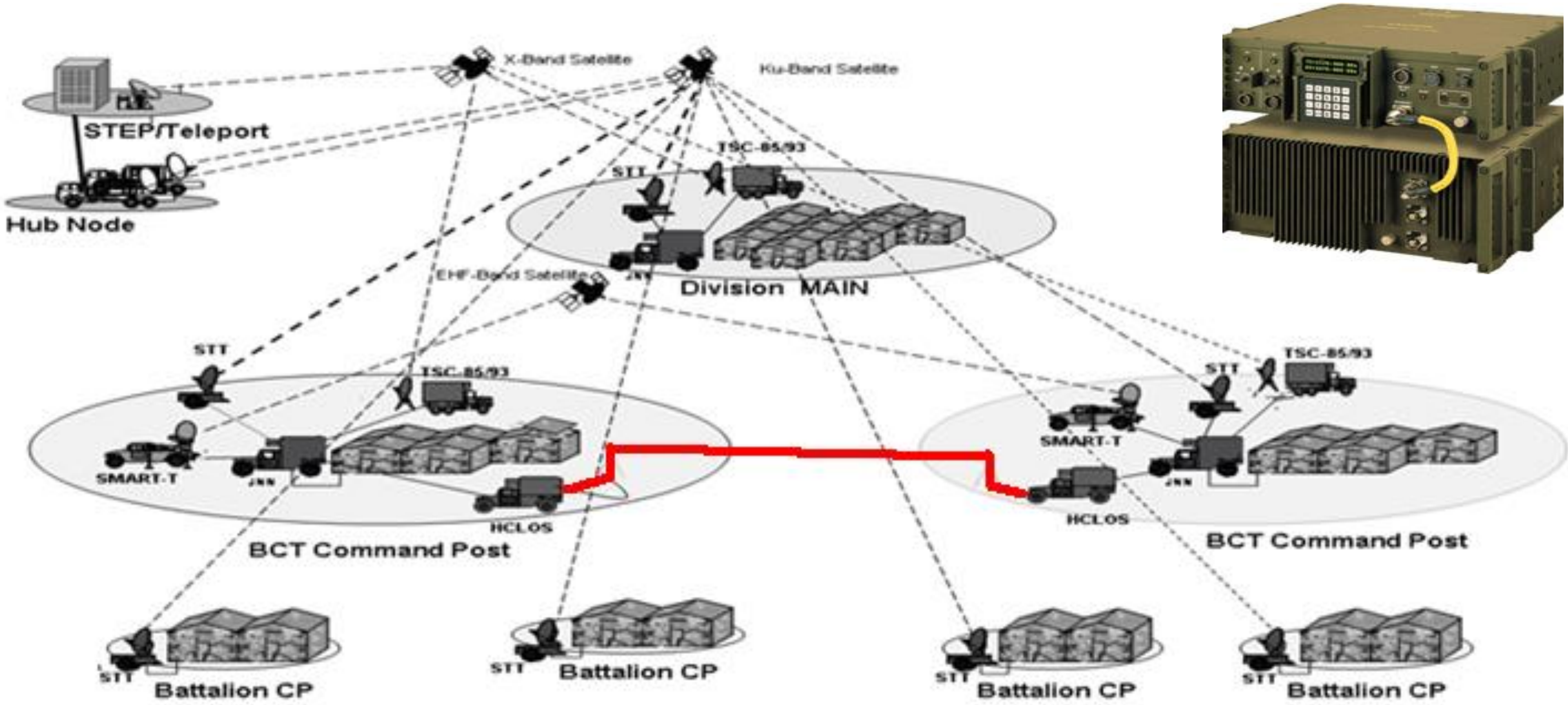
- All microwave systems will be relocated within 10 years
- Sharing with microwave systems is straight forward and was successful in AWS-1.

WG4 Recommendations for Microwave Systems

- Relocate microwave systems to spectrum identified in Fast Track Report
- Support transitional sharing to permit early access to the spectrum before Federal systems are relocated
- Consider prioritization of systems for relocation to correspond with commercial deployment
  - Spectrum: concentrate on 1755-1780 MHz band initially
  - Locations: coordinate with commercial carriers as feasible

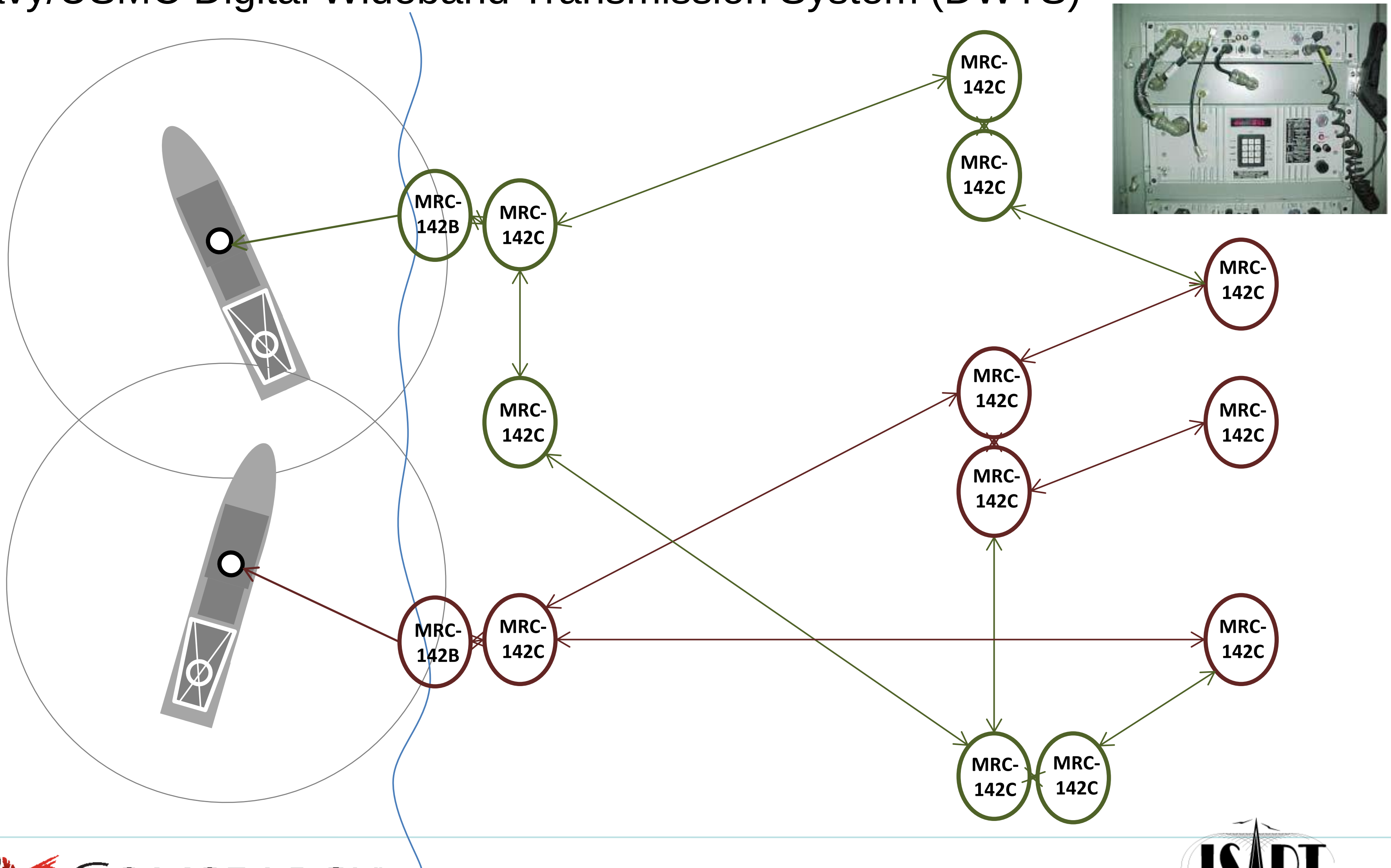
Tactical Radio Relay (TRR)

Army High Capacity Line of Sight (HCLOS)



Tactical Radio Relay (TRR)

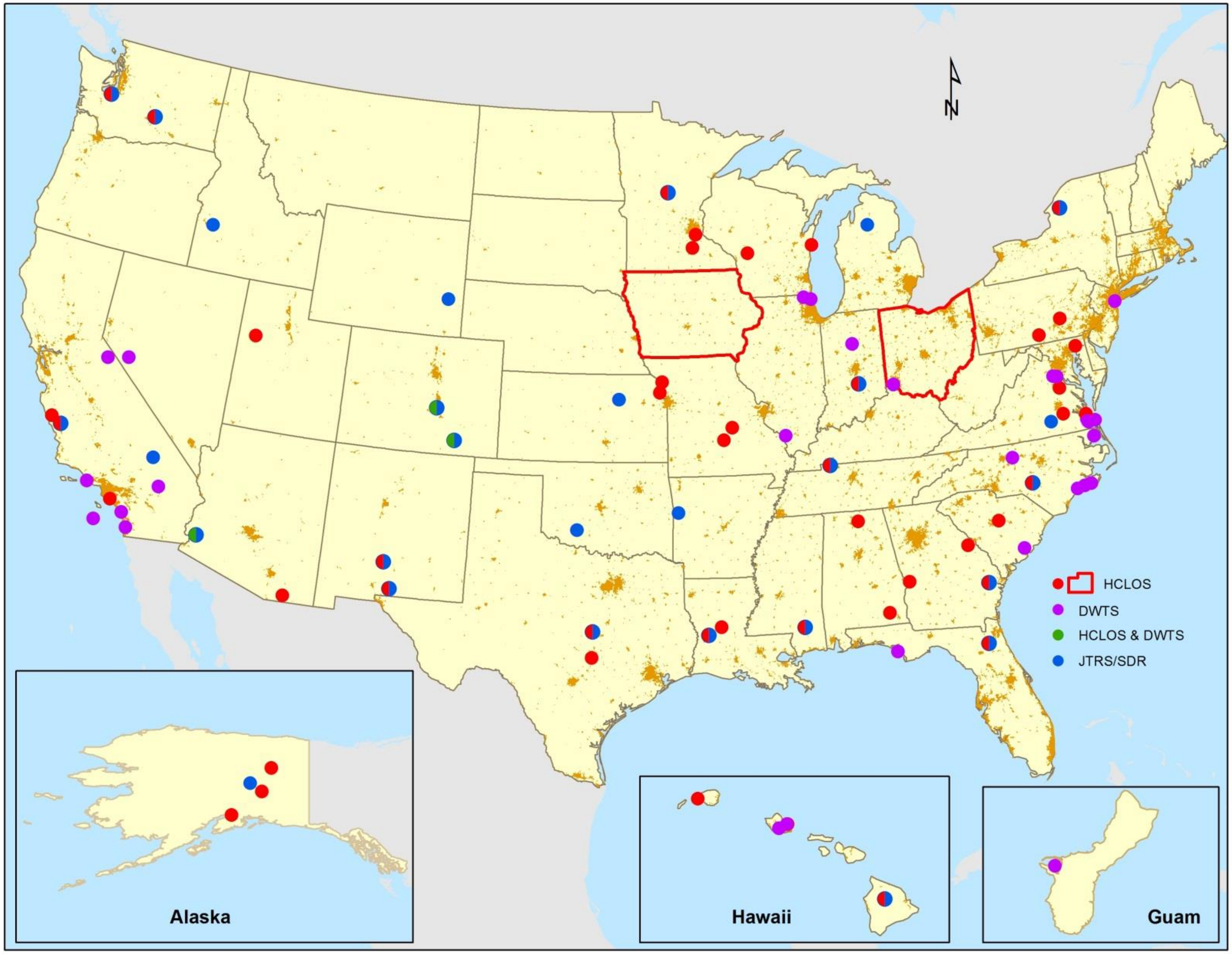
Navy/USMC Digital Wideband Transmission System (DWTS)



Joint Tactical Radio Systems (JTRS)

- JTRS is not just about the radios or waveforms
  - Networked combat units
  - Ability to add capability to deployed systems strictly through software enhancements
- JTRS Ground Radio Domains
  - Ground
  - Handheld Manpack Small Form-Fit (HMS)

TRR & JTRS Operating Locations



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Interference Analysis Methodologies

- Original analyses for NTIA reports used incorrect or outdated assumptions and methodologies
- WG agreed to redo interference analyses using widely-agreed updated parameters and methodologies
  - LTE device parameters
  - Actual “randomized” base station layout

Interference Analysis Goals

- Assess EMC between Army TRR and JTRS with Long Term Evolution (LTE) commercial wireless systems associated with possible sharing in 1755-1850 MHz
  - From LTE User Equipment (UE) handset environment to TRR & JTRS receivers
  - From TRR & JTRS emitters to LTE base stations
  - Three selected sites for TRR & JTRS: Fort Lewis, Camp Blanding, and Fort Carson
- Perform a reasonable worst-case analysis for 3 selected TRR & JTRS sites
  - Assess distances required to protect TRR & JTRS receivers at each of the 3 selected site
  - Assess applicability of the required distances for all TRR & JTRS sites
  - Identify critical determinant parameters in technical analysis
  - Assess distances required to protect LTE base station receivers
- Identify issues to be addressed in possible follow-on analyses

LTE Characteristics

- UEs
  - Antenna height of 1.5m
  - Max EIRP of 20 dBm
  - Tx power modeled in simulation using an urban and rural cumulative distribution functions as in baseline document
  - Geographic distribution based on actual network of – approved and provided by industry
  - carrier – base station locations slightly randomized at local level
  - Single UE is 1.67MHz wide, given 6 UEs evenly distributed in frequency in a 10 MHz channel,

- Base Stations
  - Antenna heights – 30m urban, 15-60m rural
  - Sector coverage – pattern as described in ITU-R F.1336-3
  - Downtilt – 3 degrees from the horizontal

Analysis Assumptions

- For TRR & JTRS as interference victim
  - Initial assessment for 3 TRR site ranges
  - UE transmit power modeled using urban & rural CDFs
  - UEs modeled as being physically located a base of urban/rural base stations (3 per UE carrier frequency at each base station)
  - UE geographic distribution according to “randomized” real network
  - UE environment selected out to radio horizon
  - UE interference modeled as six 1.67 MHz channels per sector per base station

- For TRR & JTRS as interference source
  - LTE 10 MHz receive channel
  - Base station heights (30m and 60m)
  - Interference assessed for on-azimuth
  - Will also address mitigation of 60º off-axis, 180º off-axis

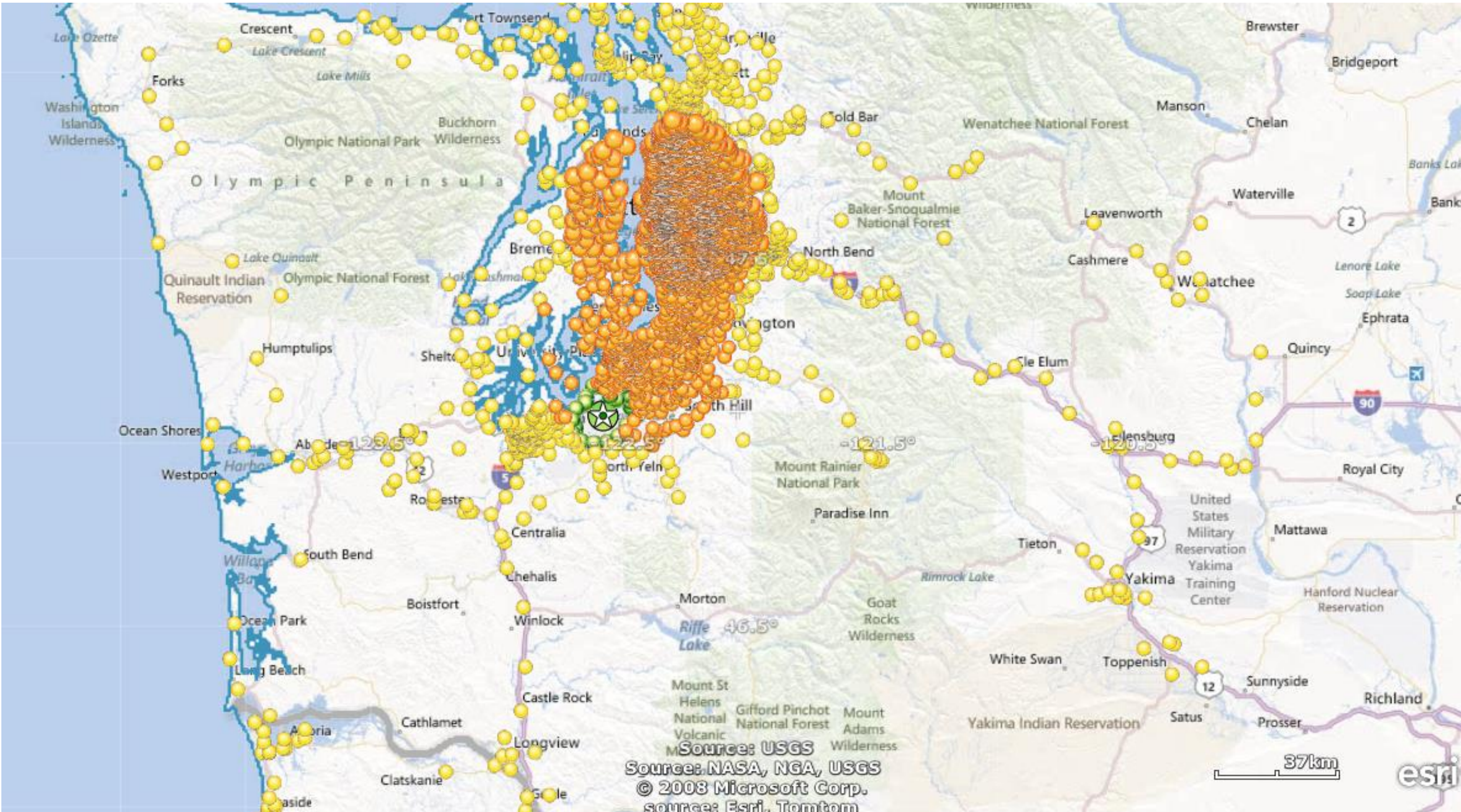
Notes on the Analysis

- Interference power calculations performed using Visualyse automated software tool
- Used Irregular Terrain Model (ITM) Propagation Model
- Clutter not considered
- When UE is source, $P_t + G_t$ not to exceed 20 dBm
- Additional TRR receive system losses estimated ~ 4 dB
- Additional JTRS receive system losses estimated ~ 1 dB
- Base station cable, insertion, and other receive losses assumed to be 2 dB
- Used aggregated interference

Notes on the Analysis

- Calculated interference power compared to receive system interference threshold
- Thresholds provided by Program Office and LTE Baseline document (I/N of -6 dB for both TRR and base station receivers)
- For interference to TRR & JTRS
  - Interference calculated for positions around op area boundaries and locations of TRR & JTRS as appropriate
  - Visualyse used to determine distances beyond which UE operations not expected to exceed interference threshold
- For interference to LTE base stations
  - TRR & JTRS transmitters simulated at multiple boundary locations
  - Visualyse used to determine distances beyond which base stations not expected to receive interference

Example of Handset Distribution

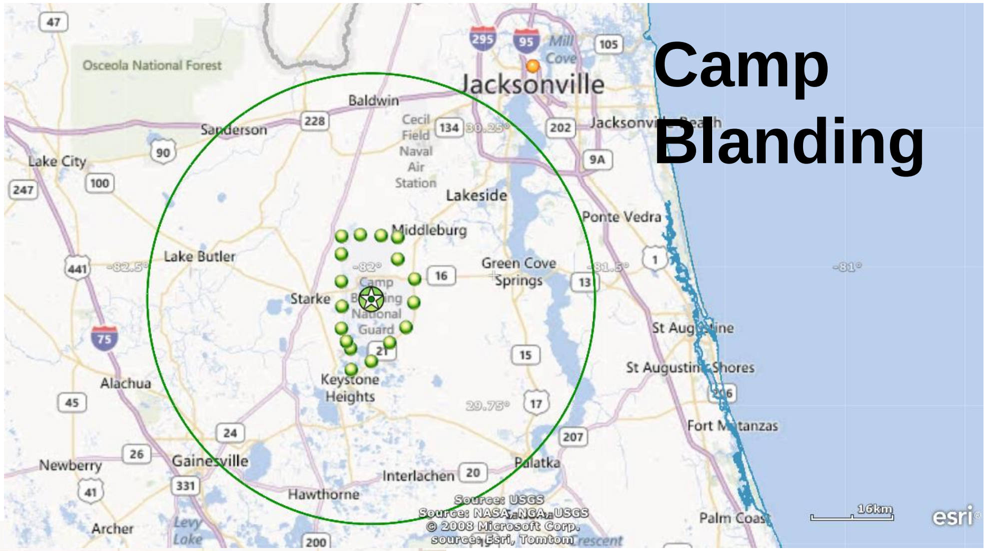


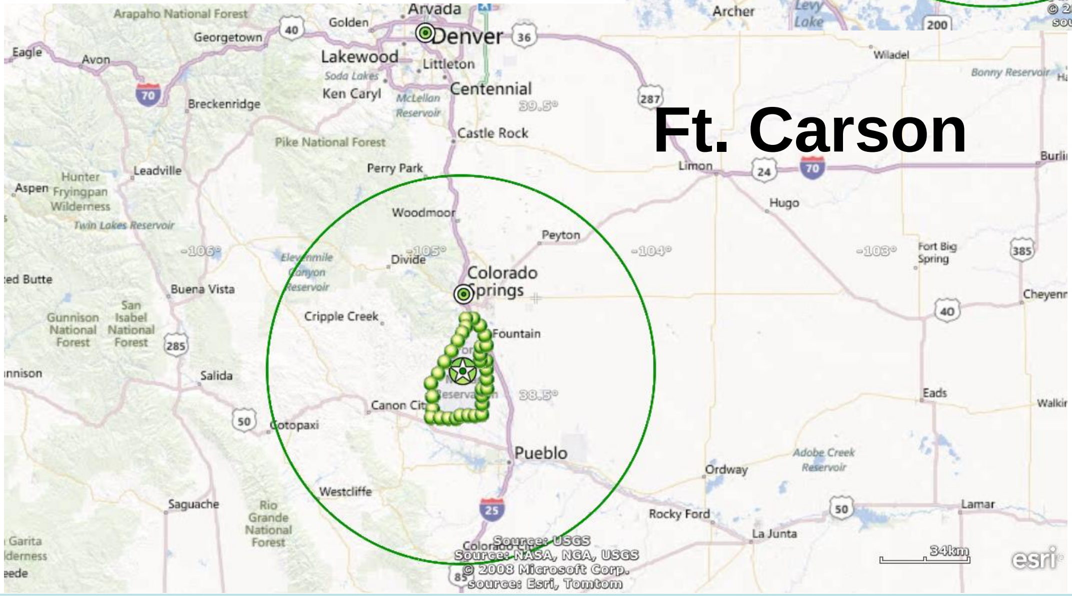
	Seattle & Tacoma Urban Area (CSMAC WG2 Top 100 Market City)		Ft. Lewis Perimeter
	Rural Area		Ft. Lewis Center Coordinate

Results Summary

Interference to Army TRR & JTRS from LTE Handsets							
Selected TRR Sites			**Propagation Model**	**I/N Threshold (dB)**	**Clutter (dB)**	**Protection Distance Radius (km)**	**JTRS Protection Distance (km)**
Name	**Approx. Size (width x length) (km)**	**Center Coordinates**				**TRR at Base Center (Mainbeam)**	**From Center Coordinate**
Fort Lewis	21 x 19	47° 4'12.00"N, 122°34'12.00"W	ITM (50%)	-6	0	**115**	**65**
Camp Blanding	15 x 28	29°56'31.00"N, 81°59'13.00"W	ITM (50%)	-6	0	**45**	**30**
Fort Carson	22 x 39	38°34'48.00"N, 81°58'48.00"W	ITM (50%)	-6	0	**75**	**60**

TRR Results Depicted





Analysis Constraints

- Possible effects of clutter not considered
- UE physical distributions using a “randomized” real network
- UE urban and rural transmit power modeled w/ CDFs
- Single UE is 1.67 MHz, 6 UEs in a 10 MHz channel
- Base station receiver threshold taken as I/N value from baseline document
- Base stations modeled with sector antenna directionality as provided in baseline document
- TRR & JTRS modeled using Spectrum Certification data
- TRR & JTRS receiver interference threshold used was - 6 dB
- Ground-to-ground propagation modeled using ITM point-to-point, 50% reliability, 50% confidence

WG4 Recommendations for TRR & JTRS

- Relocate or compress TRR systems as indicated in NTIA Report.
- Establish a TRR relocation schedule in the transition planning process in concert with the carrier community.
- Proposed Study Topics to potentially improving the current analysis.
  - Impact of clutter
  - Use of antenna effects (i.e., off-axis and polarization discrimination
  - Effects of operational tempo
  - Improved interference protection criteria
- Develop Transition Plans that address relocation of assignments, compression into 1780-1850 MHz, and comparable spectrum.
- Develop a Transitional Sharing approach to permit deployment in Protection Zones

WG4 Recommendations for TRR & JTRS

- Develop a testing program to demonstrate the viability and effectiveness of interference protection/mitigation methods before commercial licensees commence deployments in Protection Zones.

- Allow TRR systems to remain in the 1755-1850 MHz band in regions where there is little or no commercial interest.

Updates since CSMAC Work

- DoD proposed to relocate TRR to 1780-1850 MHz & 2020-2110 MHz.
- JTRS will relocate at all but six sites:
  - Fort Irwin, CA
  - Fort Polk, LA (JRTC)
  - Fort Bliss; TX and WSMR
  - Fort Hood, TX
  - Fort Bragg, NC (Includes Camp MacKall)
  - Yuma Proving Ground , AZ

CSMAC AWS-3 Working Groups

WG5: 1755-1850 MHz Airborne Operations (Air Combat Trainings System, Unmanned Aerial Vehicles, Precision-Guided Munitions, Aeronautical Telemetry)

WG5: 1755-1850 MHz Airborne Operations

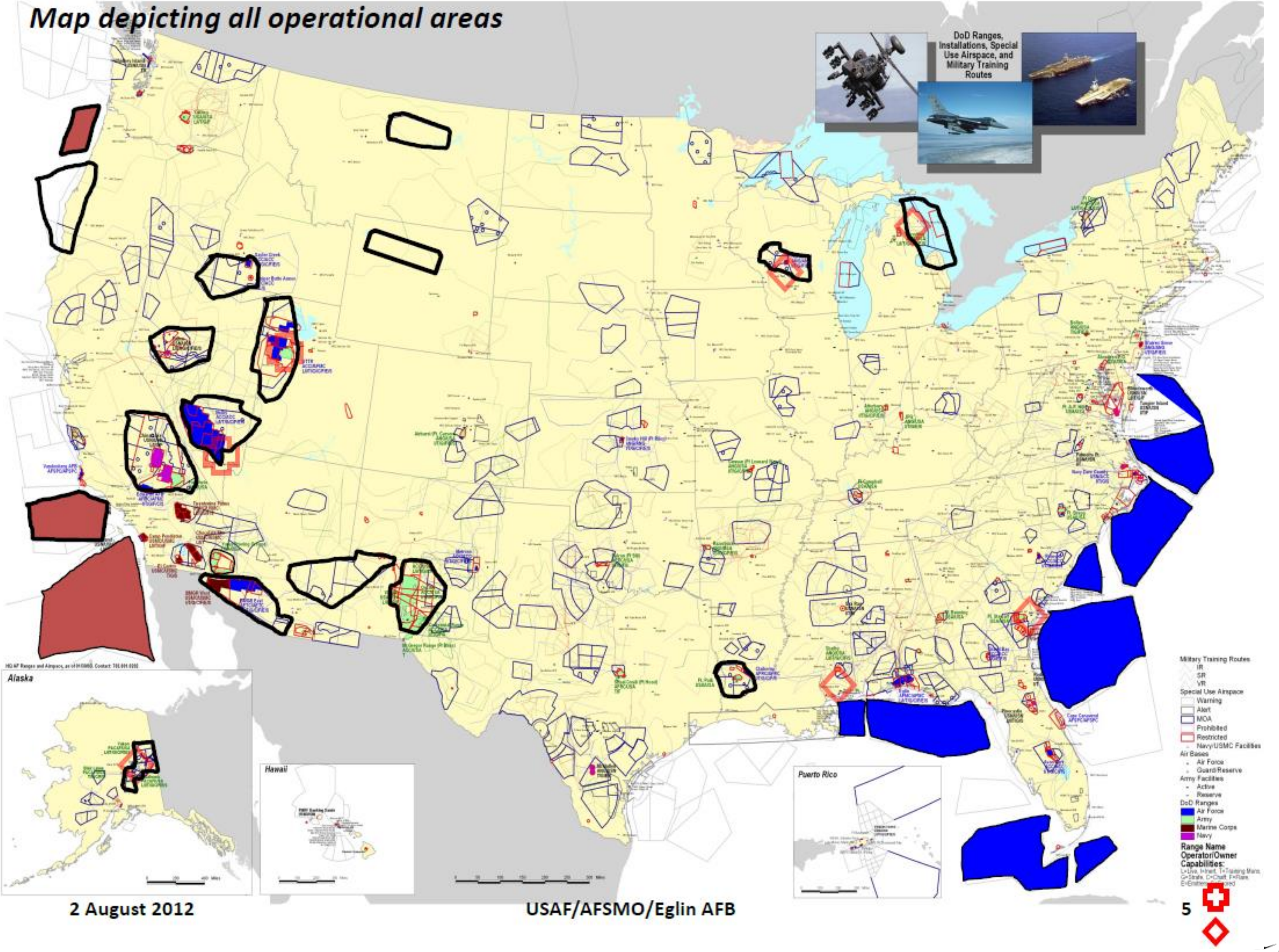
- Focus of Work
  - Determination of protection requirements for federal operations
  - Understanding of periodic nature and the impact to commercial wireless of government airborne operations
- Study Areas:
  - Focused on studying Air Combat Trainings System, Unmanned Aerial Vehicles, Precision-Guided Munitions, Aeronautical Telemetry
  - Refine interference analysis (from Fast Track Report)
    - LTE System Parameters (used by the rest of the WGs)
    - Improved analysis parameters
      - Propagation Models
      - IPC
      - Use of clutter
    - Government System Parameters
  - Protection Zone vs. Exclusion Zone

Air Combat Trainings System

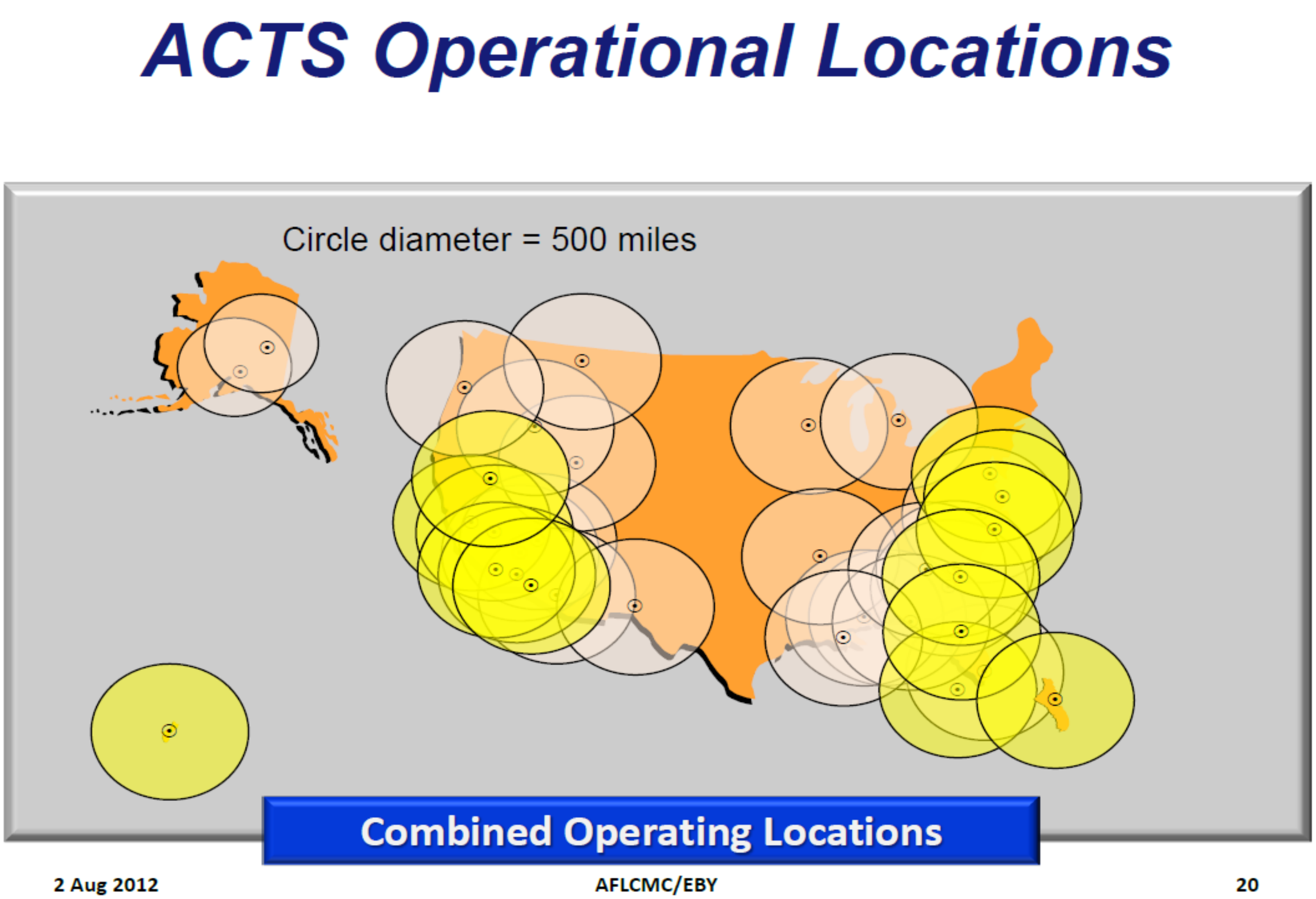
- Primary System Users Navy / AF
- Mission Description
  - Provide training systems to enable combat readiness through robust and realistic aircrew training
  - Incorporates long range data link allowing both rangeless as well as tethered training operations-live monitoring
- Typical Use
  - Live Monitor system aboard ship for deployed training
  - Continuous operations daily across CONUS, 0700-2200
  - Unit-level training, Integrated Air Wing and Battlegroup training, advanced weapons & tactics training/development
  - 17-20 instrumented Large Force Exercises (LFE) annually
  - 24/7 ops up to 6 weeks duration

P5 ACTS System Overview

ACTS Operational Areas



ACTS Operational Locations



ACTS DoD Sharing Concerns

- High power transmitters on aircraft and unrestricted areas of flight can produce potential interfering signals at long distances
  - 200 miles and more
- Interference with the ACTS airborne Network is highly probable
- Aircrew training has no definitive scheduling requirements
  - Multiple training missions occur in two hour intervals each day including night training
    - Potential Restricted Operating Schedules Reduces Combat Readiness
    - Affects ability to train as you fight
- Due to spectrum spacing requirements, P5 ACTS cannot compress to 1780-1850 MHz

ACTS Interference Analysis Methodologies

- Original analyses for NTIA reports used incorrect or outdated assumptions and methodologies
- WG agreed to redo interference analyses using widely-agreed updated parameters and methodologies
  - LTE device parameters
  - Actual “randomized” base station layout

ACTS Interference Analysis Goals

- Perform a worst-case analysis for 3 selected ACTS training sites
  - Assess distances required to protect ACTS receivers at each of the 3 sites
  - Assess applicability of the required distances for all ACTS sites
  - Identify critical determinant parameters in technical analysis
  - Assess distances required to protect LTE base station receivers
- Identify issues to be addressed in possible follow-on analyses

ACTS Characteristics

- Nominal characteristics
  - TDMA system
  - 100 watt Tx power
  - Airborne antenna is omni-directional
  - RRUs have low-gain omni-directional antennas
- Additional parameters from technical certification documents (J/F 12) and program elements, not publicly releasable
- Modeling analysis being performed based on data from 3 selected ACTS sites agreed upon by CSMAC WG5
  - Seymour Johnson Air Force Base, NC
  - Naval Air Station Key West, FL
  - Nevada Test and Training Range (NTTR) near Nellis Air Force Base, NV

LTE Characteristics

- UEs
  - Antenna height of 1.5m
  - Max EIRP of 20 dBm
  - Tx power modeled in simulation using an urban and rural cumulative distribution functions as in baseline document
  - Geographic distribution based on actual network of major carrier – base station locations slightly randomized at local level – approved and provided by industry
  - Single UE is 1.67MHz wide, given 6 UEs evenly distributed in frequency in a 10 MHz channel,

- Base Stations
  - Antenna heights – 30m urban, 15-60m rural
  - Sector coverage – pattern as described in ITU-R F.1336-3
  - Downtilt – 3 degrees from the horizontal

ACTS Analysis Assumptions

- Analysis assumptions evaluated and agreed upon by CSMAC WG5
- For ACTS as interference victim
  - Initial assessment for 3 designated ACTS sites
  - Assessed as single aircraft within the sites or RRU if appropriate
  - UE transmit power modeled using urban & rural CDFs
  - UEs modeled as being physically located a base of urban/rural base stations (3 per UE carrier frequency at each base station)
  - UE geographic distribution according to “randomized” real network
  - UE environment selected out to radio horizon
  - UE interference modeled as single 1.67 MHz UE emitter per sector per base station (i.e., each base station has three on-tune UEs)
- For ACTS as interference source
  - LTE 10 MHz receive channel
  - Base station at 30m heights
  - Interference assessed for on-azimuth
  - Will also address mitigation of 60º off-axis, 180º off-axis

Note on the Analysis

- Interference power calculations performed using Visualyse automated software tool
- Clutter not considered
- When UE is source, $P_t + G_t$ not to exceed 20 dBm
- Propagation loss calculated using ITU-R P.528 for air/ground interactions
- Longley-Rice and terrain data (30' USGS data) used for ground/ground interactions, antenna heights above local terrain
- Additional ACTS receive system losses estimated ~ 2 dB
- Base station cable, insertion, and other receive losses assumed to be 2 dB
- On-tune rejection taken as $10\log(BW_{tx}/BW_{rx})$ in dB
- In this initial analysis, on-tune case considered only

Notes on the Analysis

- Calculated interference power compared to receive system interference threshold

- Thresholds provided by Program Office and LTE Baseline document (I/N of -6 dB for both ACTS and base station receivers)

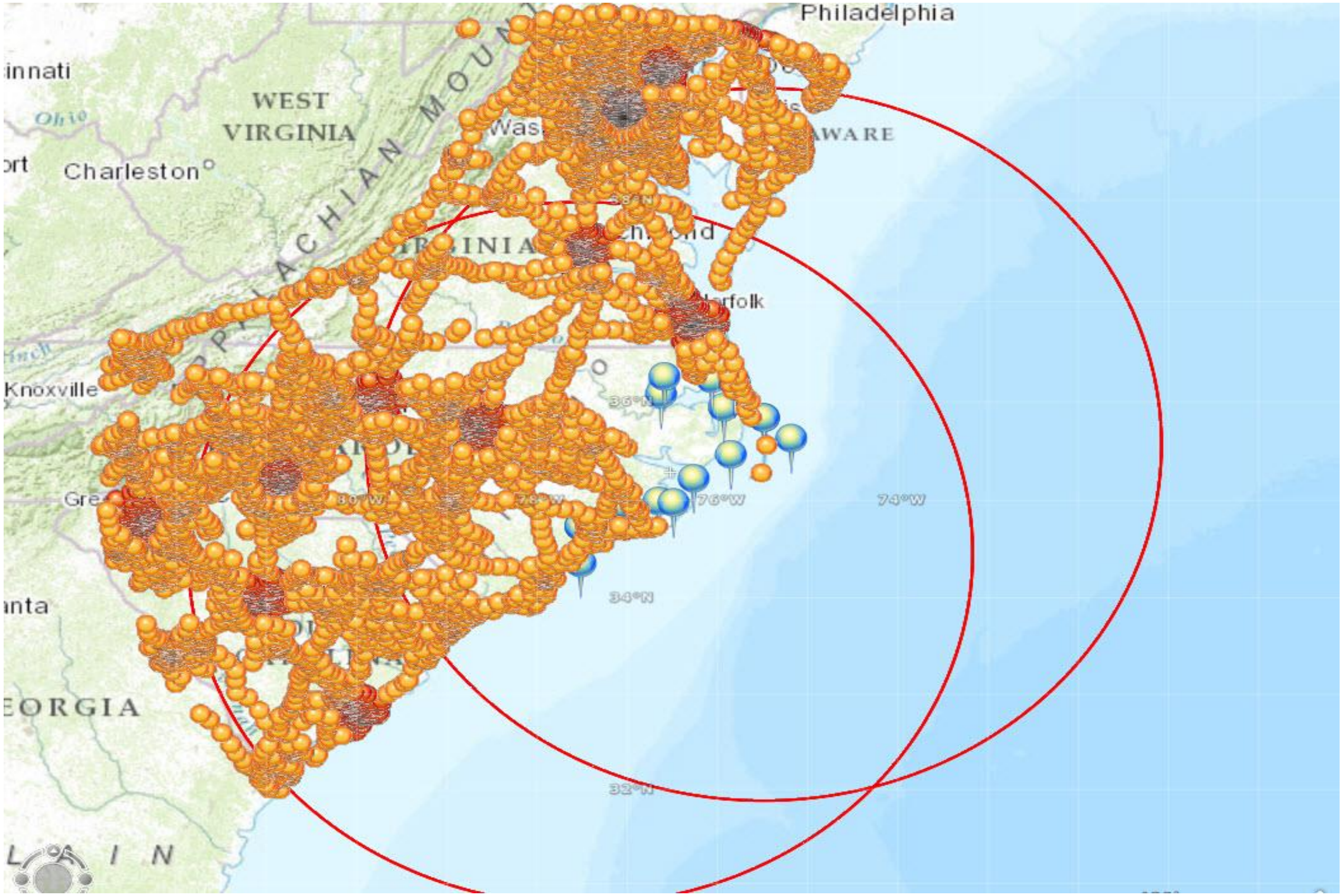
- For interference to ACTS
  - Interference calculated for positions of simulated flight path around op area boundaries and locations of RRUs as appropriate
  - Visualyse used to determine distances beyond which UE operations not expected to exceed interference threshold

- For interference to LTE base stations
  - ACTS transmitters simulated at multiple boundary locations
  - Visualyse used to determine distances beyond which base stations not expected to receive interference

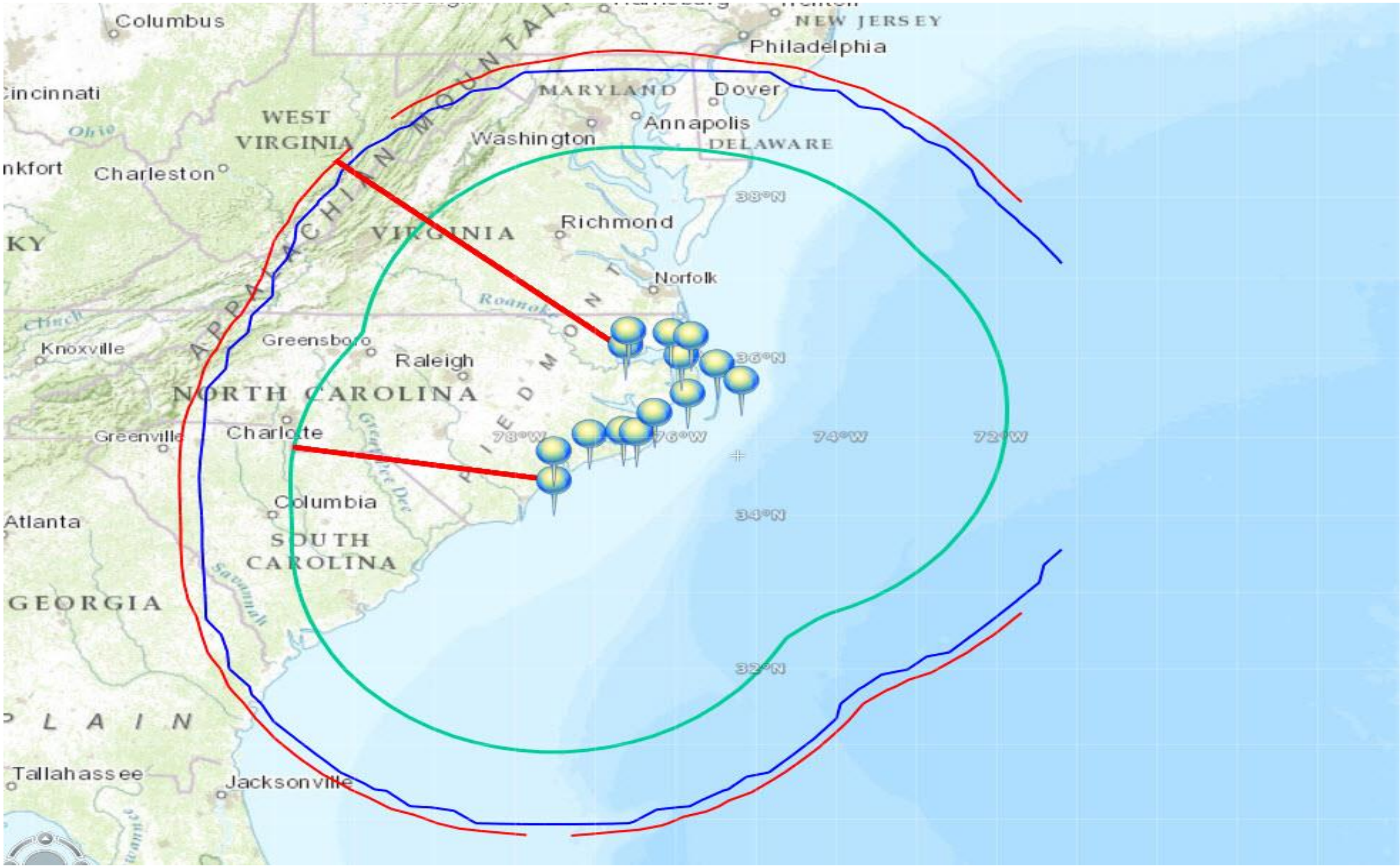
ACTS Sites Studied

- Time and resources limited initial study to three majors ACTS sites
  - Seymour Johnson Air Force Base (AFB)
  - Naval Air Station (NAS) Key West
  - Nevada Test & Training Range (NTTR)

Cell Layout at Seymour Johnson Air Force Base



Protection Zone at Seymour Johnson Air Force Base



Summary of Initial Distance Assessment

From UEs-to-ACTS Receivers[1]		From ACTS Transmitters[1]-to-LTE Base Stations		
ACTS Site	Estimated Protection Distance (km)	ACTS Site	Estimated Minimum Distance[2] (km)	Estimated Maximum Distance[3] (km)
Seymour Johnson AFB	350	Seymour Johnson AFB	285	410
NAS Key West	325	NAS Key West		
NTTR	375	NTTR		

[1] - Assumes ACTS platform can be anywhere on perimeter of the sties.

[2] - Assumes Base Station antenna is 180 degrees off-azimuth from ACTS sites with downtilt of 3 degrees.

[3] - Assumes Base Station antenna is zero degrees off-azimuth from ACTS sites with downtilt of 3 degrees.

Analysis Constraints

- Possible effects of clutter not considered
- UE physical distributions using a “randomized” real network
- UE urban and rural transmit power modeled w/ CDFs
- Single UE is 1.67 MHz, 6 UEs in a 10 MHz channel
- Base station receiver threshold taken as I/N value from baseline document
- Base stations modeled with sector antenna directionality as provided in baseline document
- ACTS modeled using Spectrum Certification data
- ACTS aircraft modeled at 10,000m
- ACTS receiver interference threshold taken as I/N value
- ACTS transmit EIRP taken as 60 Watts
- Systems considered on-tune only, only on-tune rejection considered
- Air-to-ground, ground-to-air propagation modeled using ITU-R P.528 for 50%
- Ground-to-ground propagation modeled using Longley Rice point-to-point, 50% reliability, 50% confidence

Aeronautical Mobile Telemetry Overview

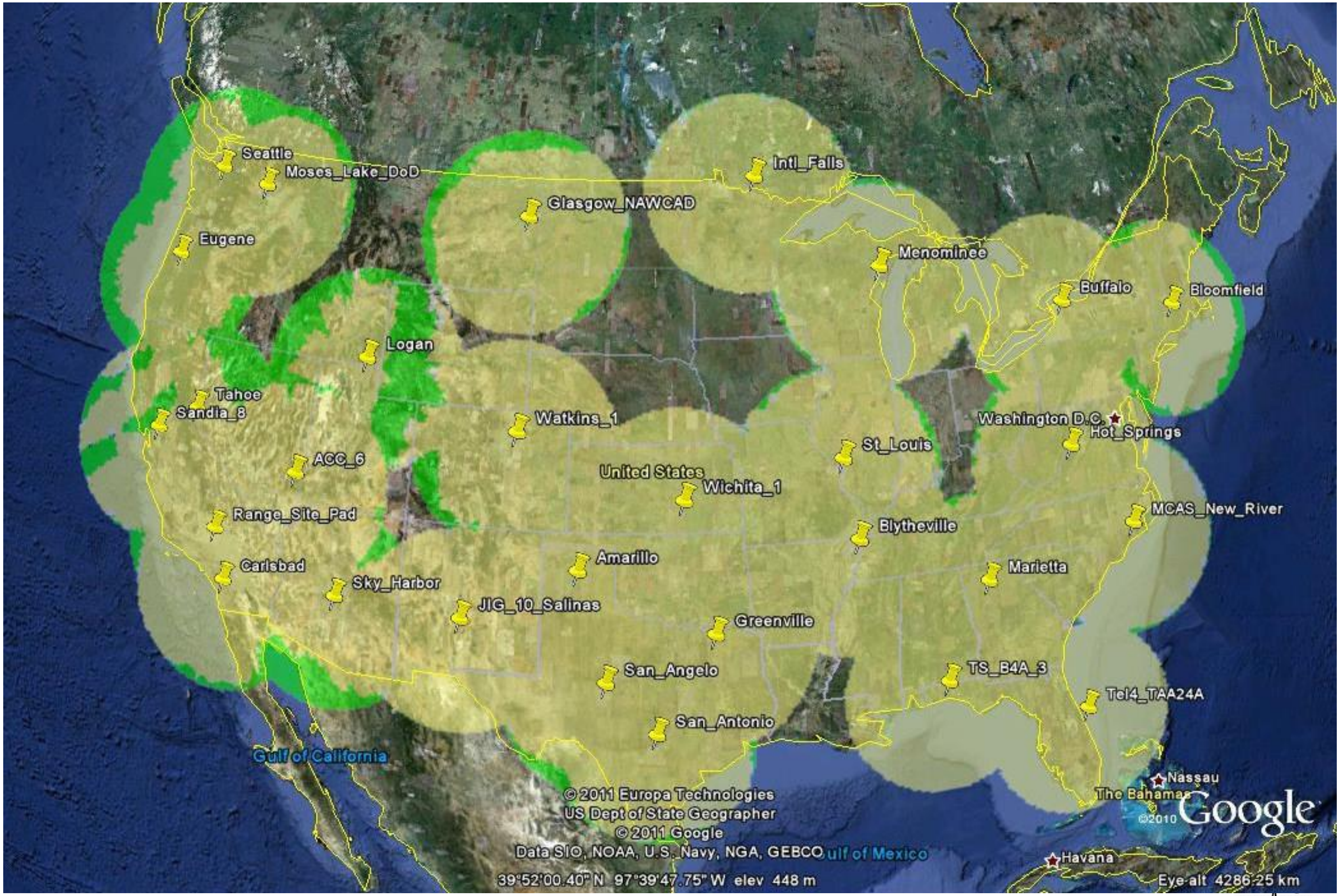
- Support testing and evaluation of
  - Manned aircraft
  - Unmanned aerial systems
  - Missiles, or other ordnance devices
- Provides real-time flight characteristics
  - Real-time video of cockpit
  - Real-time monitoring of flight research data
  - Real-time command and control of systems

Aeronautical Mobile Telemetry Overview

- Telemetry systems can “typically” be broken into two segments
  - Airborne Test Asset
    - Transmitting data omnidirectionally at power levels in the 1-10W range
    - Varying slant ranges (0.5 to over 200nm) and altitudes (just above ground level to over 60k’)
  - Ground Station Asset Track airborne test assets
  - Parabolic dishes of varying sizes ranging between 4’-30’
  - Minimum level of data quality required

- Use is driven by programmatic requirements coupled with available spectrum for telemetry operations

Aeronautical Mobile Telemetry Operational Locations



AMT Interference Analysis Methodologies

- Original analyses for NTIA reports used incorrect or outdated assumptions and methodologies
- WG agreed to redo interference analyses using widely-agreed updated parameters and methodologies
  - LTE device parameters
  - Actual “randomized” base station layout

AMT Interference Analysis Goals

- Perform a worst-case analysis for 3 selected ACTS training sites
  - Assess distances required to protect ACTS receivers at each of the 3 sites
  - Assess applicability of the required distances for all ACTS sites
  - Identify critical determinant parameters in technical analysis
  - Assess distances required to protect LTE base station receivers
- Identify issues to be addressed in possible follow-on analyses

AMT Characteristics

- Nominal characteristics taken from ITU-R Recommendation M.1459, as agreed within CSMAC WG5
  - 10 Watt TX power
  - 1 MHz, 5 MHz, 10 MHz and larger channels, with 5 MHz typical
  - Aircraft antenna is omni-directional
  - AMT ground stations have high gain (26 – 40 dBi, with 30 dBi typical) parabolic dish tracking antennas
    - Typical elevation angle above horizon during flight is 0 degrees, and ranges from -2 degrees to + 2 degrees for most of flight, with aircraft operating to 300 miles. At close range, AMT ground stations track from horizon to zenith
  - Systems are noise limited, with typical system noise of 250K or less
    - Rec. M.1459 permits aggregate I/N of ~ -4 dB
- Modeling and simulation has been performed based on data from multiple selected sites, including
  - Pt. Mugu, Eglin AFB, Patuxent River/Atlantic Test Ranges (ATR)
  - Detailed analytical descriptions of the geography and air space usage for each location are provided in the annexes to this presentation

LTE Characteristics

- UEs
  - Antenna height of 1.5m
  - Max EIRP of 20 dBm
  - Tx power modeled in simulation using an urban and rural cumulative distribution functions as in baseline document
  - Geographic distribution based on actual network of major carrier – base station locations slightly randomized at local level – approved and provided by industry
  - Single UE is 1.67MHz wide, given 6 UEs evenly distributed in frequency in a 10 MHz channel,
- Base Stations
  - Antenna heights – 30m urban, 15-60m rural
  - Sector coverage – pattern as described in ITU-R F.1336-3
  - Downtilt – 3 degrees from the horizontal

AMT Analysis Assumptions

- Analysis assumptions evaluated and agreed upon by CSMAC WG5
- For ACTS as interference victim
  - Initial assessment for 3 designated ACTS sites
  - Assessed as single aircraft within the sites or RRU if appropriate
  - UE transmit power modeled using urban & rural CDFs
  - UEs modeled as being physically located a base of urban/rural base stations (3 per UE carrier frequency at each base station)
  - UE geographic distribution according to “randomized” real network
  - UE environment selected out to radio horizon
  - UE interference modeled as single 1.67 MHz UE emitter per sector per base station (i.e., each base station has three on-tune UEs)
- For ACTS as interference source
  - LTE 10 MHz receive channel
  - Base station at 30m heights
  - Interference assessed for on-azimuth
  - Will also address mitigation of 60^{o} off-axis, 180^{o} off-axis

Note on the Analysis

- Interference power at victim receiver,
  - Specified as a power flux density (pfd) that is elevation angle dependent
    - This takes into account that at high elevation angles, aircraft at maximum altitude are close to the ground station
  - The pfd protection level to be used is -180 dBW/m^2 per 4 kHz averaged over the AMT channel bandwidth
    - Aggregation computations are performed, as a function of AMT antenna azimuth pointing angle, using the composite antenna pattern in Rec. M.1459. Computations are done for -180 to +180 degree azimuths in 0.5 degree increments

- Interference power calculations performed using Visualyse automated software tool

- ITM/Longley-Rice and terrain data (30" USGS data) used for ground/ground interactions, antenna heights above local terrain

Notes on the Analysis

- Total aggregate interference over 360 degrees is computed for each possible antenna azimuth pointing angle, at 0.5 degree increments, in order to include aggregate signal power received in the AMT antenna sidelobes

- Interference received in AMT ground station antenna sidelobes is converted to a single equivalent interference level into the ground station antenna mainlobe using an appropriate scaling factor of $G(\theta)/G_{max}$, where G is the gain function for the composite antenna provided in Rec. M.1459

- Total aggregate interference is not to exceed M.1459 level

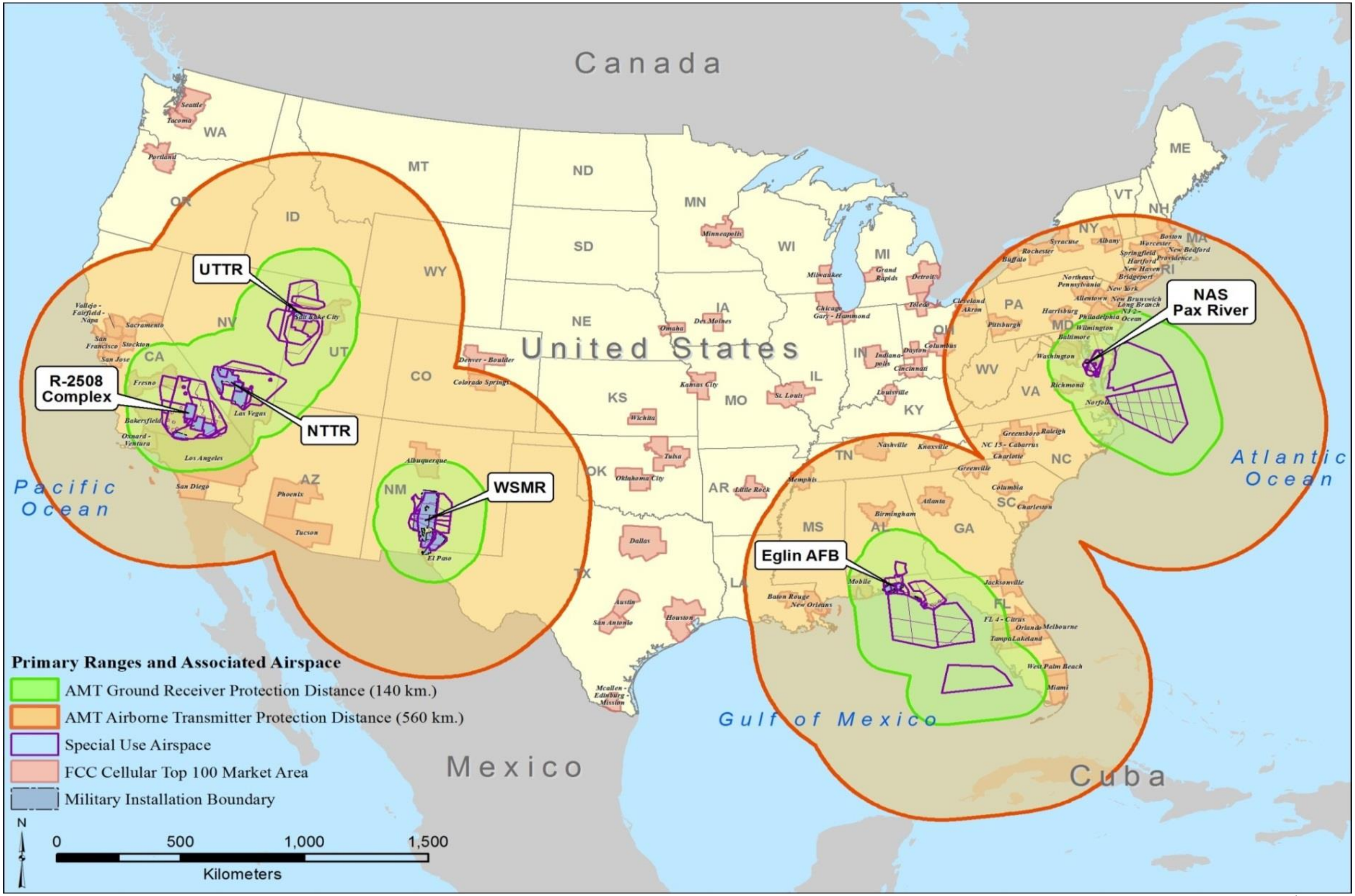
- At many AMT ground station sites, there are multiple antennas 1 – 15 km apart
  - The Alion analyses considered one to four antennas per site
  - Multiple antennas per site extends the protection distances

Analysis Assumptions

- For AMT ground stations as interference victim
  - Initial assessment for different antenna locations at 3 sites
    - Patuxent River/ATR, Pt. Mugu, Eglin
  - UE transmit power modeled using urban & rural CDFs
  - UE geographic distribution according to randomized real network data

- For AMT equipped aircraft as interference source
  - LTE 10 MHz receive channel
  - Base station at 30m and 60m heights as appropriate
  - Interference assessed for on-azimuth, 60^o off-axis, 180^o off-axis, and with 3 degree down tilt

Initial Results



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Refined Analysis

- DoD and Industry agreed to reanalyze AMT with refined analysis parameters
  - Using clutter (reviewed a paper by ITS suggesting clutter values for different morphologies)
  - 3 arcsec terrain
  - Revised carrier network loading for urban and rural use cases
  - Revised IPC
- Results produced smaller Protection Zones, but were not publically releasable
- Results were used in Transition Plans

Precision-Guided Munitions (PGMs) and other miscellaneous airborne systems

- Analysis with PGMs was similar to previous analyses for ACTS and AMT
- WG5 concluded sharing is not feasible
- Results:

DoD System	Estimated Protection Distances[1] (km)	
	UEs to DoD Receiver	DoD Transmitter to LTE Base Station
PGM	290	43 - 423
TactiLink Eagle	Not applicable	145 - 230
JTRS AMF	130 - 165	180 - 245
Navy TTNT	330 - 360	291 - 440
Army/USMC TTNT	350 (air), 25 (gnd)	260 - 415
LITENING CMDL	80 - 300	40 - 280
Sniper CMDL	80 - 300	Not applicable
Dragoon	45 - 94	145 - 325
VORTEX	80 - 300	160 - 420
ROVER	5 - 30	Not modeled – characteristics similar to CMDL

[1]Distances are for the sites included in the assessment

Small Unmanned Aircraft Systems (SUAS)

- Analysis with SUASs was similar to previous analyses for ACTS and AMT
- Due to data classification issues, WG5 was not able to determine the feasibility of sharing
- Results:

SUAS Site	Predicted Protection Distance (km)		Predicted Distance[2] (km)	
	From UEs-to-SUAS Receivers[1]	From UEs-to-GCS Receivers[1]	From SUAS Transmitters[1]-to-LTE Base Stations	From GCS Transmitters[1]-to-LTE Base Stations [3]
Eglin AFB	100	40	235 / 215 / 160	90
Dahlgren	130	45	165 / 154 / 137	127
Ft. Irwin	100	45	190/170/140	150
Twenty-Nine Palms	120	25	155/138/95	125
Bridgeport	100	80	154/141/96	114
Camp Pendleton	110	140	153/138/95	130

[1] – Assumes SUAS platform can be anywhere on the perimeter of the designated flight area (ranges) at the sites.
[2] – Assumes the Base Station antenna is 0° /60° /180° off-axis from SUAS sites with a down tilt angle of 3°.
[3] – Assumes the Base Station antenna is pointed on-axis

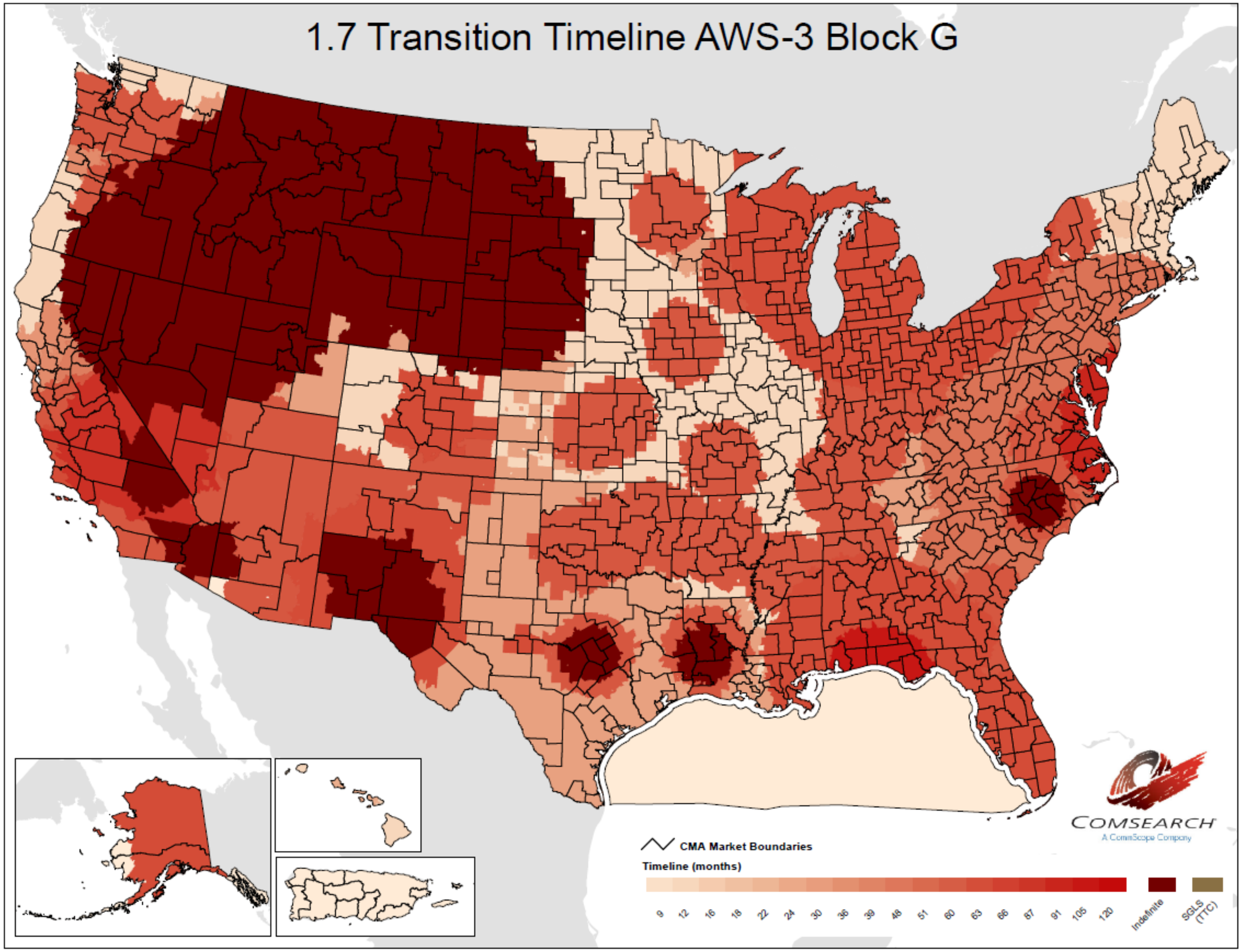
WG5 Further Study Items

- Possible Effects of Clutter and Terrain
- Time-Based Sharing
- Effects of frequency off-tuning
- Possible notches in wireless use of frequencies at selected locations
- The impact of reducing the separation distances based on a C/((I+N) protection rather than I/N (or pfd) threshold.
- Consideration of different interference threshold based on the desired signal to noise plus interference level desired rather than defining interference as a rise in the noise floor
- UE Antenna Height and Network Loading
- Consideration of government assignment information and the potential to prioritize access to markets prioritized by commercial wireless industry

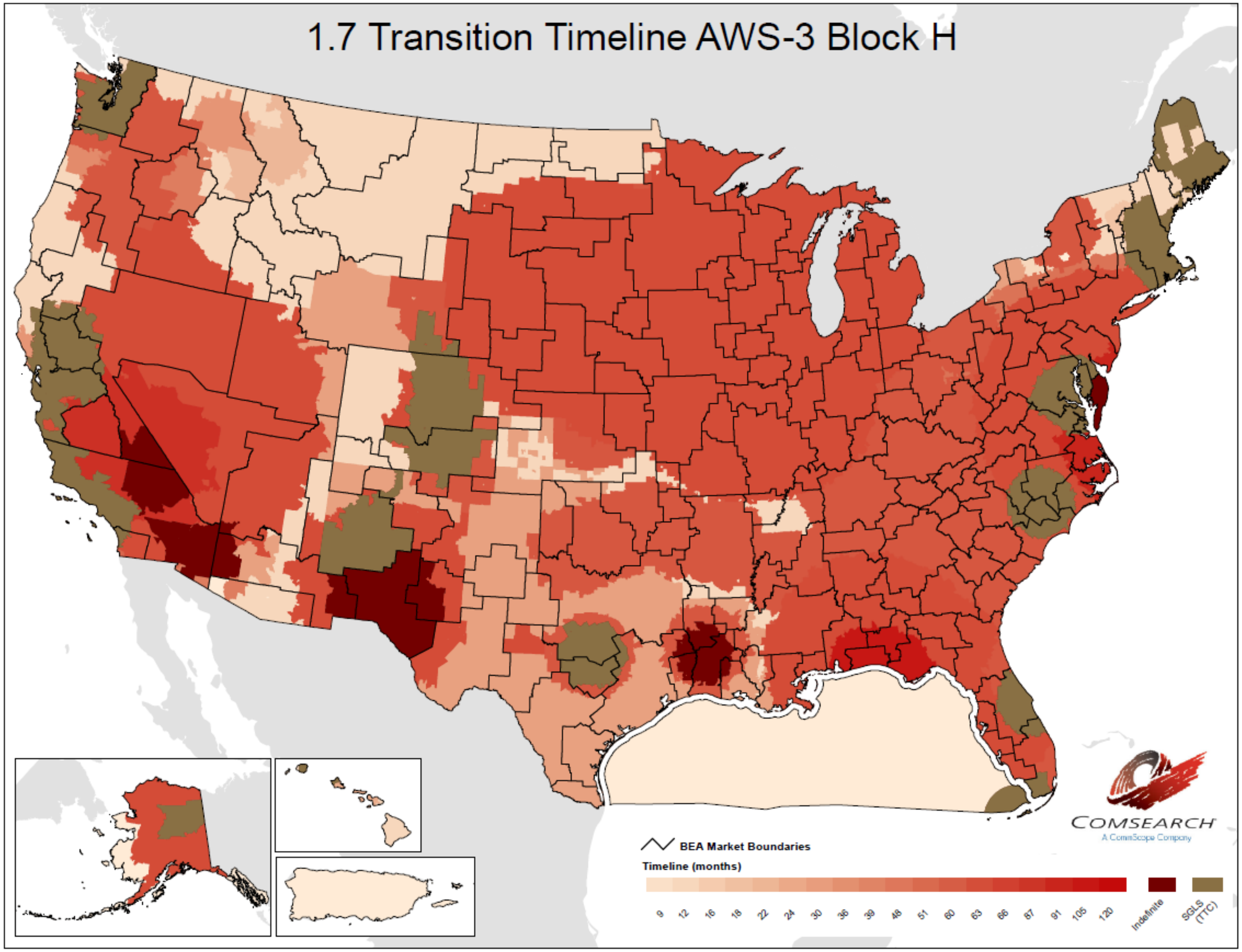
Summary

Commerce Spectrum Management Advisory Committee

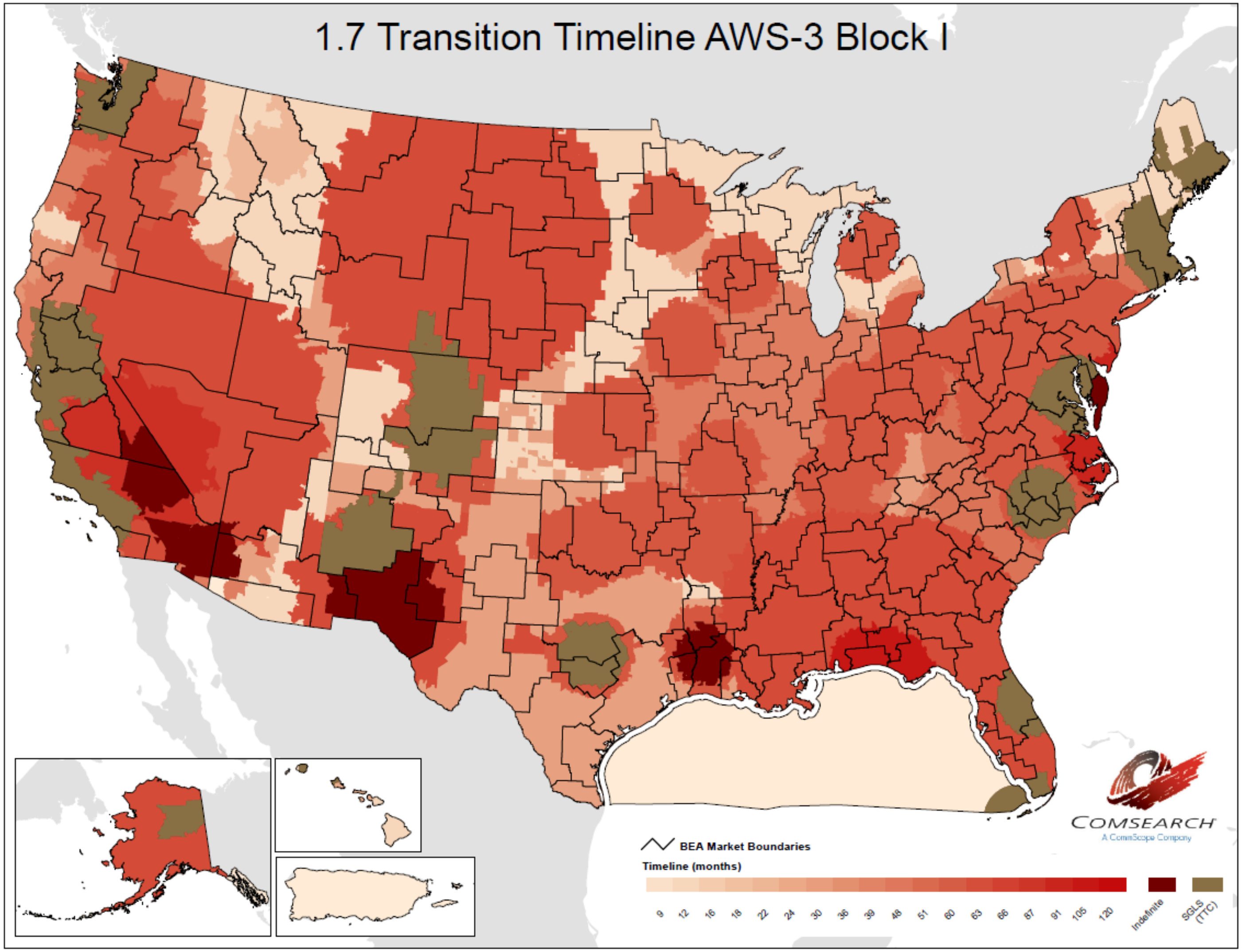
Protection Zones



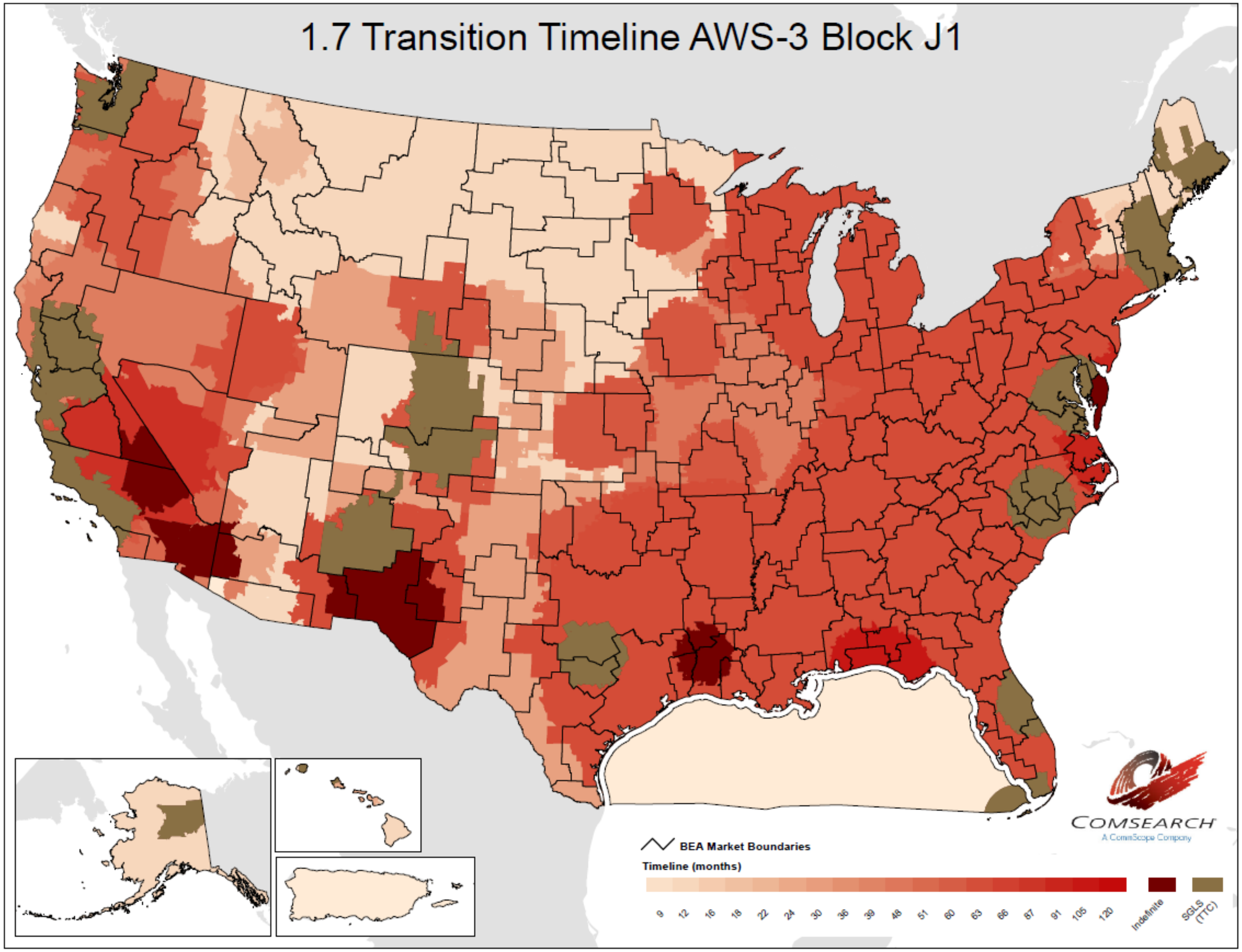
Protection Zones



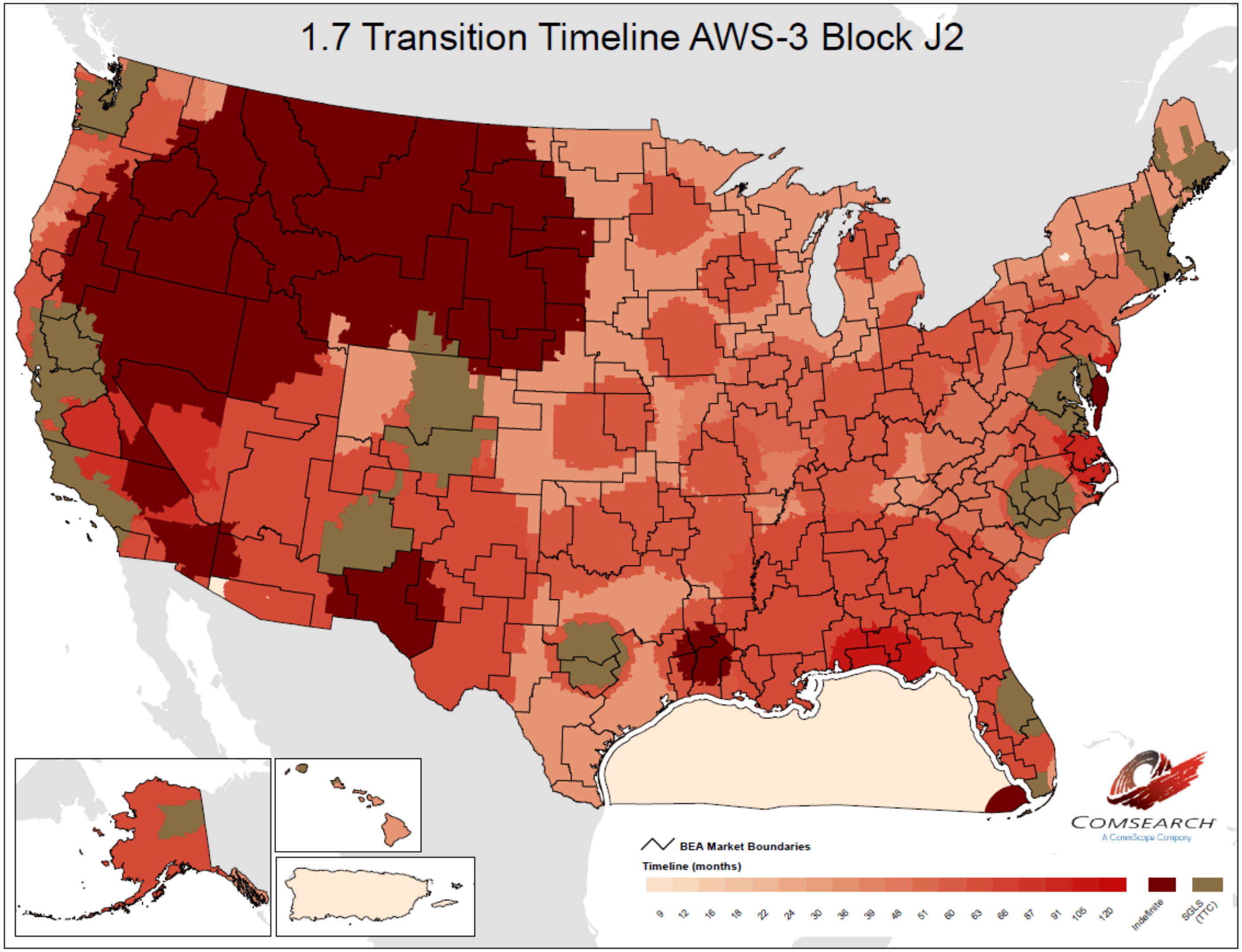
Protection Zones



Protection Zones



Protection Zones



Summary

- Effort took close to 18 months and produced over 100 documents.
- DoD and Industry spent significant resources to complete study.
- Work was collegial and collaborative.
- Additional work took place under "Trusted Agent" process.
- Need more study on:
  - Effects of propagation and updated models
  - Use of clutter
  - Interference protection criteria
  - Ways to share data

Thanks