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March 4, 2014

SUBMITTED ELECTRONICALLY

Marlene H. Dortch
Secretary
Federal Communications Commission
445 12th Street, S.W.
Washington, DC 20554

Notice of Ex Parte Presentation

GN Docket No. 13-185, ***Amendment of the Commission's Rules with Regard to Commercial Operations in the 1695-1710 MHz, 1755-1780 MHz, and 2155-2180 MHz Bands***

Dear Ms. Dortch:

On February 27, 2014, the undersigned, John Hunter, and Nelson Ueng (by telephone conference) of T-Mobile US, Inc.; Neeti Tandon and Abdulrauf Hafeez (by telephone conference) of AT&T, Inc.; Frank Jager (by telephone conference), Sanyogita Shamsunder (by telephone conference), and Patrick Welsh of Verizon Wireless; Kurt Oliver of Comsearch; and Chriss Hammerschmidt and Paul McKenna (both by telephone conference) of NTIA's Institute for Telecommunication Sciences met with each of the following Commission staff: John Leibovitz, Blaise Scinto, Janet Young, and Peter Daronco (by telephone conference), all of the Wireless Telecommunications Bureau, and Julius Knapp and Michael Ha of the Office of Engineering and Technology.

The attached presentation was distributed and highlights the points that were discussed at the meeting. In particular, we discussed the interference analysis conducted by the Commerce Spectrum Management Advisory Committee ("CSMAC") on spectrum sharing. We explained that CSMAC's analysis was conservative and that real-world data demonstrates that protection areas for federal systems could be greatly reduced. We pointed out that this strongly supports the use of coordination zones, rather than exclusion zones, in spectrum sharing scenarios.

Pursuant to Section 1.1206(b)(2) of the Commission's rules, electronic copies of this letter and the attachment are being filed for inclusion in the above-referenced docket. Copies of this letter and the attachment are also being provided to all Commission employees who attended the meeting. Please direct any questions regarding this filing to the undersigned.

Respectfully submitted,

/s/ Steve B. Sharkey

Steve B. Sharkey
Chief of Engineering & Technology Policy
Federal Regulatory

Encl.

cc: (each electronically)
John Leibovitz
Blaise Scinto
Janet Young
Peter Daronco
Julius Knapp
Michael Ha

Airborne Measurements

FCC Analysis Briefing

Introduction

- CSMAC Interference Analysis
  - CSMAC analysis used extremely conservative assumptions
    - 100% network loading
    - I/N -6dB IPC was used
    - No inclusion of terrain, antenna gain patterns, and clutter
    - No consideration of link quality for government operations
    - Conservative LTE handset parameters
    - All UEs were modelled as being outside, a certain percentage will be inside which adds additional attenuation
  - Conservative assumptions led to extreme estimated separation requirements of hundreds of kilometers
  - CSMAC reports recognize that refining the analysis could impact results
- Industry sought to acquire real world information that could be used to verify or refine CSMAC Analysis
  - Airborne measurements provide a basis to more accurately understand interference potential
  - Contracted with Comsearch to develop test plan and conduct airborne measurements working with industry representatives
  - Received input from DoD on test plan
- Coordination Zones Should be adjusted to reflect refined analysis
- Rules must provide for coordination zones rather than exclusion zones

Area Under Study - Flight Paths

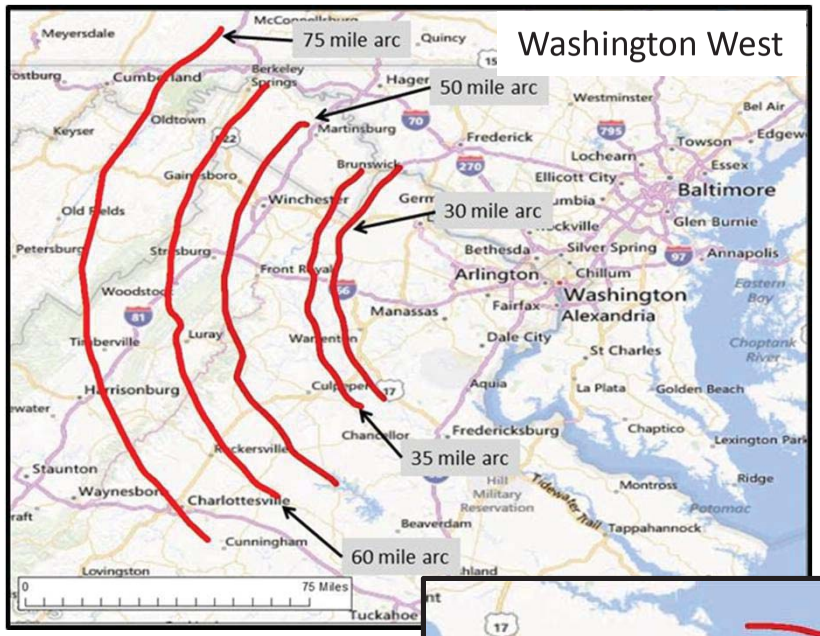
Washington West		Date	Flight Times (Local EST)		Flight Times (GPS)	
Arc Dist (mi)	Altitude (ft)		Start	Stop	Start	Stop
30	3000	10/28/2013	11:11	11:40	15:11	15:40
35	4000	10/28/2013	11:47	12:17	15:47	16:17
50	4000	10/28/2013	12:26	12:48	16:26	16:48
50	6000	10/28/2013	13:13	13:59	17:13	17:59
60	6000	11/8/2013	11:38	12:42	16:48	17:42
60	9000	11/8/2013	12:54	13:38	17:54	18:38
75	6000	11/13/2013	15:46	16:42	20:46	21:42
75	8000	11/13/2013	12:23	13:35	17:23	18:35
75	10000	11/13/2013	11:24	12:15	16:24	17:15
Washington Southeast		Date	Flight Times (Local EST)		Flight Times (GPS)	
Arc Dist (mi)	Altitude (ft)		Start	Stop	Start	Stop
30	3500	11/4/2013	10:55	11:25	15:55	16:25
35	4000	11/4/2013	11:44	12:12	16:44	17:12
50	4000	11/4/2013	12:21	12:43	17:21	17:43
50	6000	11/4/2013	12:46	13:56	17:46	18:56
75	4000	11/11/2013	12:32	13:35	17:32	18:35
75	6000	11/11/2013	11:14	12:26	16:14	17:26
75	8500	11/6/2013	16:37	17:33	21:37	22:33
75	9500	11/6/2013	11:14	12:36	16:14	17:36
Norfolk East		Date	Flight Times (Local EST)		Flight Times (GPS)	
Arc Dist (mi)	Altitude (ft)		Start	Stop	Start	Stop
30	3000	11/6/2013	15:48	16:10	20:48	21:10
35	4000	11/6/2013	13:37	13:59	18:37	18:59

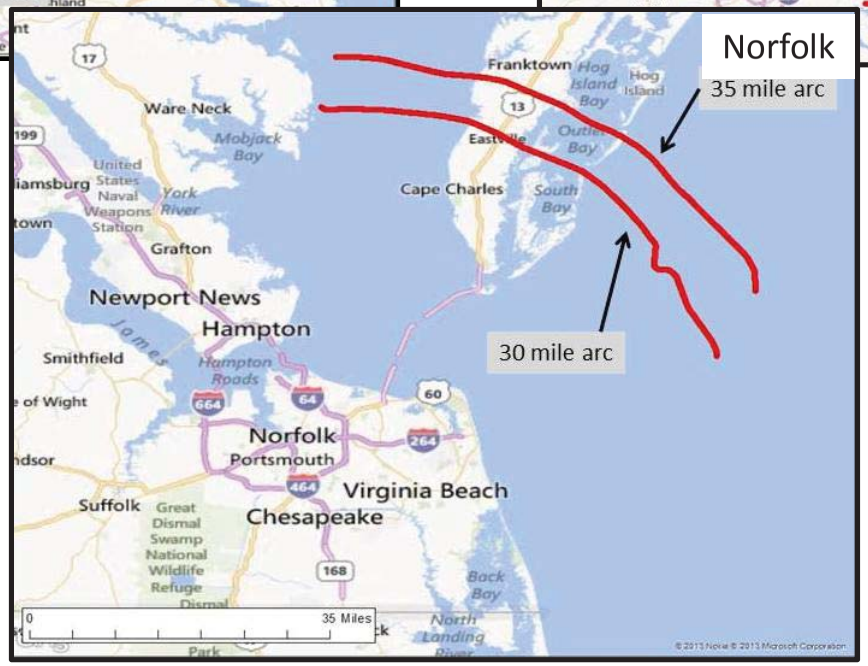
Figure 1 – Omni-Directional Antenna Mounting Location

- The purpose of this measurement study was to characterize the aggregate UE uplink signal level environment at several altitudes in an effort to assess the potential interference impact to federal aeronautical systems, such as the ACTS system.

- Several flight paths were flown at various altitudes to measure UL emissions in the AWS, PCS, Cellular and 700 MHz bands.

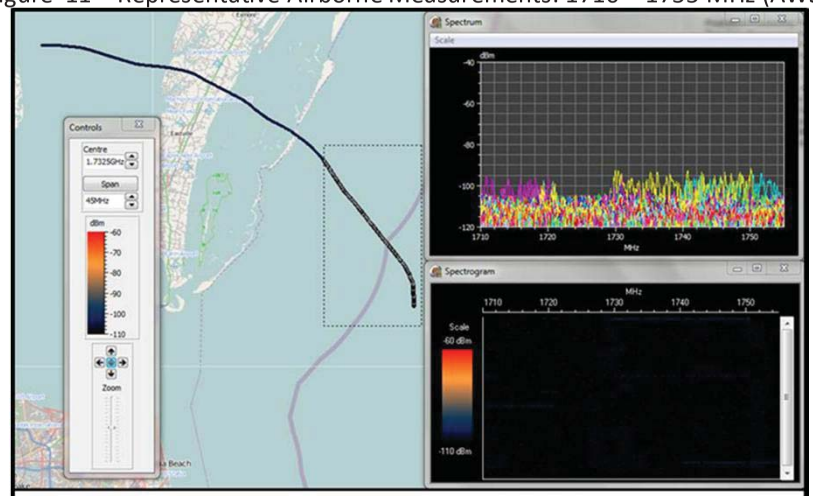
Area Under Study - Flight Paths



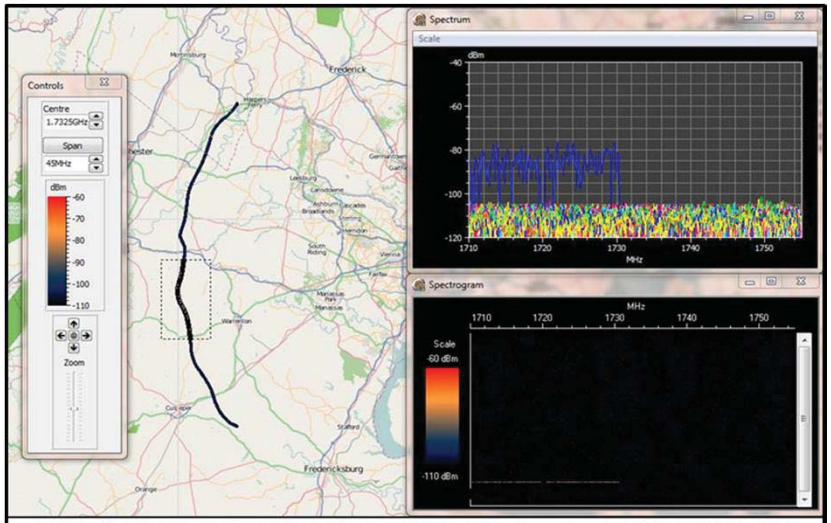


RF Emissions Collected

Figure 11 – Representative Airborne Measurements: 1710 – 1755 MHz (AWS



AWS Uplink (1710 – 1755 MHz) Norfolk, VA East 35 mile radius at 4000' at 100 kHz RBW
11/06/13: 13:37 – 13:59; Maximum RSL ≤ -91.5 dBm
Spectrum and Waterfall Displayed Area Identified in Rectangle on Overview Map



AWS Uplink (1710 – 1755 MHz) Washington, DC West 35 mile radius at 4000' at 100 kHz RBW
10/28/13: 11:47 – 12:17; Maximum RSL ≤ -76.5 dBm
Representative Rogue Signal

- Emission measurements were conducted every two seconds with GPS tracking using a RBW of 100 KHz for each band under study.
- A total of 19 flight paths were flown (considering locations and altitudes).
- Unidentified "rogue" signals were occasionally detected during the airborne measurements – these emissions are inconsistent with a UE uplink signal (e.g., 20 MHz BW). Nonetheless, they were insignificant in the total analysis.
- A CW signal was also implemented as an additional reference source for documenting path loss between the CW transmitter location and the flight path.

Measurement Equipment Sensitivity Levels

Airborne Measurement Sensitivity (dBmi)				
	LTE	Cellular	AWS	PCS
	750 MHz	835 MHz	1730 MHz	1880 MHz
Receiver Noise Level (RNL) at 100 kHz Measurement Bandwidth (dBm)	-124.0	-124.0	-124.0	-124.0
CRFS Receiver Noise Figure (NF) in dB	8.0	8.0	8.0	8.0
Omni-Directional Antenna Gain (G_A) in dBi*	1.8	2.3	2.0	1.2
Cable Loss (CL) in dB between antenna output and receiver input	2.1	2.3	3.8	3.6
Measurement Sensitivity (dBmi) = RNL+NF-G_A+CL	**-115.7**	**-116.0**	**-114.2**	**-113.6**
*Antenna gain is the peak gain per manufactures specifications. Actual gain and antenna pattern as mounted on aircraft is unknown				

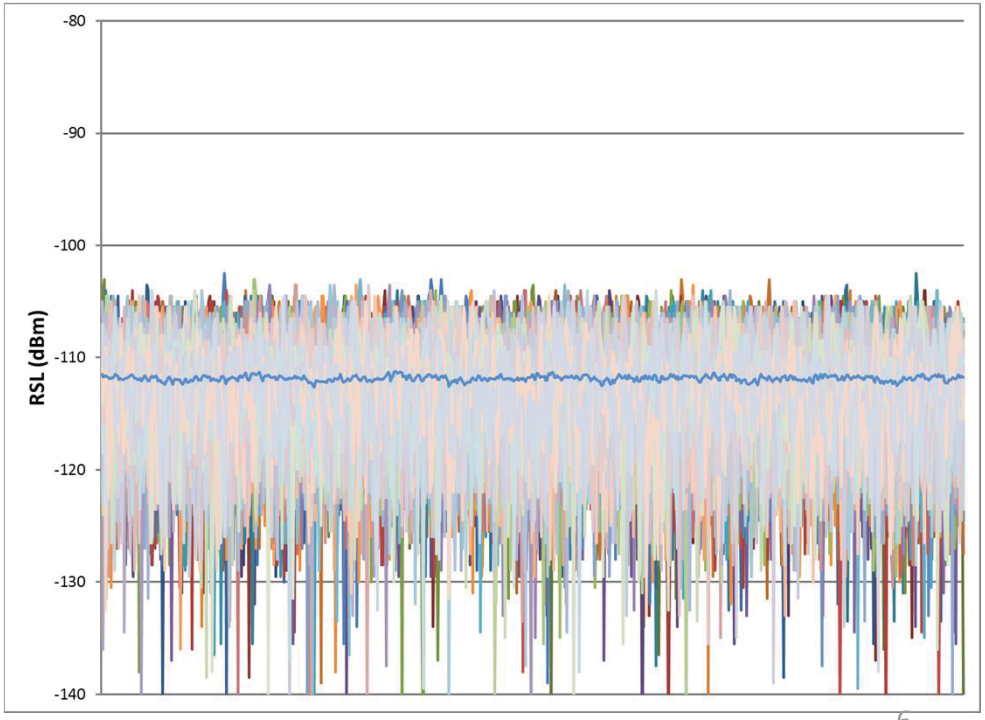
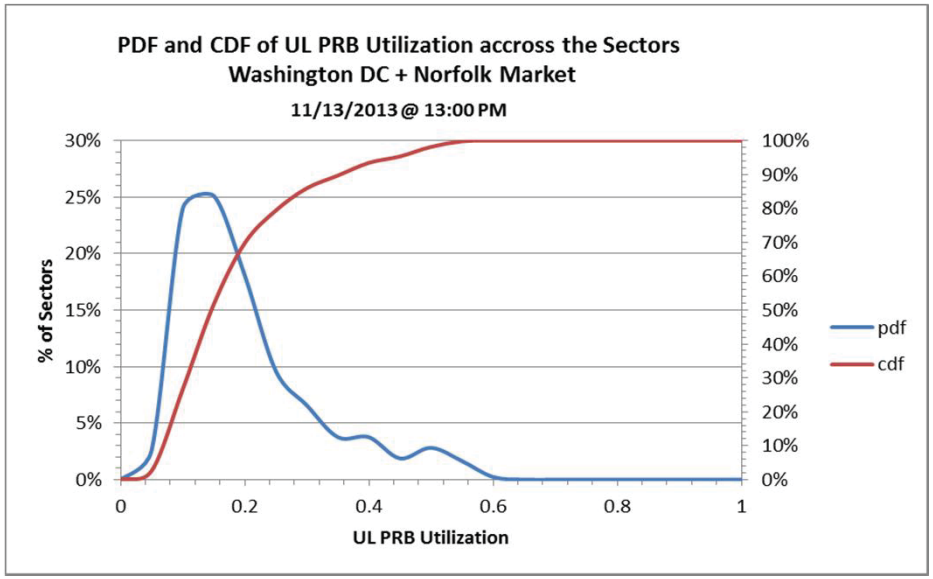


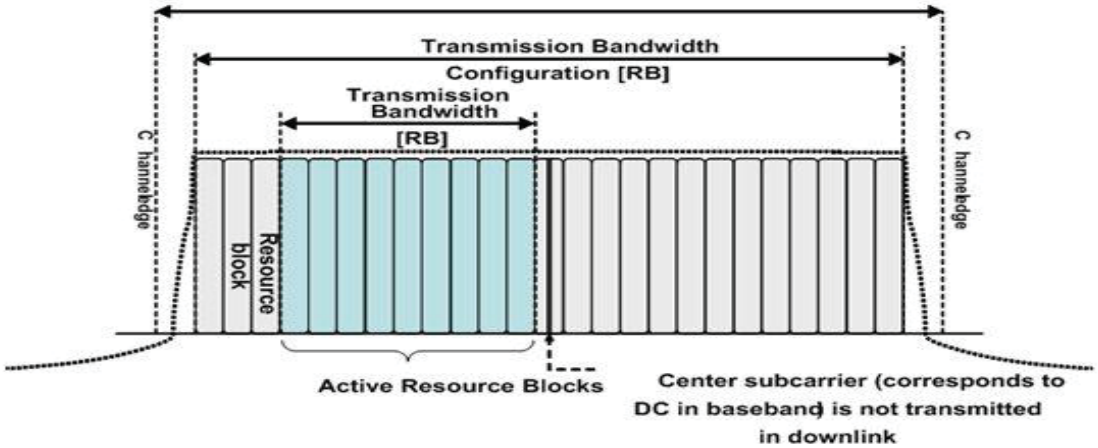
Fig. 2 - System Noise Figure

AWS & PCS UL Measurements

- What we know:
  - Measured noise floor of the system (see Fig. 2) shows the peak system noise level at -105 dBm and the mean system noise level around -114 dBm.
  - For the Washington West 75 mile arc at a 10,000 foot altitude, approximately 1.5% of the data values were above the peak system noise floor.
  - For the signals that appeared above the peak system noise floor, none could be positively identified as UE emissions.
  - UE received signal levels appear to be below the noise floor of the measurement system at all altitudes.

Traffic Utilization During Busy Hour (BH)





- DoD modeled total traffic utilization during CSMAC WG analysis at 100%
- As depicted, traffic is not distributed evenly across the network
- ~25% of all sectors in the network averaged UL Physical Resource Block (PRB) utilization between 10% to 15%
- UL PRB utilization did not exceed 55% during BH

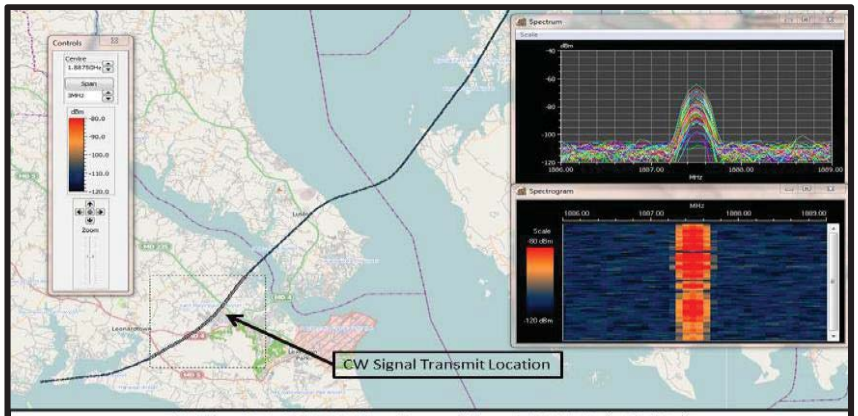
CSMAC WG-5: Clutter and Terrain

….The air-to-ground analyses, using ITU-R Recommendation P.528, did not take into account terrain effects.

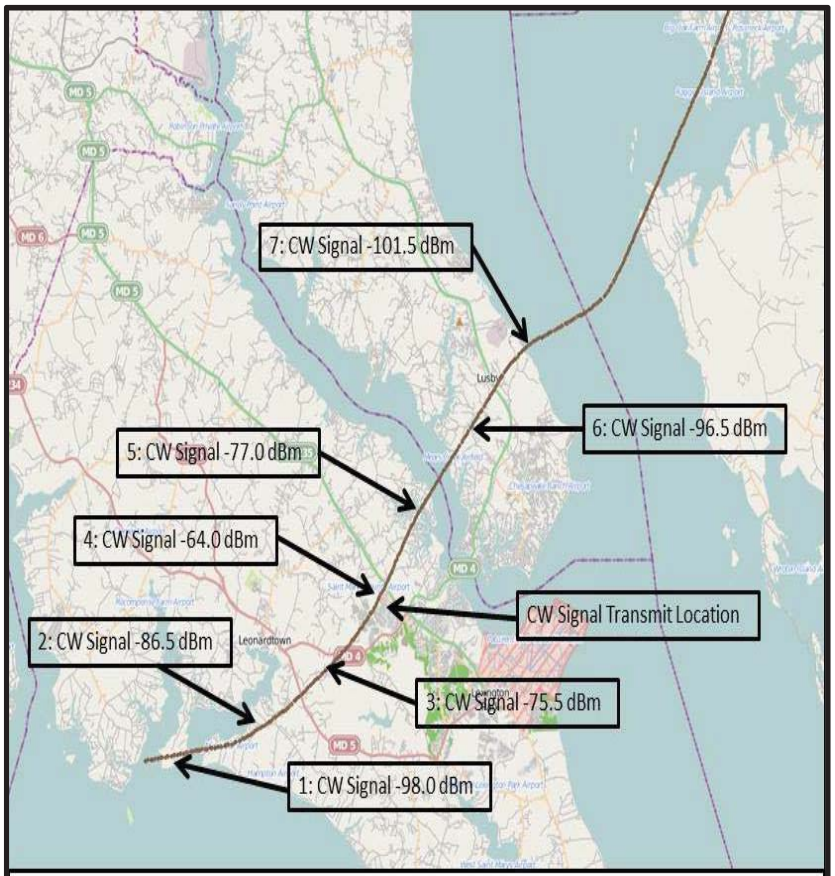
As discussed and agreed by WG5 at the outset of the work, clutter and terrain effects were not considered in any of the baseline interference analyses because timely agreement could not be reached on how they should be applied. Whether to do so, and how to do so, in future analyses remains under discussion. In particular, additional study of the impact that clutter and terrain have on propagation, particularly in air-to-ground analysis, would provide greater confidence in the analysis and may impact protection distances. (See Pg.7 http://www.ntia.doc.gov/files/ntia/publications/wg5_1755-1850_final_reportl-09-16-2013.pdf)

CW Test

- A 10 watt (+40 dBm) continuous wave (CW) signal was transmitted at 1887.5 MHz
- An omni-directional antenna was used to transmit the CW signal, located at a height of 6’ above ground level (AGL), operating in an environment surrounded by trees and buildings
- Antenna was identical to the receive antenna located on the underside of the aircraft used for the airborne measurements (Model XPO2V-0.8-6.0-GF/1441)



CW Signal at 1887.5 MHz – Transmitting at 10 Watts (+40 dBm)
Washington, DC Southeast Arc 30 mile radius at 3500’ AMSL
11/4/13: Maximum RSL -64.0 dBm

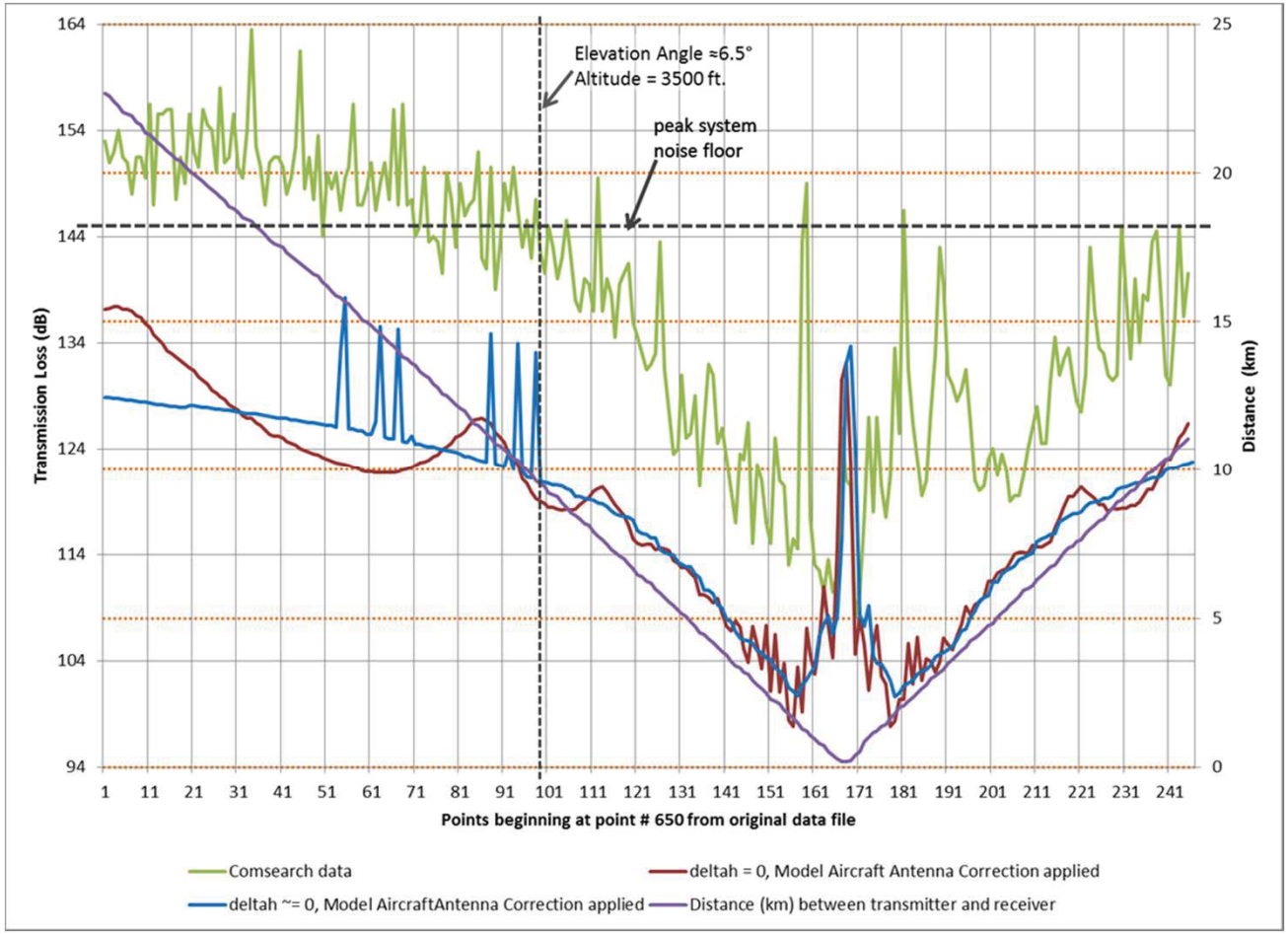


CW Signal Measured Signal Levels
Washington, DC Southeast Arc 30 mile radius at 3500’ AMSL

ITS Propagation Modelling

- ITS was asked to model the aircraft measurement data performed by Comsearch.
- ITS used the IF-77 propagation modelling tool developed at ITS which includes effects for:
  - Average Ray Bending
  - Horizon Effects
  - Surface reflection multipath
  - Very high antennas
- Model was used to understand the propagation mechanisms for emissions from a CW-transmitter deployed by Comsearch.
- Four propagation mechanisms were modelled:
  - terrain height = 0, no surface reflection multipath effects,
  - terrain height = 0, with surface reflection multipath effects,
  - terrain height ≠ 0, no surface reflection multipath effects,
  - terrain height ≠ 0, with surface reflection multipath effects,
- ITS analysis focuses on the models with surface multipath effects for both terrain height = 0, and terrain height ≠ 0

Model after including antenna gain patterns



Comsearch transmission loss data compared to predicted basic transmission loss using antenna gain patterns for the manufacturer's antenna on the ground and the scale-model Cessna 150 aircraft measured antenna gain pattern. The model and the measured data still show discrepancies; therefore, we added a model for attenuation due to vegetation (clutter).

Clutter model

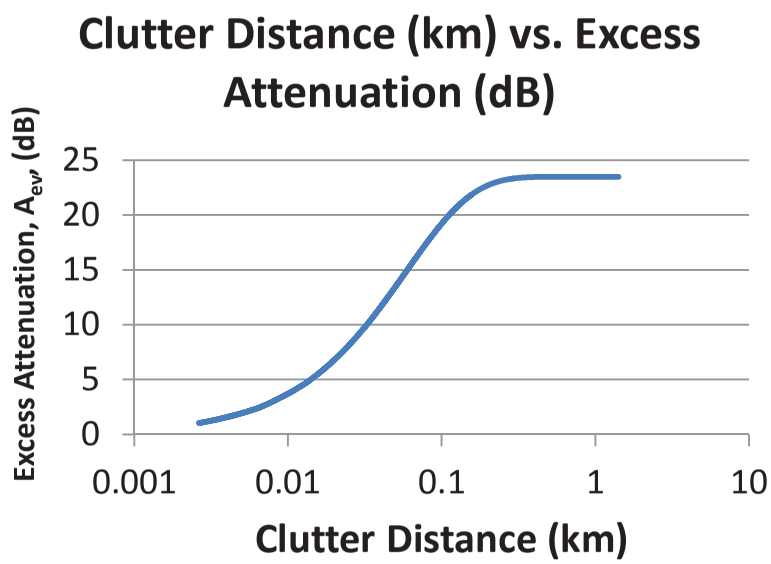
Clutter model from ITU-R Recommendation P.833-4- 'Attenuation in Vegetation'. The following equation calculates attenuation values in vegetation for frequencies below 3 GHz and for distances through vegetation < 6 km.

$$A_{ev} = A_m\left[1 - e^{-(d\gamma/A_m)}\right]$$

where A_{ev} is the calculated excess attenuation in vegetation, d is the distance of the path within the woodland in meters, γ is the specific attenuation for very short vegetative paths (< 6 km) in dB/m, and A_m is the maximum attenuation for one terminal within a specific type and depth of vegetation in dB. A_m is given by:

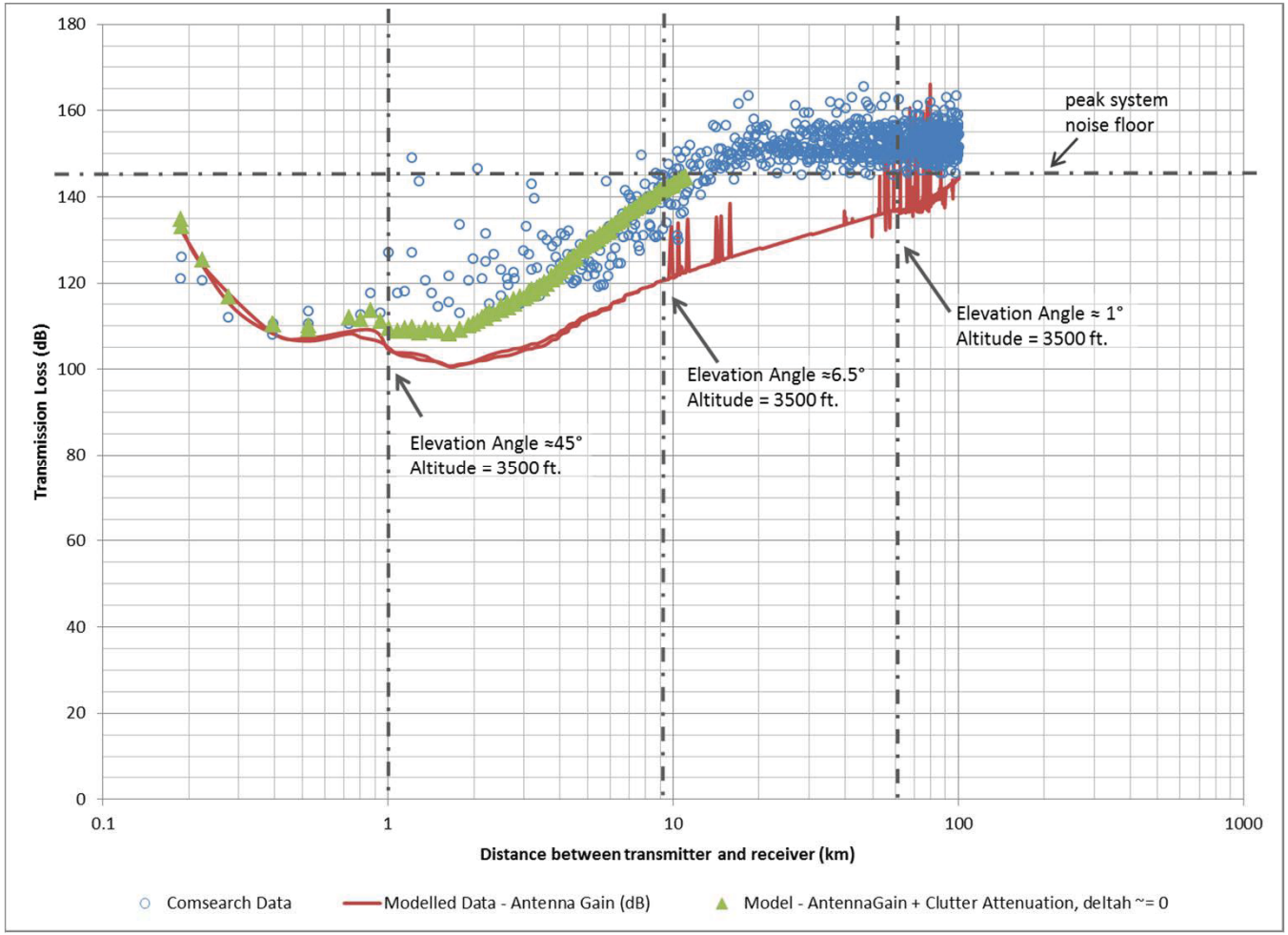
$$A_m = A_1 f^{\alpha}.$$

where A_1 = 1.15 dB and α = 0.4 dB/m, f is the frequency in MHz. Elevation angles obtained from measurements were used to calculate the distance through clutter based on a tree height of 50 feet.



Clutter distance (km) vs. excess attenuation or clutter loss(dB) . We see that at small clutter distances, clutter loss will be small, but at larger clutter distances (up to 6 km) the clutter losses can be as much as 23.5 dB.

Distance (km) vs. Transmission Loss



Comsearch measurement data (blue circles) and modelled data (green triangles) including antenna gain clutter losses as a function of distance. The red trace shows the modelled data including only antenna gains.

Interference Protection Criteria (IPC)

- During CSMAC WG deliberations, DoD used I/N -6dB which doesn't reflect actual system operations, resulting in unrealistic protection distances
- After a simple analysis, including antenna gain patterns and clutter losses, ITS presented data showing the impact of one UE into a P5 Pod at an altitude of 3.05 km (10K feet) at distances on the order of 140 km. The signal-to-noise ratio for the UE into a P5 pod is approximately -30 dB and the signal-to-noise ratio of the pod-to-pod communication is greater than 10 dB for separation distances greater than 7.8 km.
- Use of C/(I+N) is widely recognized – for instance, TIA Telecommunications Systems Bulletin (TSB) 88-A provides a methodology to determine IPC in terms of the carrier-to-interference plus-noise power ratio (C/(I+N))[1]
- CSMAC WG 5 recommended the consideration of a 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 (WG-5 Report, Recommendation 5)

[1] **NTIA Report 05-432, INTERFERENCE PROTECTION CRITERIA Phase 1 - Compilation from Existing Sources** http://www.ntia.doc.gov/files/ntia/publications/ipc_phase_1_report.pdf

Conclusions

- Prior CSMAC WG models showed that aggregate interference levels caused by UE transmissions would be higher as altitude increased, however, evidence in the measurement data showed otherwise
- Predictive models should include effects from
  - Terrain heights,
  - Surface reflection multipath,
  - Antenna gain patterns for all antennas,
  - Possible clutter losses
- After including these effects the IF-77 model was used to validate the airborne measurements
- As a result, clutter, terrain and antenna characteristics need to be considered in the model when defining coordination and/or protection zone criteria
- Appropriate BH network utilization loading figures need to be incorporated
- An IPC of C/(I+N) should be used in the analysis
- Coordination zones rather than exclusion zones are appropriate for sharing