LAW OFFICES
GOLDBERG, GODLES, WIENER & WRIGHT LLP
1229 NINETEENTH STREET, N.W.
WASHINGTON, D.C. 20036-2413

HENRY GOLDBERG
JOSEPH A. GODLES
JONATHAN L. WIENER
DEVENDRA ("DAVE") KUMAR

HENRIETTA WRIGHT
THOMAS G. GHERARDI, P.C.
COUNSEL

THOMAS S. TYCZ*
SENIOR POLICY ADVISOR
*NOT AN ATTORNEY

(202) 429-4900
TELECOPIER:
(202) 429-4912
e-mail:
general@g2w2.com
website: www.g2w2.com

October 7, 2015

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

Re: Revision of Part 15 of the Commission's Rules to Permit Unlicensed National Information Infrastructure Devices in the 5 GHz Band, ET Docket No. 13-49

Notice of *Ex Parte* Presentation

Dear Ms. Dortch:

On October 5, 2015, the undersigned, on behalf of Fastback Networks, Inc. ("Fastback"), had a telephone conversation with Julius Knapp, Chief of the Office of Engineering and Technology ("OET"). The undersigned then followed up with an October 5th e-mail to Mr. Knapp and Mark Settle, Chief of OET's Policy and Rules Division, which is attached hereto.

The purpose of the phone call and e-mail was to follow up on a previous call and Fastback slide presentation, which was the subject of an *ex parte* letter filed on September 25th and attached hereto for the convenience of the Commission. In the September 25th presentation, Fastback focused on the out-of-band-emission requirement ("OOBE") for the U-NII-1 band into the 5.091-5.15 GHz band and proposed a new limit of -17dBm/MHz, which, Fastback demonstrated, would significantly improve the range and throughput of U-NII-1 rural broadband systems without hindering the MSS, AeroMACS, and Aeronautical Mobile Telemetry ("AMT") services presently authorized for the 5.091-5.15 GHz band.

In the October 5th call, the undersigned pointed out that the U-NII-1 OOBE issue had been raised in the above-captioned proceeding in WISPA comments, Mimosa's Petition for Reconsideration, and in the WISPA-led consensus proposals for changes upon reconsideration of the

Commission's Order in the above-captioned proceeding.[1] In addition, in the call and the subsequent e-mail, the undersigned referred to recent submissions by the Aerospace and Flight Test Radio Coordinating Council, Inc. ("AFTRCC") in ET Docket No. 15-99/IB Docket 06-123 – included in the October 5th e-mail attached hereto – regarding proposed AMT allocations in the 4400-4940 MHz and 5925-6700 MHz bands and the ease with which AMT services could share the band with incumbent FS and ENG operations. In this regard, the undersigned noted that, given AFTRCC's showing, the Commission could conclude that AMT services in the 5.091-5.15 GHz band would not be adversely affected by U-NII-1 OOBE signals that were 50 dB lower than the emissions AMT would be facing as they shared the 4400-4940 MHz and 5925-6700 MHz bands with incumbent FS and ENG users.

Please direct any questions to the undersigned.

Respectfully submitted,

Henry Goldberg
Attorney for Fastback Networks, Inc.

Attachment

cc: Julius Knapp
Mark Settle

[1] *See* Comments of The Wireless Internet Service Providers Association, ET Docket No. 13-49, at 11 (submitted May 28, 2013); Petition for Partial Reconsideration of Mimosa Networks, Inc., ET Docket No. 13-49 (submitted Jun. 2, 2014); Letter of The Wireless Internet Service Providers Association *et al.*, ET Docket No. 13-49 (submitted Mar. 23, 2015).

LAW OFFICES
GOLDBERG, GODLES, WIENER & WRIGHT LLP
1229 NINETEENTH STREET, N.W.
WASHINGTON, D.C. 20036-2413

HENRY GOLDBERG
JOSEPH A. GODLES
JONATHAN L. WIENER
DEVENDRA ("DAVE") KUMAR

HENRIETTA WRIGHT
THOMAS G. GHERARDI, P.C.
COUNSEL

THOMAS S. TYCZ*
SENIOR POLICY ADVISOR
*NOT AN ATTORNEY

(202) 429-4900
TELECOPIER:
(202) 429-4912
e-mail:
general@g2w2.com
website: www.g2w2.com

September 25, 2015

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

Notice of Ex Parte Presentation Re: *Revision of Part 15 of Commission's Rules to Permit Unlicensed National Information Infrastructure Devices in the 5 GHz Band,* ET Docket No. 13-49

Dear Ms. Dortch:

On September 24, 2015, the undersigned and Dr. Kevin J. Negus, CTO, Chairman, & Co-Founder Fastback Networks, Inc. had a telephone conversation with Mark Settle, chief of Policy and Rules Division of the Office of Engineering and Technology ("OET") and Karen Rackley, Aole Wilkins, and Jamison Prime, all of OET. In that call, Dr. Negus covered the points set out in the attached slides.

Please direct any questions to the undersigned.

Respectfully submitted,

Henry Goldberg

Henry Goldberg
Attorney for Fastback Networks, Inc.

Attachment

cc: Mark Settle
Karen Rackley
Aole Wilkins
Jamison Prime

FASTBACK RECOMMENDS ADOPTION OF THE FOLLOWING 3 “WISPA CONSENSUS PROPOSAL” MODIFICATIONS FOR U-NII BAND OOBE LIMITS

Sept 15, 2015

Dr. Kevin Negus

Recommendation #1: Change U-NII-1 OOBE Limits for 5.091 – 5.15 GHz (affects 15.407 b(1) (15.209) and b(7) (15.407))

WISPA Consensus Proposal

- Change 15.209 OOBE range for U-NII-1 to end at 5.091 GHz
- Add a shoulder at -17 dBm/MHz OOBE for 5.091 to 5.15 GHz

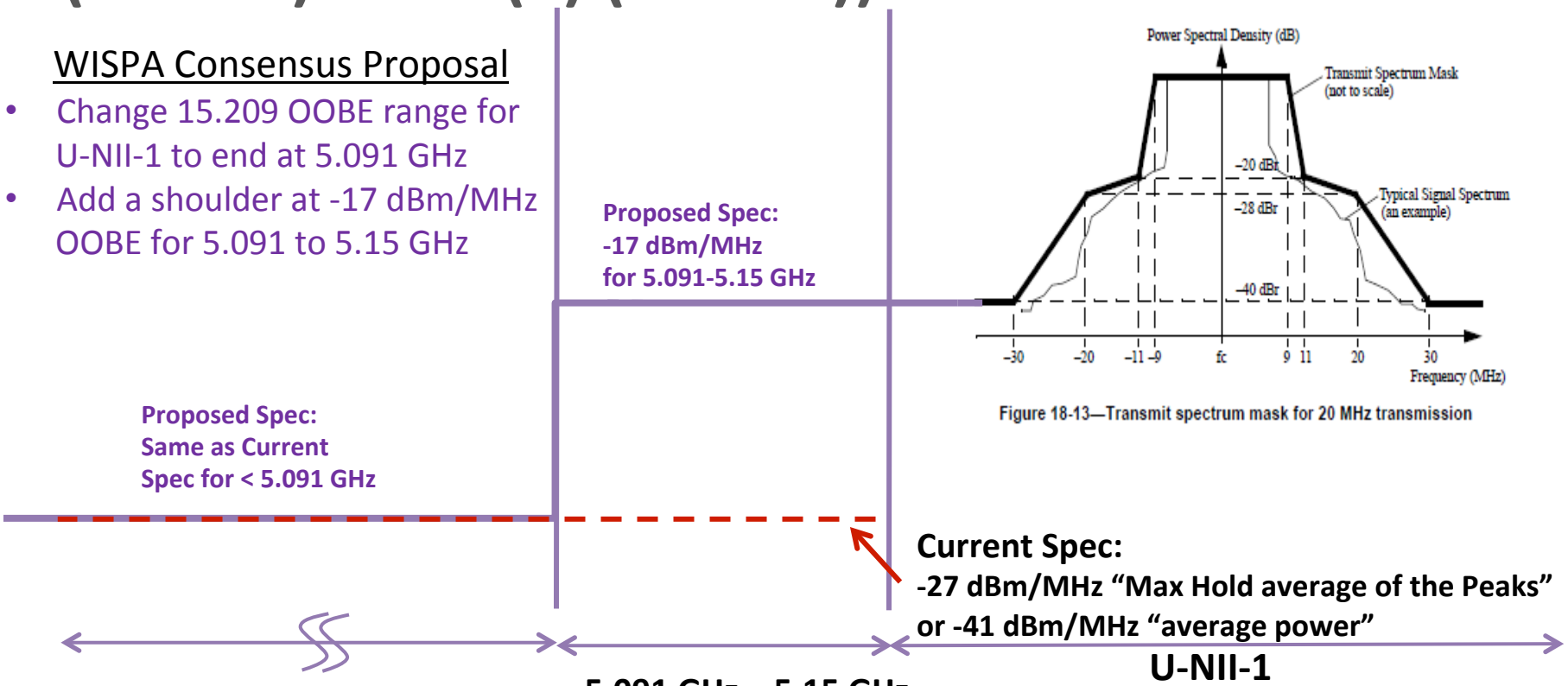


Figure 18-13—Transmit spectrum mask for 20 MHz transmission

Fastback NETWORKS
intelligent wireless transport

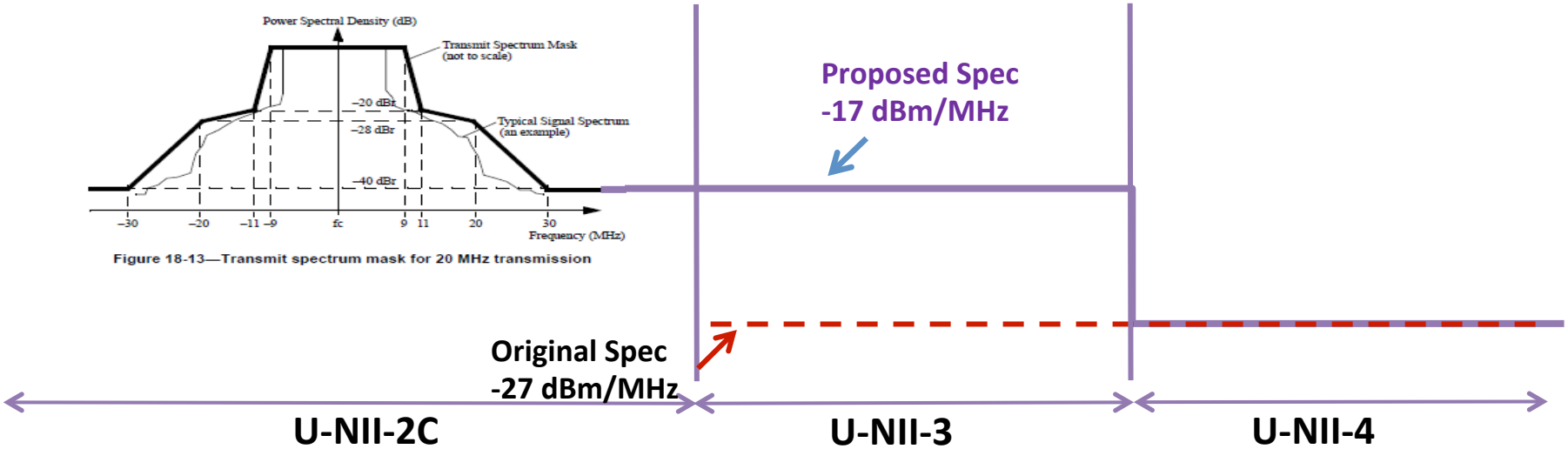
Recommendation #2: Change U-NII-2C OOBE Limits for U-NII-3 (affects 15.407 b(3))

WISPA Consensus Proposal

- Change OOBE limit for U-NII-2C to begin at 5.85 GHz (i.e. border of U-NII-3 and U-NII-4) instead of 5.725 GHz (i.e. border of U-NII-2C and U-NII-3).

- **Current rule:**
- b(3) For transmitters operating in the 5.47-5.725 GHz band: All emissions outside of the 5.47-5.725 GHz band shall not exceed an e.i.r.p. of −27 dBm/MHz.

Figure 18-13—Transmit spectrum mask for 20 MHz transmission



Fastback NETWORKS
intelligent wireless transport

Recommendation #3: Change the U-NII OOBE Measurement Method back to Previous Method

WISPA Consensus Proposal

- DROP THE "MAX HOLD" IN THE OOBE POWER MEASUREMENT
  - Use "average of peak detector output" instead at the appropriate OOBE limit
  - This "average of the peaks" method was used for U-NII OOBE measurements for over 10 years until recently changed to the current "max hold of the peaks" method.

- **CURRENT "MAX HOLD" METHOD:** MEASURES AVERAGE OF PEAK DETECTOR OUTPUT ON SPECTRUM ANALYZER, WITH MAX HOLD TURNED ON, AND WAITS UNTIL TRACE STOPS CHANGING (could be minutes and is often not repeatable)
  - The first fundamental problem is that with highly spectral efficient waveforms such as WiFi, LTE-U or SC-FDE that extremely rare spurious intermodulation products of near-zero time length produce instantaneous peaks of ~11 dB above the "average of the peaks" OOBE that more accurately predicts interference into a communications system receiver
  - Even if TDWR radar receivers were sensitive to this pathological "Max Hold" event, the FCC's current "Max Hold" OOBE measurement procedures apply to non-TDWR portions of U-NII-2 band and even apply to OOBE into bands with no known radar systems

Fastback NETWORKS
intelligent wireless transport

Action Items from 8/24/2015 Call between OET and Fastback Networks

- Why are the U-NII-1 OOBE limits a problem for Point to Point ("P2P") links?
- What are the benefits to users of P2P links from the proposed changes to U-NII-1 OOBE limits?
- How do U-NII-1 P2P links affect other 5091-5150 MHz users if proposed changes to U-NII-1 OOBE limits were adopted?

Fastback NETWORKS intelligent wireless transport

U-NII-1 OOBE Limits Constrain Transmit Power especially for P2P Links

- practical limits on filtering and intermodulation products restrict ratio of Tx EIRP to OOBE to ~52 dBc for "average Tx power to average OOBE" in an adjacent channel (and this is achieved only by backing off the Tx PA by more than 10 dB)
- thus, -27 dBm/MHz max hold limits Tx EIRP to approximately: -27 dBm/MHz – 11 dB (max hold vs avg.) + 52 dBc (Tx/OOBE ratio) = +14 dBm/MHz, or about +30 dBm EIRP for a 40 MHz channel in the lower half of U-NII-1
- this almost entirely negates the "desired" trade-off that P2P links make for higher allowable EIRP in the "boresight" because the EIRP off boresight is greatly reduced
- however, even though OOBE also greatly reduces off boresight by the antenna directivity the OOBE limits are not scaled to account for increased antenna gain

Fastback NETWORKS
intelligent wireless transport

U-NII-1 OOBE Limits Reduce Range and Throughput especially for Rural Services

- adopting the proposed Recommendation #1 OOBE limits from the WISPA Consensus proposal enables an increase in Tx EIRP for U-NII-1 P2P Links of about 6-10 dB typically
- at an 8 dB increase, this corresponds to an increase in range of typically 250% (for Fastback products this is 10 km versus 25 km "useful" range in rural usage scenarios)
- alternatively, this corresponds to typically a factor of 2 in throughput (for Fastback products at target rural usage of 10 km this is about 500 Mb/s versus 250 Mb/s)

Fastback NETWORKS
intelligent wireless transport

Proposed U-NII-1 OOBE Limits do not harm other 5.091-5.15 GHz occupants

- Incumbent occupant is Globalstar
  - additional interference at satellite repeater receiver due to U-NII-1 OOBE is negligible (i.e. more than 30 dB lower) than interference already present due to U-NII-1 in band transmissions
- Potential new occupant is AeroMACS
  - see analysis herein for impact to AeroMACS due to P2P links in U-NII-1 with proposed OOBE limits

Fastback NETWORKS
intelligent wireless transport

The AeroMACS Communication System

From FCC-15-50A1

"Allocate the 5091-5150 MHz band to the aeronautical mobile service (AMS) on a primary basis for Federal and non-Federal use, limited to aeronautical mobile telemetry (AMT) for flight testing of aircraft and "Aeronautical Mobile Airport Communications System" (AeroMACS) networks."

"The term "AeroMACS" refers to the emerging wireless communications network in the 5091-5150 MHz band that operates in the airport surface domain."

From the International Civil Aviation Organization Working Paper Aeronautical Communications Panel 29th Meeting of Working Group F March 13-19 2014*:

Operating Frequency Band – proposed 5030 – 5150 MHz globally

Transmit EIRP – at least +36 dBm

Tx/Rx Antenna Gain – ~ 13 dBi or ~ 80 degrees in azimuth

Modulation – OFDM based on WiMax 802.16

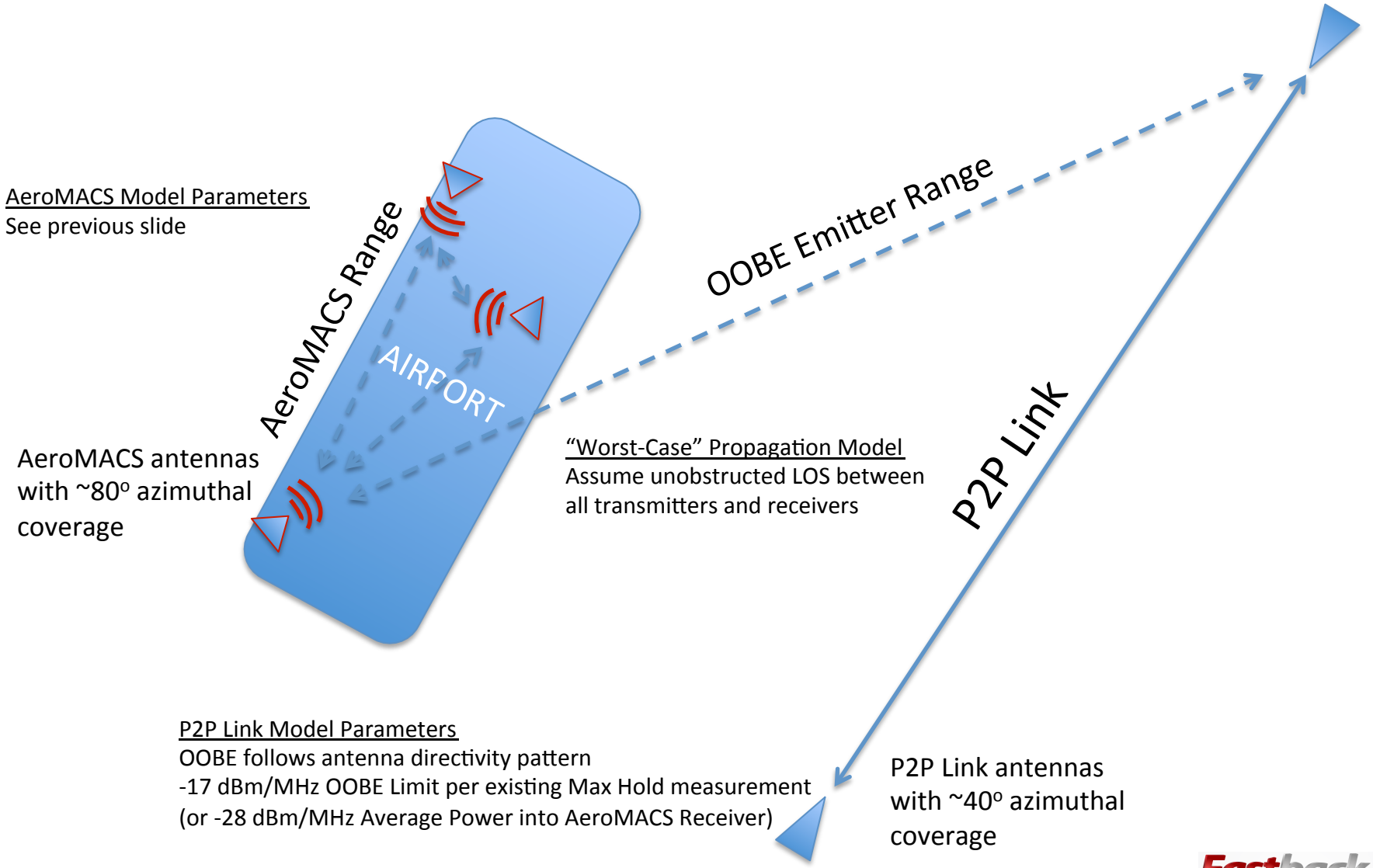
Channelization – typically 5 MHz centers or multiples

Toulouse Airport Network Trial

* See also, "AeroMACS – A Global Standard for Airport Surface Communications" by Declan Bryne of Wimax Forum at ICNS 2013, or "Aeronautical Mobile Airport Communications System (AeroMACS) for Access to SWIM" by James Budinger of NASA at Demonstration and Prototyping Information Exchange TIM6, Nov. 2010.

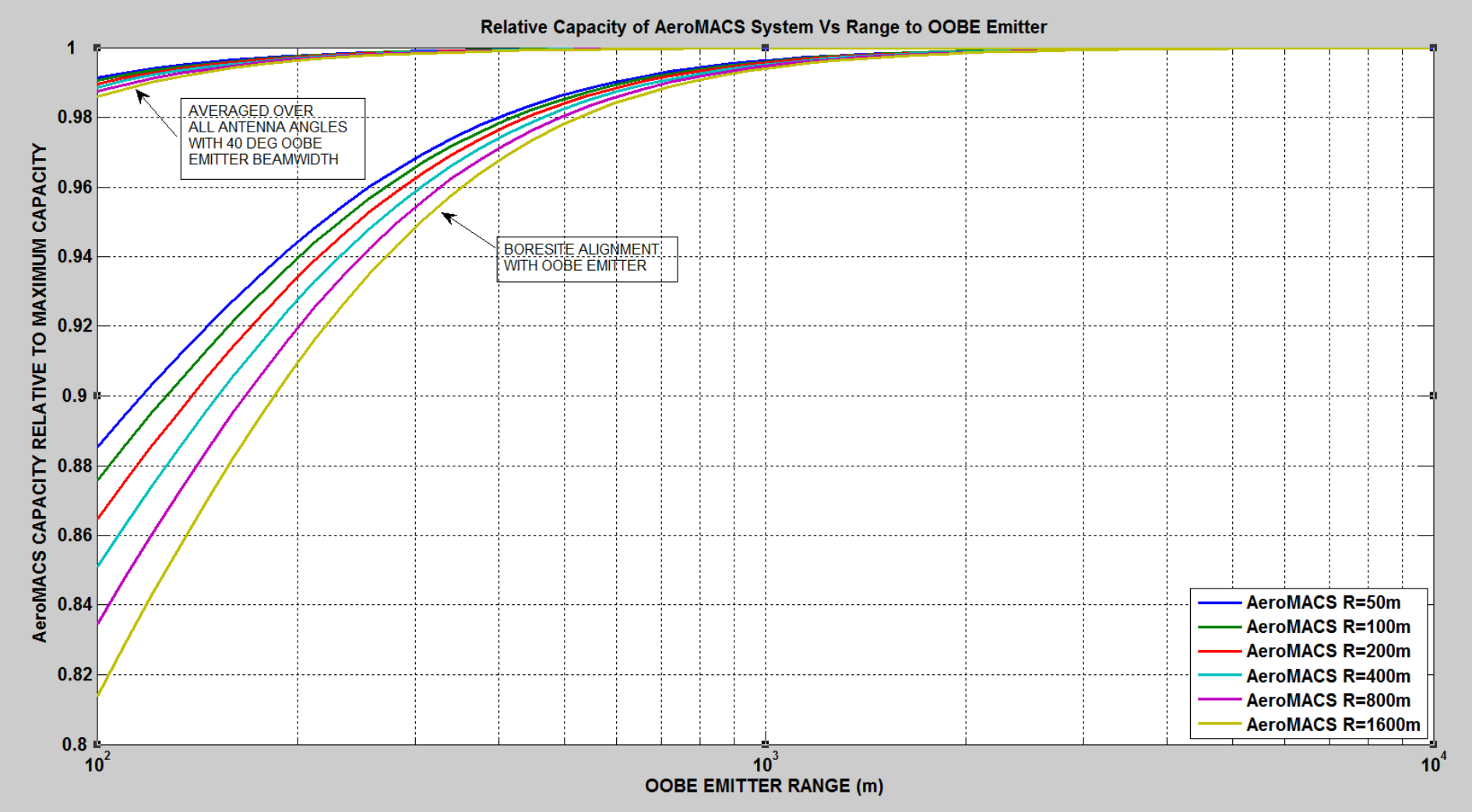
Fastback NETWORKS
intelligent wireless transport

Simulation Model for Impact of P2P Link U-NII-1 OOBE Emitter on AeroMACS Link per Recommendation #1



Fastback NETWORKS
intelligent wireless transport

Simulated AeroMACS Impact versus P2P Link U-NII-1 OOBE Emitter Range at the -17 dBm/MHz Recommendation #1 Proposed Limit



Fastback NETWORKS intelligent wireless transport

Conclusions

- Adoption of WISPA Consensus Proposal Items per Fastback Recommendations #1, #2 and #3 herein is warranted
- Adoption of Fastback Recommendation #1 for P2P Links has direct benefit to underserved rural broadband applications
- Adoption of Fastback Recommendation #1 for P2P Links has no meaningful impact on incumbent or proposed occupants of 5.091-5.15 GHz

Fastback NETWORKS
intelligent wireless transport

From: Henry Goldberg
Sent: Monday, October 05, 2015 3:36 PM
To: Julius Knapp
Cc: mark.settle@fcc.gov
Subject: AFTRCC reply comments
Attachments: 20150930 Aerospace and Flight Test Radio Coordinating Council 2.pdf; 20150930 Aerospace and Flight Test Radio Coordinating Council.pdf

As just discussed, take a look at these AFTRCC reply comments re sharing the 4400-4940 MHz and 5925-6700 MHz bands between AMT and the present users of the band. If you need ammunition in talking to NTIA about the U-NII-1 OOBE, you can note that AFTRCC claims they can co-exist peacefully with P2P links at 6 GHz while U-NII-1 OOBE would be 50 dB lower.

Before the
Federal Communications Commission
Washington, D.C. 20554

In the Matter of	)	
	)	
Amendment of Parts 1, 2, 15, 25, 27, 74, 78, 80, 87, 90, 97, and 101 of the Commission's Rules Regarding Implementation of the Final Acts of the World Radiocommunication Conference (Geneva, 2007) (WRC-07), Other Allocated Issues, and Related Rule Updates	)	ET Docket No. 12-338 (Proceeding Terminated)
	)	
Amendment of Parts 2, 15, 80, 90, 97, and 101 of the Commission's Rules Regarding Implementation of the Final Acts of the World Radiocommunication Conference (Geneva, 2012) (WRC-12), Other Allocation Issues, and Related Rule Updates	)	ET Docket No. 15-99
	)	
Petition for Rulemaking of Xanadoo Company and Spectrum Five LLC to Establish Rules Permitting Blanket Licensing of Two-Way Earth Stations With End-User Uplinks in the 24.75-25.05 GHz Band	)	IB Docket 06-123
	)	
Petition for Rulemaking of James E. Whedbee to Amend Parts 2 and 97 of the Commission's Rules to Create a Low Frequency Allocation for the Amateur Radio Service	)	
	)	
Petition for Rulemaking of ARRL to Amend Parts 2 and 97 of the Commission's Rules to Create a New Medium-Frequency Allocation for the Amateur Radio Service	)	

To: The Commission

REPLY COMMENTS OF AEROSPACE AND FLIGHT TEST RADIO COORDINATING COUNCIL, INC.

Aerospace and Flight Test Radio Coordinating Council, Inc. ("AFTRCC"), by its counsel, hereby replies to certain of the opening Comments filed in this proceeding. As discussed below, the Commission should adopt the proposed Aeronautical Mobile Telemetry ("AMT") allocations in the 4400-4940 MHz and 5925-6700 MHz bands.

DISCUSSION

Nearly a decade ago, the United States identified a "large and growing shortfall" in the spectrum available for critical AMT operations. The causes of this shortfall, including "increasing complexity of aircraft design, pressure to shorten timescales for the development of new aircraft, and telemetry spectrum being diverted to other uses," have only continued to increase as aerospace and communications systems have matured in the intervening years. NPRM at para. 207. As a result of this urgency, the United States proposed at WRC-07, and the international community adopted, a Region 2 allocation for AMT in both the 4400-4940 MHz and 5925-6700 MHz bands. Now it is time to implement this much-needed allocation. The new allocation, and its accompanying operational restrictions, recognize the dual realities of intensive spectrum use across the band and the critical need for increased AMT spectrum. Given the international support for increased AMT spectrum, and the framework established to ensure its harmonious integration with existing services, the time has come to adopt these much needed allocations, and AFTRCC strongly urges the Commission to do so without delay.

AFTRCC, The Boeing Company, and The Small UAS Coalition have filed Comments explaining the policy supporting the allocation as agreed at WRC-07.[1] Comments opposing the allocation were filed by the Fixed Wireless Communications Coalition ("FWCC") and the National Spectrum Management Association ("NSMA"), on behalf of Fixed Service ("FS") operators. The Society of Broadcast Engineers, Incorporated ("SBE"), also filed Comments in opposition on behalf of broadcast, video production, and related entities.

As explained below, the FS community appears to systematically underestimate the true extent of spectrum sharing feasible in the 4400-4940 MHz and 5925-6700 MHz bands, as well as

[1] The Small UAS Coalition Comments address UAS use of the spectrum. As explained later, however, there are issues with this proposal.

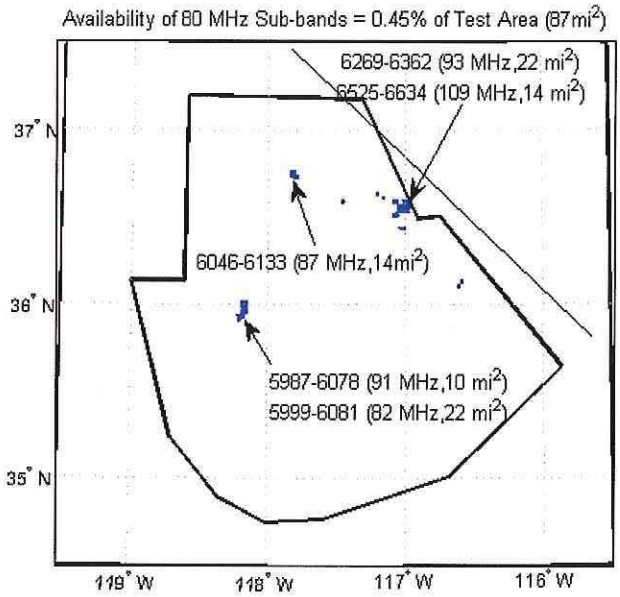
disregards the substantial inter-agency and international agreement establishing a framework for successful sharing between incumbent FS and new AMT operations.

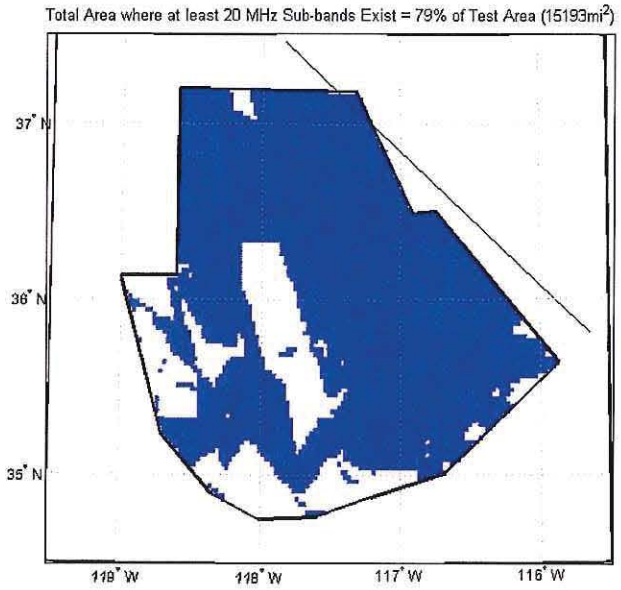
FWCC and NSMA maintain that sharing is infeasible in the bands 4400-4940 and 5925-6425/6525-6700 MHz on the grounds of potential interference to terrestrial microwave links. Among other things, they argue that the number of FS stations has increased since the time ITU-R Report M. 2119 was prepared in 2007. FWCC also contends, based on data provided by Comsearch, that "there are no geographic areas in the continental U.S. where AMT test areas would fall outside of the exclusion zones created by lower 6 GHz receiver rectangles" (FWCC, page 4); and that numerous FS stations could be affected by a single test flight. NSMA similarly asserts that there are "no unused geographic areas or unused frequencies when viewed from the airborne AMT transmitter's perspective" (pages 5-6).

These comments fail to demonstrate that sharing is infeasible throughout these bands in any area, let alone all areas. Neither Commenter shows, or even attempts to show, on a site-specific basis that there is no unused spectrum available in the vicinity of various test ranges. For example, FWCC's Figures 1 and 2 focus on only two discrete lower 6 GHz channels; no showing is made as to the other channels in the band 5925-6425 MHz. Likewise, its Figure 3 purports to show that there are no channels at all which would fall entirely outside the exclusion zone of each of the various flight test areas ("AMT Zones"). However, the relevant inquiry is not whether there is any area free of all FS channel receiver zones; the relevant inquiry is whether there are areas where at least one FS channel might be available for AMT use. And on that score, FWCC's Figures are much too generalized; for example, the Figures make no allowance for the availability of FS channels in areas smaller than that of an entire Range. To be

probative, any analysis of sharing feasibility requires a more detailed site-specific, channel-specific perspective.

Prior to WRC-07, the AMT community undertook a careful analysis of FS licensing in this band with an eye toward evaluating channel availability. Material from that analysis is attached as an Exhibit to these Comments. The analysis demonstrates the method by which careful analysis of the existing geographic and spectrum usage can reveal large contiguous geographic areas in which substantial contiguous sub-bands are available for flight test operations. For example, the test range at Edwards Air Force Base at first glance appears to be a zone where, as FWCC asserts, "successful sharing…[is] highly improbable (if not impossible)." (FWCC, page 2). More detailed analysis, however, reveals that large expanses of airspace were available for 20 and even 30 MHz of spectrum. The excepts from the analysis below demonstrate the difference between the FS community approach and the analysis used by the U.S. government and the international community. The diagram on the left shows the exceedingly limited regions available for spectrum sharing when seeking 80 MHz of contiguous unused sub-bands. In contrast, the diagram on the right shows the dramatic difference in available spectrum when seeking only 20 MHz of contiguous spectrum.





While the situation is more challenging today given growth in the FS, the Exhibit shows that sharing is feasible through detailed, site-specific analysis utilizing co-channel avoidance and spatial separation techniques. And of course, the analysis did not account for the substantial evolution over the last eight years in technologies capable of aggregating disparate unused bands into usable spectrum.[2]

AFTRCC believes that the operational restrictions and emerging technical solutions discussed above can ensure that integration of the incumbent FS and new AMT operations serve the Commission's goals of increased efficiency of spectrum use, non-interference, and sufficient spectrum for critical services.

Formulation of the original U.S. proposals for AMT in the 4400-4940 MHz and 5925-6700 MHz bands benefitted from significant input from, and cooperation with, representatives of the FS (and Fixed Satellite Service) communities. It is to be hoped that the Commenters will exhibit a similar spirit of cooperation as this proceeding unfolds.[3]

With respect to the 6425-6525 MHz band, SBE argues that the band is heavily used for mobile electronic newsgathering ("ENG") operations; that these operations are unpredictable, and difficult to coordinate "other than on an intra-service basis" (para. 1); that AMT footprints are large with "unpredictable flight paths" (para. 8), and that use of the "entirety of the 6425-6525 MHz band" over an area of up to 500 miles in diameter for hours at a time could not be

---

[2] At the end of its pleading, FWCC expresses the same concerns with respect to sharing 4400-4940 MHz as it does with respect to 5.9-6.7 GHz. AFTRCC is at a loss to understand the basis for this. There is no non-Federal FS allocation in this band. Nor does the Commission propose a new non-Federal allocation other than for AMT.

[3] AFTRCC anticipates that updated analyses will be provided reflecting growth in the FS since the original sharing studies were done.

coordinated in advance with broadcast auxiliary use (*ibid*). SBE further maintains that its operations could cause interference to AMT ground stations unless the Commission were to constrain use of the band by broadcasters whose spectrum has already been compromised by earlier allocation decisions.

The SBE Comments do not warrant a conclusion that sharing is not feasible. In this regard, AFTRCC's earlier observations as to 5925-6425/6525-6700 MHz are in large measure applicable to the sub-band 6425-6525 MHz -- with one conspicuous distinction: There are far fewer stations in 6425-6525 MHz than in the larger band, i.e. about 3,263 broadcast auxiliary and satellite earth stations versus 103,034 microwave and satellite earth stations, according to the Commission's own count. NPRM at para. 213.

Moreover, SBE makes no showing of channel occupancy or assignments in any given market in an attempt to demonstrate sharing will be difficult. And it should also be stressed that, by virtue of Resolution 416 (WRC-07), AMT operations in 5.9-6.7 GHz would not be for safety-related communications. Unlike AMT operations in other bands where safety-of-flight concerns are paramount, incumbent operators in this spectrum would not be burdened with the special obligations attendant to sharing with safety communications.

Insofar as coordination is concerned, AFTRCC appreciates that the broadcast community is accustomed to coordinating usage between and among themselves, and has well-established procedures for same. However, AFTRCC likewise has long experience coordinating frequency usage and is confident that the aeronautical and broadcast communities could work together harmoniously. Finally, AFTRCC does not anticipate AMT using "the entirety of the 6425-6525 MHz band" for hours at a time in any given area (Comments at para. 8).

With respect to The Small UAS Coalition, the Commenter maintains that the band should also be made available for UAS purposes. However, the U.S. studies upon which the proposal and the allocation are based, contemplated AMT use only. No studies have been done showing UAS compatibility with the incumbent services. Likewise, Resolution 416 (WRC-07) speaks only to AMT and conditions for use of the spectrum by AMT. Under the circumstances, AFTRCC does not see how UAS use would comport with these principles.

Finally, AFTRCC submits that Federal AMT users should be granted access to the 5925-6700 MHz band, and non-Federal AMT users access to the 4400-4940 MHz band. Federal and non-Federal AMT users have worked together throughout this long process in order to secure additional spectrum resources for the AMT community, it being understood that access to the respective bands would be reciprocal. Nothing in the opposition Comments undermines this basic premise.[4]

CONCLUSION

The Notice of Proposed Rulemaking makes the point that, in its proposals to the World Radiocommunication Conference, the United States stated that:

> "[T]here was a large and growing shortfall in the spectrum available for AMT use. Further, due to rapidly increasing data rates associated with the testing of new and emerging technologies, 'as much as an additional 650 megahertz may be required for aeronautical flight test telemetry.'"

Notice, at para. 207 (footnotes omitted). Thus, the U.S. proposed, and the international community endorsed, the allocations which are the basis for this domestic proposal. The conditions which gave rise to the U.S. proposal have not changed: If anything, the need is greater.

---

[4] With respect to adjacent, 4 GHz public safety users (NPRM at para. 221), AFTRCC does not envision that special coordination procedures need be applied beyond any already in use; however, this is a matter which can be examined further, if warranted.

Accordingly, for the foregoing reasons, the Commission should conclude that coordination with incumbent operators in the 5.9-6.7 GHz is indeed feasible, and proceed as expeditiously as possible to finalize the proposed 4/6 GHz allocation which the AMT community and the U.S. have been working towards for the last ten years.

Respectfully submitted,

AEROSPACE AND FLIGHT TEST RADIO
COORDINATING COUNCIL, INC.

By: /s/ William K. Keane
William K. Keane

Duane Morris LLP
505 9th Street NW
Suite 1000
Washington, D.C. 20004
(202) 776-5243

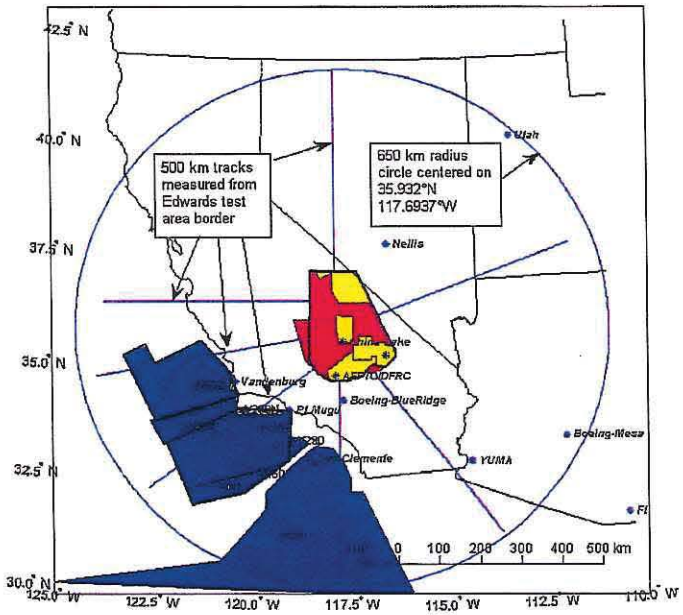
Its Counsel

September 30, 2015

Scenario Assumptions

- Consider test range in southwest United States
- Consider all FS receive stations within 500 km of test range (in this case 6084 stations) operating in 5925-6700 MHz

Figure 1. Test Area and Circular Region of Interest for FS Data



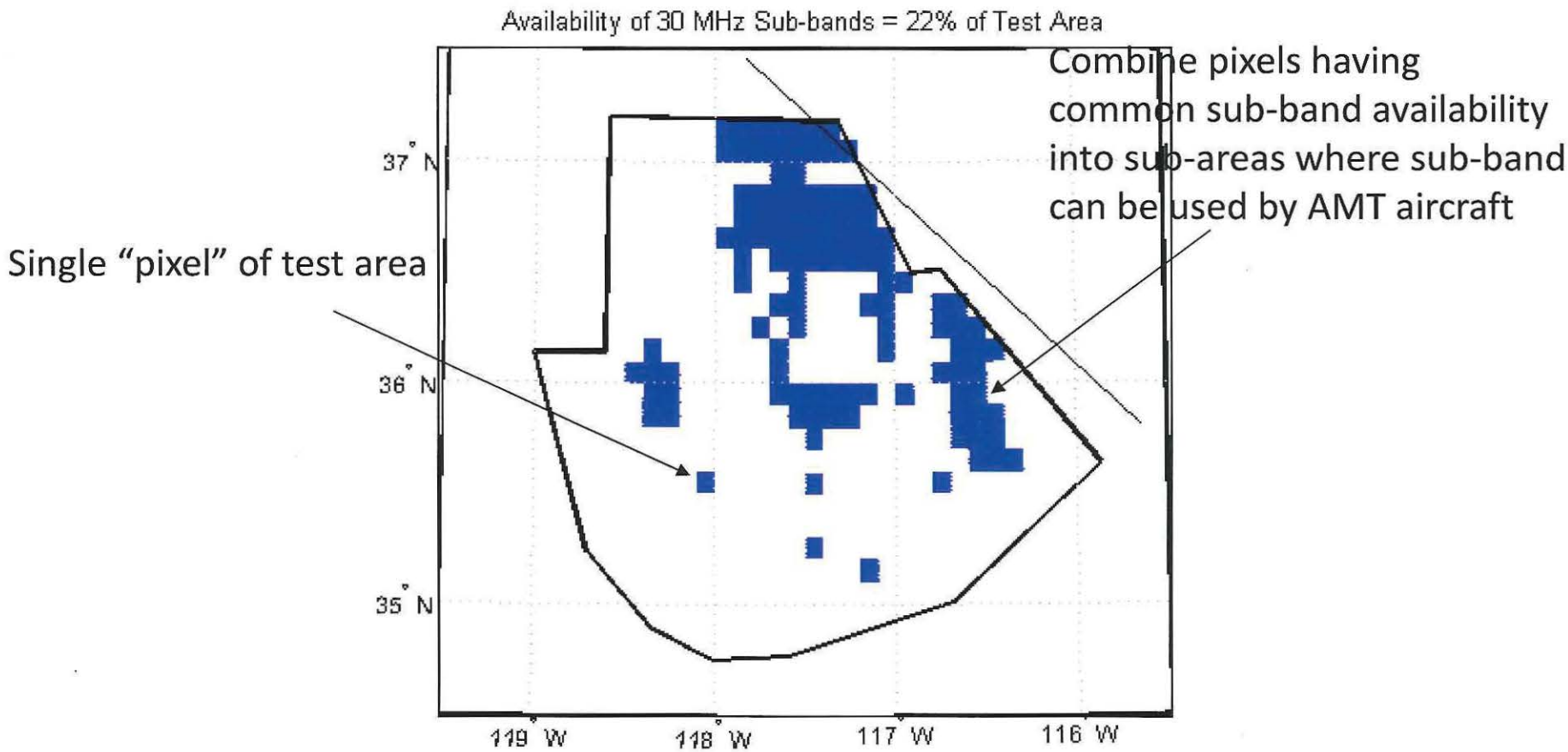
Exhibit

Analysis Approach

- **Instead of trying to find available spectrum sub-bands usable over the *entire* test area, consider smaller sub-spaces within the test area**
- **Subdivide the test area into large number of "pixels" (e.g. 160x120 = 19200 pixels) and determine spectrum availability for *each* pixel (e.g. 2.8 x 2.8 km) by applying draft Res [AMT4-6GHz] interference criteria**
- **A particular sub-band is assumed to be available for use by AMT aircraft in a particular "pixel" if there are no FS RX stations operating in the sub-band whose antenna boresights intersect the pixel or come within 12 km of the pixel (per draft Res)**
- **After determining sub-band availability for each of the 19200 pixels, consolidate/combine the pixels where appropriate in order to determine sub-areas within the test range where sub-bands are available**
- **Expect wide sub-bands to be available over only small areas and narrower sub-bands to be available over larger areas**

Analysis Approach (continued)

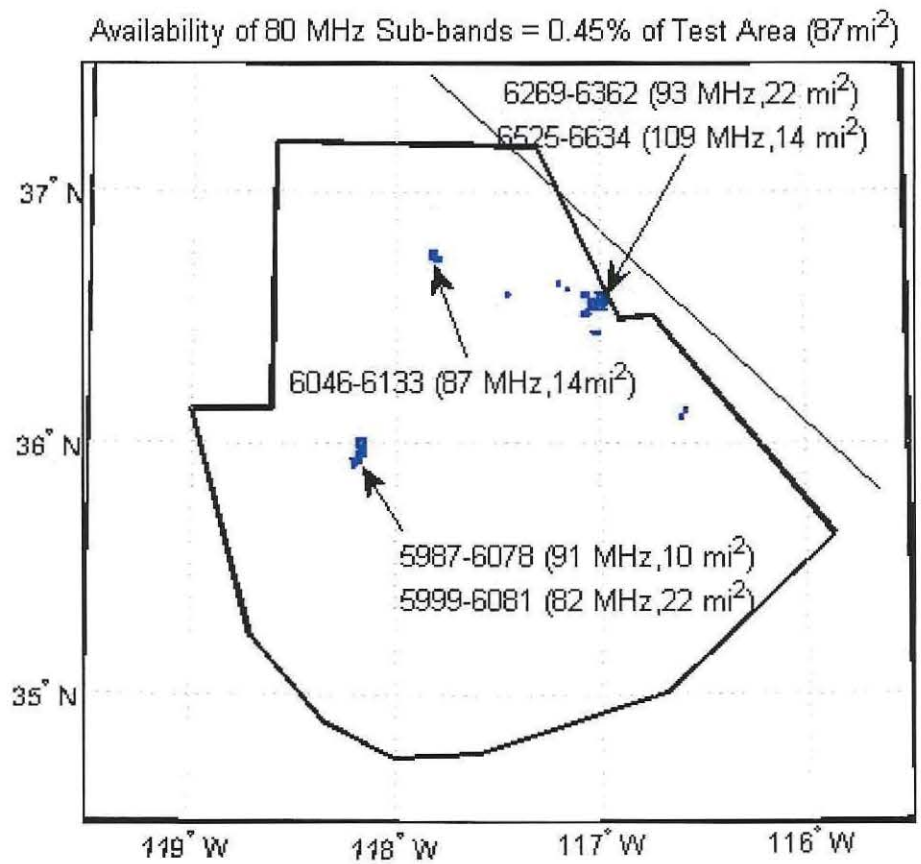
Figure 4. Sub-Dividing the Total Test Area into Pixels



Test area covered by 4deg x 3deg quadrangle -→ 40 pixels/deg → 160 x 120 = 19200 pixels (each pixel is approx 2.8 x 2.8 km)

Analysis Results

Figure 5. Areas where at least 80 MHz sub-bands are available



Note: Total test area is 19,246 sq mi

Table 1. Size of Sub-Areas where at Least 80 MHz Contiguous Bandwidth is Available

Sub-Band (MHz)		BW (MHz)	Area(mi^2)	% Test Area
5999	6081	82	21.78	0.113
6269	6361	92	21.65	0.112
6282	6362	80	16.82	0.087
6525	6634	109	14.41	0.075
6046	6133	87	14.38	0.075
5987	6078	91	9.68	0.050
6221	6333	112	9.60	0.050
6557	6641	84	7.21	0.037
6135	6223	88	4.81	0.025
6555	6636	81	4.80	0.025
6201	6300	99	4.80	0.025
6054	6140	86	2.40	0.012
6254	6348	94	2.40	0.012

Figure 6. Areas where at least 70 MHz sub-bands are available

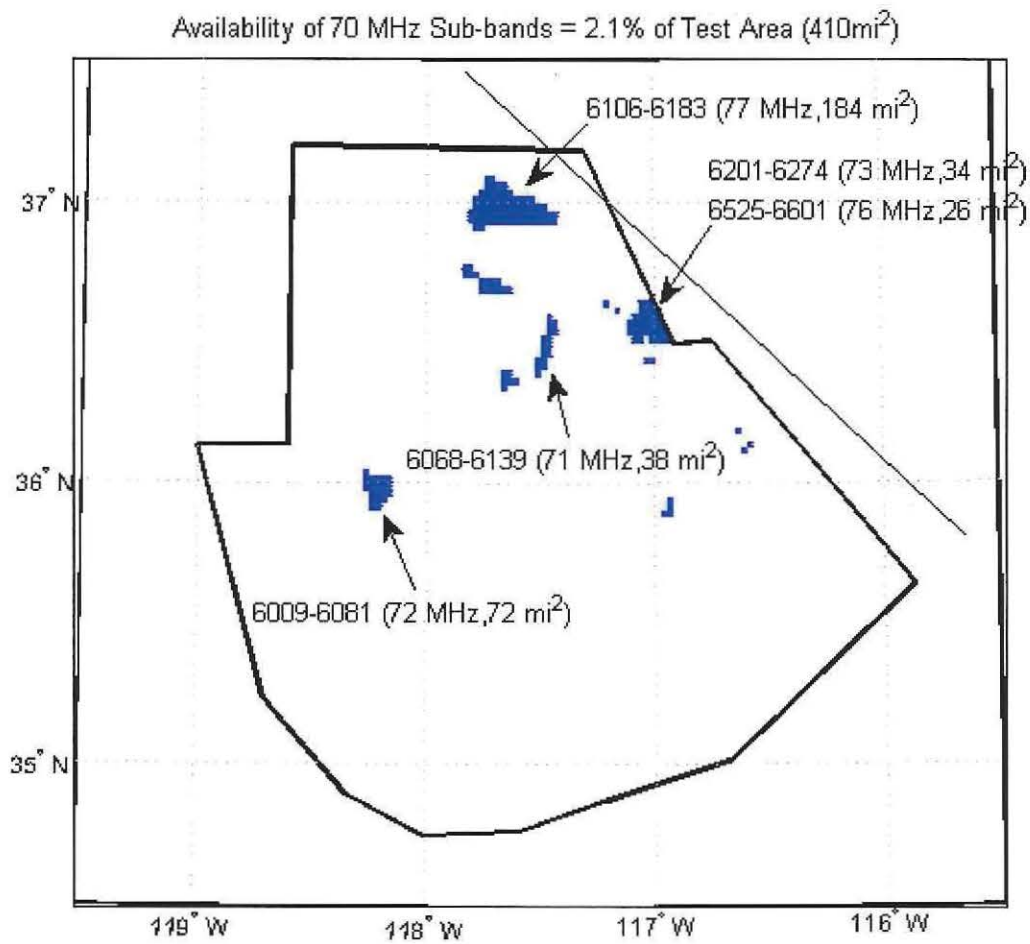


Table 2. Size of Sub-Areas where at Least 70 MHz Contiguous Bandwidth is Available

Sub-Band (MHz)		BW (MHz)	Area(mi^2)	% Test Area
6106	6183	77	184.07	0.956
6114	6185	71	78.95	0.410
6009	6081	72	72.38	0.376
6002	6078	76	48.40	0.251
6068	6139	71	38.47	0.200
6201	6274	73	33.61	0.175
6070	6140	70	26.45	0.137
6525	6601	76	26.43	0.137
5999	6071	72	21.78	0.113
6269	6361	92	21.65	0.112
6292	6362	70	16.82	0.087
6167	6244	77	16.82	0.087
6557	6634	77	16.81	0.087
6532	6626	94	14.41	0.075
6046	6133	87	14.38	0.075
6354	6425	71	9.69	0.050
5987	6068	81	9.68	0.050
6221	6333	112	9.60	0.050
6565	6641	76	7.21	0.037
6205	6278	73	7.20	0.037
6135	6223	88	4.81	0.025
6209	6290	81	4.80	0.025
6064	6137	73	2.40	0.012
6264	6338	74	2.40	0.012

Figure 7. Areas where at least 60 MHz sub-bands are available

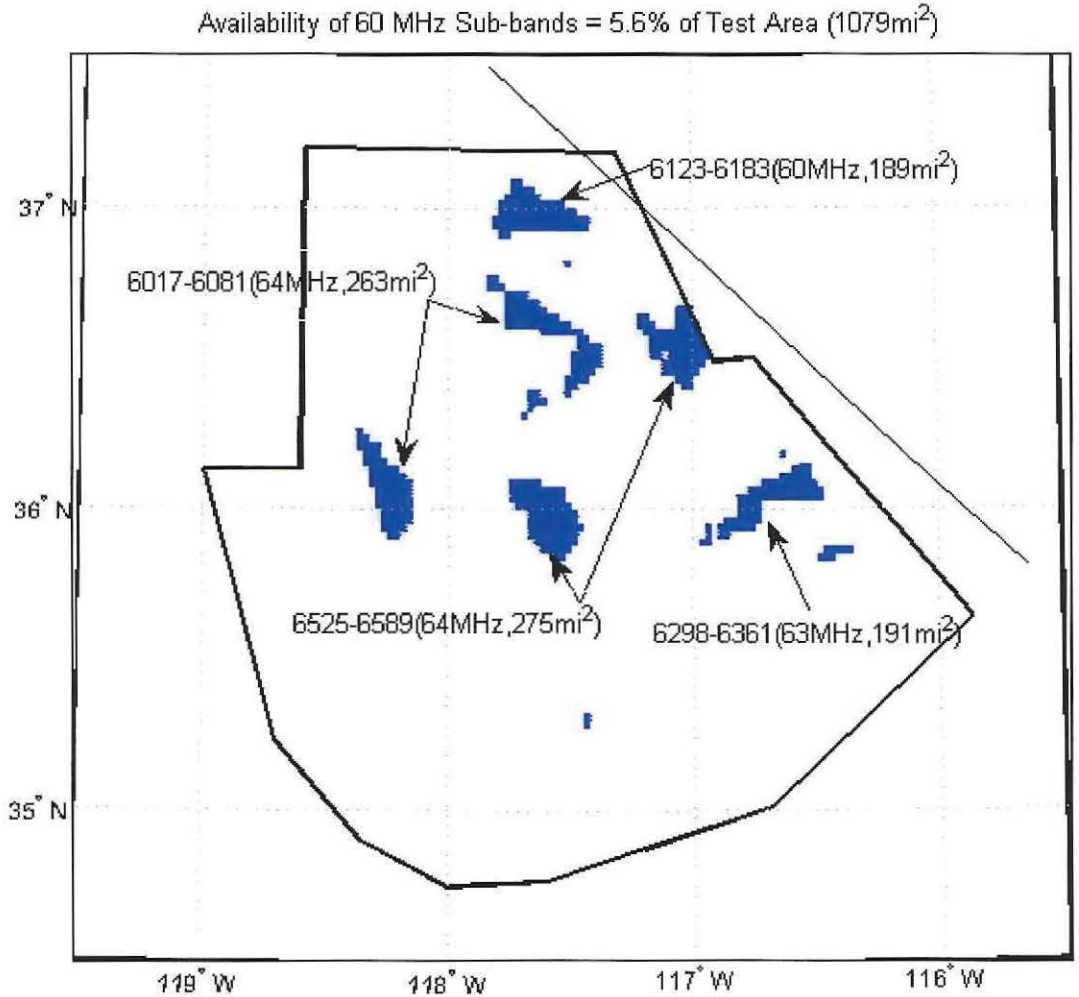


Table 3. Size of Sub-Areas where at Least 60 MHz Contiguous Bandwidth is Available

Sub-Band (MHz)		BW (MHz)	Area(mi^2)	% Test Area
6525	6589	64	275.31	1.431
6017	6081	64	262.70	1.365
6298	6361	63	190.80	0.991
6123	6183	60	188.95	0.982
6106	6172	66	186.48	0.969
6113	6182	69	184.07	0.956
6530	6591	61	178.58	0.928
6302	6362	60	89.29	0.464
6124	6185	61	83.83	0.436
6009	6076	67	72.38	0.376
6076	6139	63	67.32	0.350
6269	6333	64	60.07	0.312
6303	6363	60	55.67	0.289
6068	6133	65	50.45	0.262
6002	6068	66	48.40	0.251
6209	6274	65	40.81	0.212
6074	6135	61	38.47	0.200
6201	6268	67	33.61	0.175
6147	6213	66	28.83	0.150
6080	6140	60	26.45	0.137
6532	6601	69	26.43	0.137
6294	6357	63	24.05	0.125
6274	6337	63	24.05	0.125
5999	6061	62	21.78	0.113
6278	6353	75	21.65	0.112
6629	6691	62	19.39	0.101
6167	6244	77	16.82	0.087
6557	6634	77	16.81	0.087
6632	6694	62	14.54	0.076
6542	6616	74	14.41	0.075
6046	6127	81	14.38	0.075
5925	5992	67	12.03	0.063
6354	6425	71	9.69	0.050
5987	6058	71	9.68	0.050
6215	6278	63	9.61	0.050
6221	6328	107	9.60	0.050
6575	6641	66	7.21	0.037
6135	6206	71	4.81	0.025
6154	6223	69	4.81	0.025
6219	6280	61	4.80	0.025

Figure 8. Areas where at least 50 MHz sub-bands are available

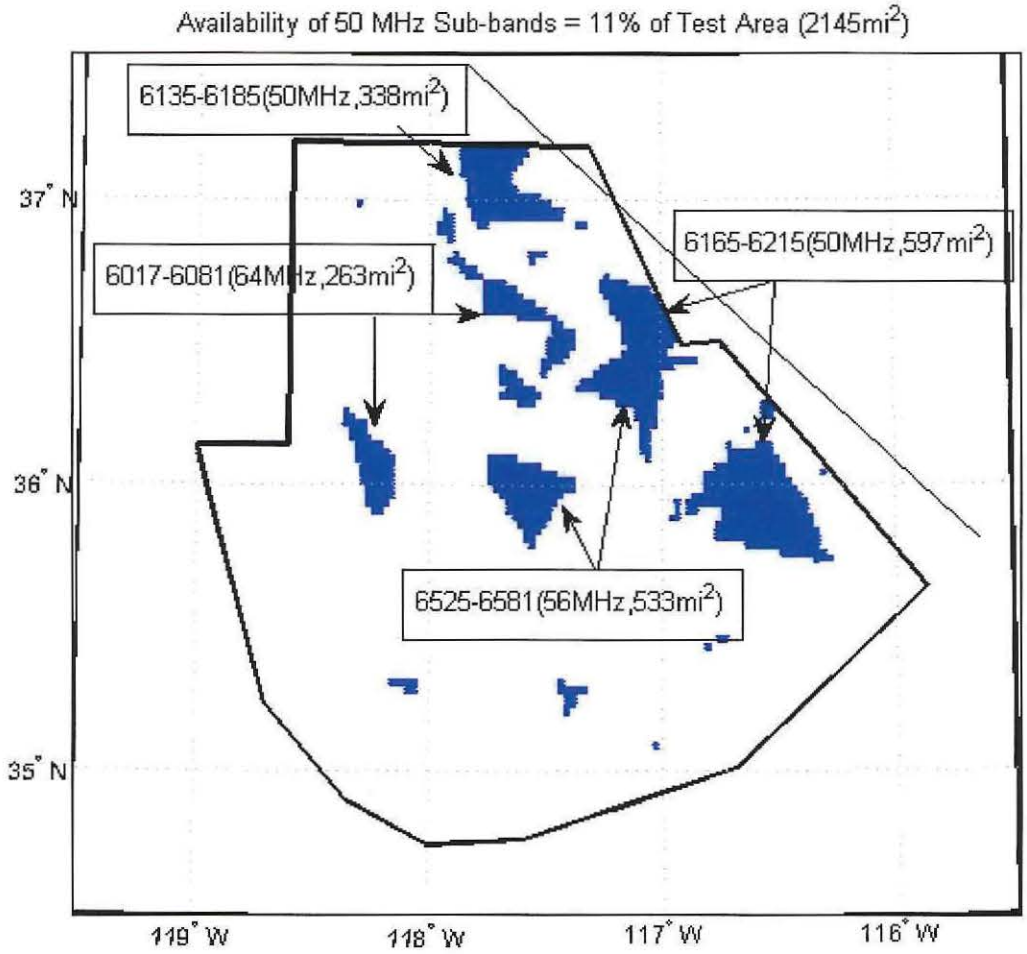


Table 4. Size of Sub-Areas where at Least 50 MHz Contiguous Bandwidth is Available

Sub-Band (MHz)		BW (MHz)	Area(mi^2)	% Test Area
6165	6215	50	597.50	3.105
6525	6581	56	533.10	2.770
6135	6185	50	338.15	1.757
6532	6589	57	275.31	1.431
6017	6081	64	262.70	1.365
6133	6183	50	196.18	1.019
6298	6361	63	190.80	0.991
6123	6182	59	188.95	0.982
6106	6172	66	186.48	0.969
6540	6591	51	178.58	0.928
6167	6223	56	175.71	0.913
6166	6216	50	118.02	0.613
6221	6274	53	115.16	0.598
6076	6133	57	91.27	0.474
6312	6362	50	89.29	0.464
6134	6184	50	88.65	0.461
6009	6066	57	72.38	0.376
6084	6139	55	67.32	0.350
6269	6333	64	60.07	0.312
6313	6363	50	55.67	0.289
6068	6125	57	50.45	0.262
6002	6058	56	48.40	0.251
6209	6270	61	40.81	0.212
6639	6691	52	38.69	0.201
6201	6258	57	33.61	0.175
6147	6213	66	28.83	0.150
6090	6140	50	26.45	0.137
6542	6601	59	26.43	0.137

Figure 9. Areas where at least 40 MHz sub-bands are available

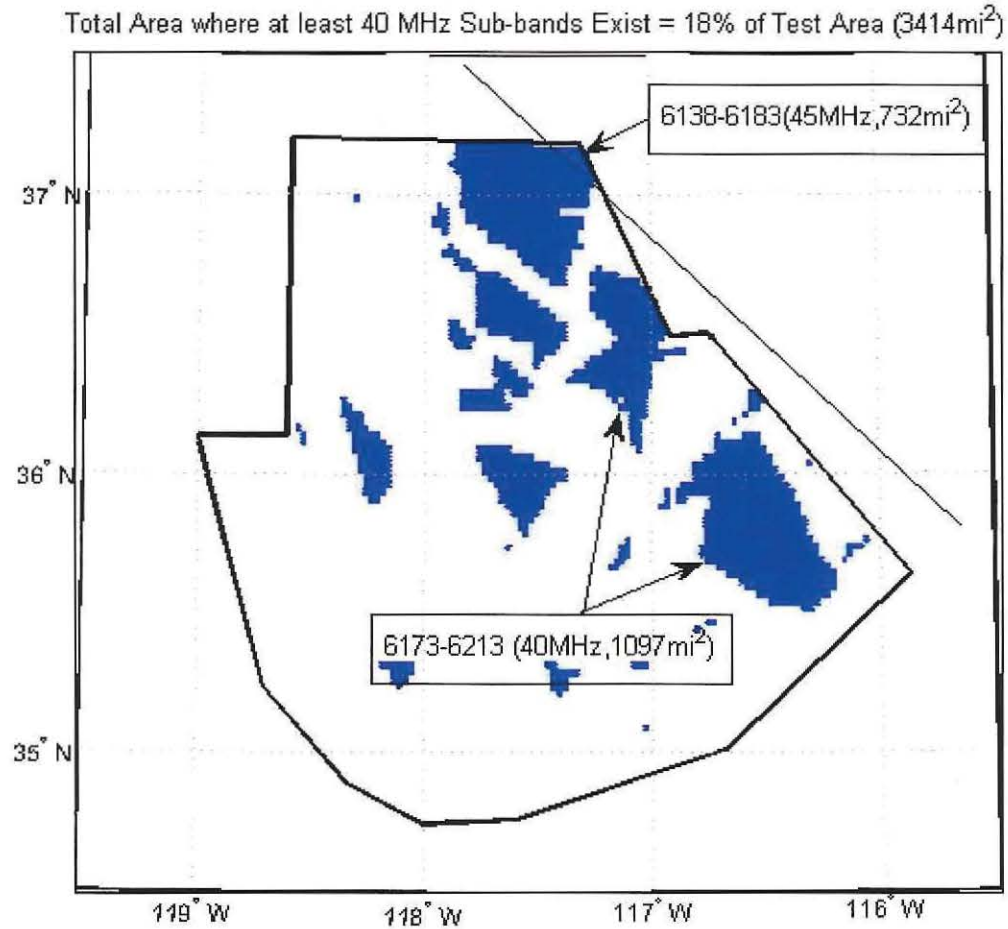


Table 5. Size of Sub-Areas where at Least 40 MHz Contiguous Bandwidth is Available

Sub-Band (MHz)		BW (MHz)	Area(mi^2)	% Test Area
6173	6213	40	1097.08	5.700
6167	6212	45	1089.79	5.663
6174	6215	41	1070.66	5.563
6138	6183	45	732.38	3.805
6135	6177	42	727.60	3.781
6165	6206	41	621.52	3.229
6525	6581	56	533.10	2.770
6106	6148	42	452.15	2.349
6017	6060	43	394.85	2.052
6549	6589	40	385.87	2.005
6144	6185	41	342.93	1.782
6547	6588	41	292.31	1.519
6550	6591	41	284.31	1.477
6542	6586	44	275.31	1.431
6021	6081	60	262.70	1.365
6123	6172	49	198.69	1.032
6320	6361	41	198.12	1.029
6133	6174	41	196.18	1.019
6298	6359	61	190.80	0.991
6109	6162	53	186.48	0.969
6176	6223	47	175.71	0.913
6559	6601	42	125.00	0.649
6221	6274	53	115.16	0.598
6076	6133	57	91.27	0.474
6322	6362	40	89.29	0.464
6098	6139	41	76.88	0.399
6009	6056	47	72.38	0.376
6147	6193	46	72.04	0.374

Figure 10. Areas where at least 30 MHz sub-bands are available

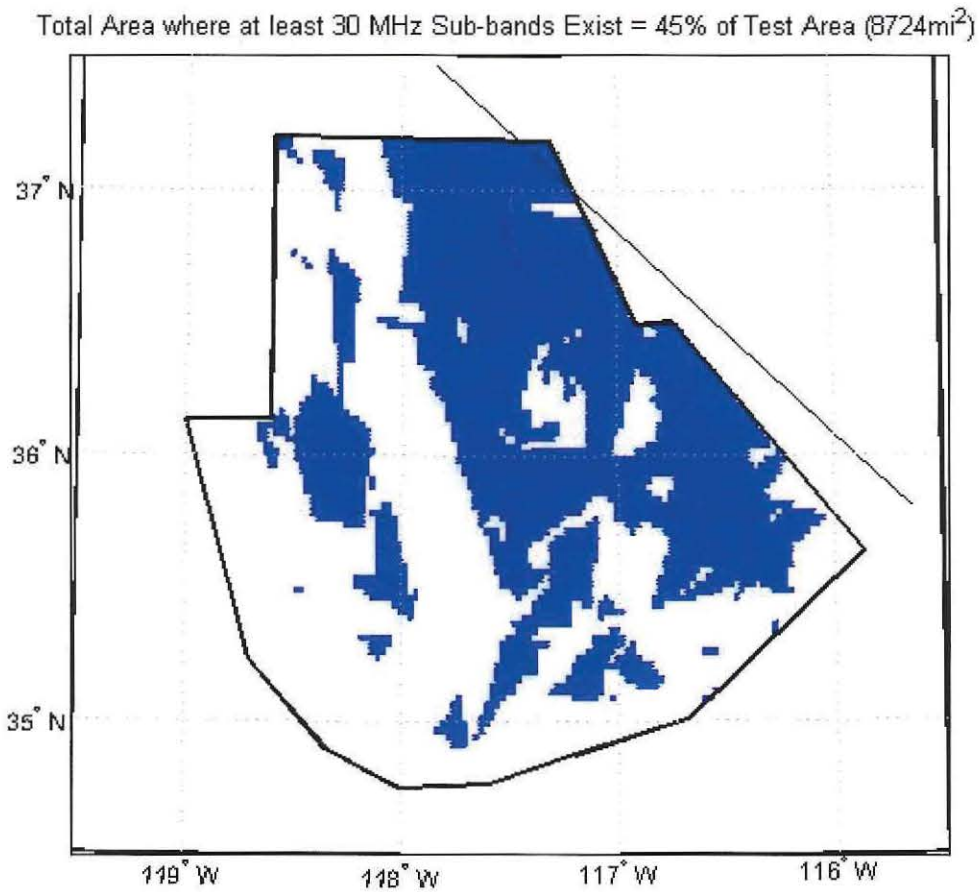


Table 6. Size of Sub-Areas where at Least 30 MHz Contiguous Bandwidth is Available

Sub-Band (MHz)		BW (MHz)	Area(mi^2)	% Test Area
6549	6581	32	2201.66	11.440
6106	6139	33	1673.90	8.698
6528	6561	33	1478.75	7.684
6525	6557	32	1413.07	7.342
6148	6183	35	1212.10	6.298
6559	6589	30	1195.82	6.213
6547	6578	31	1137.48	5.910
6173	6213	40	1097.08	5.700
6167	6202	35	1089.79	5.663
6110	6140	30	1072.75	5.574
6184	6215	31	1070.66	5.563
6138	6172	34	1069.90	5.559
6017	6052	35	1042.17	5.415
6560	6591	31	978.36	5.084
6147	6177	30	964.00	5.009
6135	6167	32	886.19	4.605
6557	6588	31	870.11	4.521
6046	6081	35	828.90	4.307
6298	6333	35	789.01	4.100
6154	6185	31	747.01	3.881
6143	6176	33	732.38	3.805
6328	6361	33	680.80	3.537
6165	6196	31	621.52	3.229
6111	6143	32	579.89	3.013
6532	6576	44	533.10	2.770
5925	5963	38	500.94	2.603
6114	6148	34	452.15	2.349
6552	6583	31	417.47	2.169

Figure 11. Areas where at least 20 MHz sub-bands are available

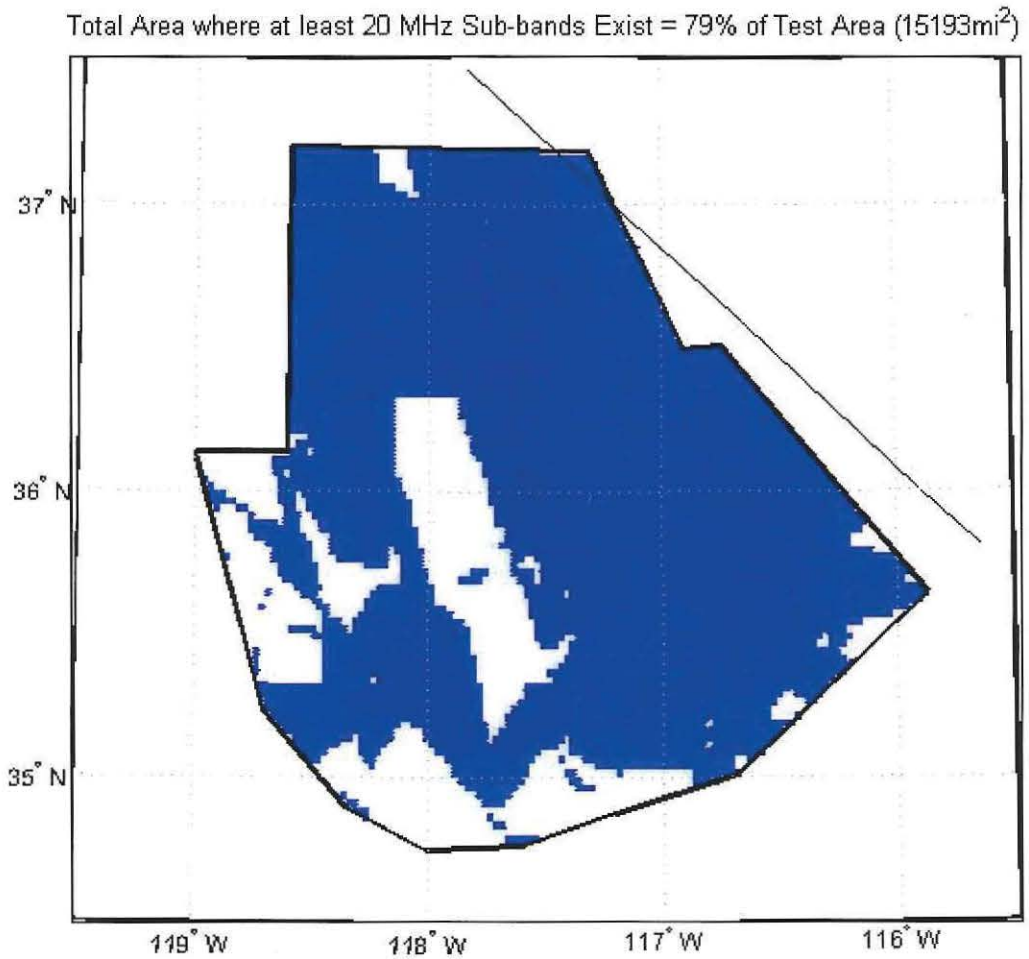


Table 7. Size of Sub-Areas where at Least 20 MHz Contiguous Bandwidth is Available

Sub-Band (MHz)		BW (MHz)	Area(mi^2)	% Test Area
6165	6185	20	7310.41	37.985
6559	6581	22	6990.95	36.325
6528	6548	20	4639.19	24.105
6529	6549	20	4553.55	23.660
6530	6551	21	4486.79	23.313
6525	6547	22	4446.91	23.106
6557	6578	21	3486.11	18.114
6554	6576	22	2426.73	12.609
6569	6589	20	2354.08	12.232
6552	6573	21	2206.43	11.465
6549	6571	22	2201.66	11.440
6157	6183	26	2093.31	10.877
6570	6591	21	2059.24	10.700
6532	6552	20	1836.23	9.541
6106	6128	22	1813.19	9.421
6113	6133	20	1767.47	9.184
6111	6132	21	1753.08	9.109
6109	6130	21	1743.34	9.058
6533	6553	20	1743.21	9.058
6114	6139	25	1693.24	8.798
6148	6172	24	1689.01	8.776
6629	6651	22	1511.96	7.856
6173	6193	20	1489.87	7.741
6138	6158	20	1484.73	7.715
6167	6192	25	1482.58	7.703
6534	6561	27	1478.75	7.684
6147	6167	20	1440.91	7.487
6135	6157	22	1301.03	6.760