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February 23, 2009

Ms. Marlene S. Dortch
Secretary
Federal Communications Commission
445 12th Street, S.W.
Washington, D.C. 20554

Re: ET Docket No. 08-59
<u>Ex Parte Statement</u>

Dear Ms. Dortch:

Submitted herewith, on behalf of Aerospace and Flight Test Radio Coordinating Council, is an ex parte submission for association with the above-referenced docket.

Any questions regarding this matter may be directed to the undersigned.

Respectfully submitted

William K Keane

William K. Keane
Counsel for AFTRCC

Enclosures

AFTRCC

AEROSPACE & FLIGHT TEST RADIO COORDINATING COUNCIL®

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February 23, 2009

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

Re: ET Docket No. 08-59
Ex Parte Statement

Dear Ms. Dortch:

Over the course of recent months, Aerospace and Flight Test Radio Coordinating Council ("AFTRCC") has commissioned a series of laboratory and field tests to evaluate further the risk of interference from body sensor network ("BSN") devices, to aeronautical mobile telemetry receivers. Those tests have been conducted by the Johns Hopkins Applied Physics Laboratory (APL) at the Naval Air Weapons Center, Aircraft Division (the Patuxent River Naval Air Test Center).

The methodology and results of the tests are detailed in the Test Report attached hereto, and summarized herein. In addition, this filing addresses several misconceptions and misstatements set forth in General Electric Healthcare ("GEH") filings.

Before discussing the test results it is important to clarify the record in this proceeding: Contrary to GEH's assertions, the issues in this proceeding have not been narrowed to the point where a notice of proposed rulemaking is appropriate.[1] On the contrary, there remain major points of disagreement, the materiality of which call into question the very premises for an allocation proceeding as sought by GEH.

First, take GEH's proposal to specify geographic exclusion zones around each flight test site, to require coordination and registration of BSNs, and to limit operation to fixed locations.[2] GEH has made no showing that exclusion zones are practical or enforceable. Based on the APL tests, it is clear that any exclusion zones would have to be very large (radio line of sight). Zones of this size would eliminate major metropolitan areas proximate to flight test centers as markets for BSN devices. This in turn calls into question the enforceability of any such zones, and indeed the very feasibility of the proposal.

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[1] GEH ex parte filed February 19, 2009.
[2] GEH ex parte filed November 7, 2008, Report at 7-9.

Beyond this, GEH has offered no showing as to how exclusion zones could work given the fact that aerospace manufacturers and the Military Departments make regular use of mobile telemetry vans and portable telemetry facilities. These mobile facilities are in addition to fixed telemetry sites. GEH's specious claim that exclusion zones can provide a measure of protection for BSNs and telemetry operations is thus wholly without merit. The Commission should not consider a proposal for claimed protection of primary facilities that cannot begin to protect those facilities.

Second, there is an issue even more basic: The spectrum requirement. To this point, GEH has done little more than offer conclusory statements seeking to justify its desire for spectrum, let alone a four-fold increase from its first to its second proposal, i.e. from 5-10 MHz initially[3], to 20-40 MHz currently. A spectrum requirement study is the first, essential step in any serious allocation proposal yet, to this point, GEH has offered little more than summary Power Points in support.

The spectrum requirement issue becomes even more important given the APL analysis suggesting that BSNs could be accommodated compatibly in only 10 MHz of spectrum without the regulatory problems inherent with exclusion zones, and without the risks of trying to mix two safety services, one with noise-limited high gain antennas, and the other consisting of interference-limited, no-gain consumer devices. A combination of 2300-2305 and 2395-2400 MHz, for example, would provide GEH with 10 MHz of usable spectrum, representing a major increase in the amount available for the purpose. Such a result would ensure protection of AMT as against BSNs, and the protection of BSNs as against transmitting test aircraft and high power, omnidirectional iNet uplinks.[4]

For these and the other reasons discussed below, AFTRCC urges that the Commission not issue an NPRM until a detailed analysis is conducted by GEH of its spectrum requirement, and thereafter, consideration is given to possible spectrum solutions. Based on a searching assessment of that analysis, a determination can then be made as to whether adoption of an NPRM would be potentially useful, or would continue to divert resources on a proposal that is at present neither justified by its proponent, nor appropriate from a spectrum management perspective.

Background

In its effort to secure a spectrum allocation in a band Restricted exclusively for flight test communications within the meaning of Rule 15.205, GEH has claimed that, even though its BSNs would cause interference to flight test telemetry, the probability of such interference is low and that, in any event, the flight test community can work around it. GEH argues that flight

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[3] GEH Reply Comments filed December 4, 2006 in ET Docket No. 06-135 at 6 (only 5-10 MHz would be needed "*after* taking into account spectrum that may be in use by incumbent spectrum users at any point in time and thereby not available for BSN communications") (emphasis in original). GEH also stated that it could utilize disconnected pieces of spectrum as long as the pieces were not separated by more than 150 MHz. *Id.*

[4] GEH itself has previously identified these and other bands as potential candidates. GEH Reply Comments filed December 4, 2006 in ET Docket No. 06-135 at 7-12.

testing experiences out-of-band emissions from Part 15 devices operating in the 2.4 GHz band with signal strengths greater than GEH's proposed BSNs; that aeronautical mobile telemetry links display excess margin; and that ITU-R Recommendation M.1459 is overly-stringent.

GEH further claims that the risk of interference to flight test telemetry must be based on a probabilistic approach; that GEH has done such an analysis with "overly-conservative operational parameters;"[5] and that, based on this analysis, there is negligible risk of interference to AMT.

Probability Analysis is Inappropriate.

GEH's probability-based analysis is wholly inappropriate in trying to determine compatibility between flight-test telemetry operations, a safety service, and BSNs. First, the Commission itself has used static analysis when assessing the risk of interference from one technology to another. Most recently, for example, the Office of Engineering and Technology conducted a careful series of tests designed to assess the risk of interference from proposed time-division duplex operations in the AWS-3 band to incumbent operations in the adjacent AWS-1 band. Those tests expressly recognized and relied upon a static case analysis, rather than the probability approach espoused by GEH.[6] The static case approach is even more appropriate here given the fact that flight testing involves safety of flight communications, a fact that GEH fails to recognize.

Flight test telemetry exists to enhance safety in a high-risk enterprise. The Commission has acknowledged this on repeated occasions. In 1984 the Commission stated that flight test telemetry "involves the safety of life and property" and acted "to protect this safety service from harmful interference that could result in loss of life."[7]

In 1989, the Commission determined that the telemetry bands should be classified as Restricted and protected from fundamental emissions of unlicensed devices (such as, effectively, BSNs which would be licensed merely by Rule). In so doing the agency stressed that the telemetry band "involv[es] safety of life."[8]

In 1990, the Commission explained:

> "[S]haring of [flight test] frequencies with unlike services is difficult at best because schedules of telemetry flight tests are unpredictable and delays costly. Further, interference cannot be

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[5] Paul Kolodzy letter dated October 20, 2008 ("October 20 ex parte").

[6] Advanced Wireless Service Interference Test Results and Analysis, October 10, 2008, at note 8.

[7] *In the Matter of Amendment of Part 2 of the Commission's Rules Regarding Implementation of the Final Acts of the World Administrative Radio Conference, Geneva*, 1979. FCC 84-306, released July 2, 1984, at 2 (emphasis added).

[8] *In the Matter of Revision of Part 15 of the Rules Regarding the Operation of Radio Frequency Devices Without an Individual License*, 4 FCC Rcd 3493, 3502 (1989) (emphasis added).

> tolerated. For example, in the event of a crash the telemetry data may be the only means available to determine the cause of the crash. In this case, interference to the telemetry transmission could be disastrous."[9]

The Commission likewise concluded that secondary use of flight test frequencies for air shows could result in significant harmful interference "impair[ing] the efficiency and safety of the flight test industry."[10]

Finally, the Commission has determined that

> "[F]light test, telemetry, and telecommand operations are vital to the U.S. aerospace industry to produce, deliver, and operate safe and efficient aircraft and space vehicles. Because the nature of the BSS (Sound) operations is 24 hour a day ... and the test and telemetry operations are in the proximity of many major metropolitan areas, we believe, as AFTRCC asserts, that the BSS (Sound) transmissions will cause interference to these operations and threaten safety of life and property. Consequently, we do not believe it is feasible to share aeronautical mobile telemetering frequencies with BSS (Sound) or terrestrial broadcasting systems."[11]

In other words, GEH's use of a Monte Carlo analysis is misguided and irrelevant. The issue is not how often BSNs would interfere, but whether interference from BSNs would cause harmful interference risking a potentially catastrophic event.[12] And it is clear from the test results described below, that this would be the case.

The APL Tests

APL's tests entailed multiple steps beginning with a review of wireless medical telemetry literature; the design of BSN devices utilizing chips manufactured by a vendor whose product GEH has previously endorsed; the validation of device performance in APL's laboratory; and

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[9] *Amendment of the Frequency Allocation and Aviation Services Rules (Parts 2 and 87) to Provide Frequencies for Use by Commercial Space Launch Vehicles*, 5 FCC Rcd 493, 495 (1990) (emphasis added).

[10] *In the Matter of Petition to Amend Part 87 of the Commission's Rules to Allot VHF Aeronautical Frequencies for the Coordination of Air Show Events*, Order, DA 90-957, 5 FCC Rcd 4641, 4642 (1990) (emphasis added).

[11] *Second Notice of Inquiry in GEN. Docket No. 89-554, In the Matter of An Inquiry Relating to Preparation for the International Telecommunication Union World Administrative Radio Conference for Dealing with Frequency Allocations in Certain Parts of the Spectrum,* FCC 90-316, 5 FCC Rcd 6046, 6060, para. 101 (1990) (emphasis added). The Commission even went on to say that "We have previously determined that aeronautical flight test and telemetry operations should not share spectrum with unlicensed devices because of the threat to safety of life." *Id*. at 6061 para. 102.

[12] Rule 2.1 (defining harmful interference).

field tests conducted at different times, on different days, in different months, and under different operating conditions (outdoors, indoors, through foliage, etc.). In the process, steps were also taken to gauge the effects on the noise floor from the claimed presence of out-of-band signals under these varying conditions.

The tests were conducted under the supervision of Daniel G. Jablonski, Ph.D. Dr. Jablonski has extensive experience in the design and development of RF devices and software-controlled circuitry, as well as in the practice and techniques of flight test telemetry.

The BSN devices developed at APL used the same Nordic Semiconductor chips as proposed by GEH in earlier filings. The tests revealed that signals from these devices are easily detected at long distances by AMT receive stations -- even through foliage, vehicles, and buildings. BSN content can be read by AMT receive dishes at two miles and BSN interference was easily detected at 12 miles.

GEH's probability analysis is inappropriate for yet another reason. It rests on the premise that AMT systems are interference-limited (i.e. that their performance is a function of their ability to operate in the presence of interference sources), rather than noise-limited (meaning that their performance is a function solely of the noise-generating characteristics of the receiver itself).

The problem with GEH's theoretical argument is that it is contradicted by the long-standing, real-world experience of flight test professionals. Measurements taken by Dr. Jablonski at Patuxent River under a wide variety of optimal and sub-optimal conditions, corroborate his experience that shows the band is not interference-limited.

AFTRCC is not saying that emissions from out-of-band sources are never a problem. Such interference has occurred but when it does, it is normally at the top end of the band, namely 2390-2400 MHz, which has served in effective as a guard band for telemetry operations utilizing the band 2360-2390 MHz. In other words, the S-band is generally free of interference from unlicensed devices operating in the 2400 MHz to 2483 MHz ISM band (consistent with the notion that this is a Restricted Band).

Responses to Other GEH Points

GEH's assertions about AMT links having "excess margin" reflect another fundamental misconception.[13] As the Engineering Statement explains, the flight test link margin is essential to compensate for fading and multipath when test aircraft are maneuvering at long range. During those maneuvers the signal strength received at the dish antenna is subject to fluctuations on the order of 20 – 30 dB. Thus, the margin established in ITU-R Rec. M.1459 is essential for safety. It is not available for parties seeking to demonstrate compatibility.

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[13] GEH November 7 ex parte at 3rd page

GEH argues that "AFTRCC's comments regarding the proximity of some government test sites to populated areas are misleading" and references a United States contribution to an ITU-R Working Party where it was said that "flight tests are typically conducted over sparsely populated areas."[14]

There was nothing inconsistent, much less misleading, in AFTRCC's reference to the proximity of the named government test sites to populated areas test centers: On the contrary, the contribution cited by GEH references the very same sites previously named by AFTRCC as being proximate to populated areas, i.e. "Panama City, Florida; Wichita, Kansas; Seattle, Washington; and St. Louis, Missouri."[15]

More basically, GEH's criticism misses the point: The issue is not where the test aircraft maneuvers are conducted; the issue is where the telemetry transmitted by the aircraft during those maneuvers is received. The liaison statement, and AFTRCC's ex partes, are entirely consistent in noting the proximity of major flight test centers to metropolitan areas. The risk of interference from BSNs to extraordinarily sensitive telemetry receivers located at those centers, and interference from flight test aircraft on taxi, take-off, and landing to BSNs, is real.

GEH references alternatives to flight test telemetry, such as on-board recording, as tools to mitigate AMT failures due to interference, and suggests that new technologies such as iNet will "enable use of less spectrum."[16] However, AFTRCC has explained in detail exactly why on-board recording is no substitute for real-time telemetry.[17] Among other things, recording is frequently not suitable for tactical aircraft or missiles that do not have the space, weight budget, or power supply to support on-board recorders. Moreover, real-time telemetry enables manufacturers to minimize the number of personnel aboard larger aircraft during tests, a significant safety factor. Importantly, real-time telemetry also provides a capability which recording can not: Disaster analysis. In the event an aircraft is lost, real-time telemetry transmitted via the S-band enables engineers to reconstruct the cause, and make modifications to prevent a recurrence. GEH does not address these points.

GEH's references iNet, the new uplink technology under development for flight testing. The driver for iNet is the need to achieve further efficiency of spectrum use in the face of exponentially increasing telemetry data rates -- not free up spectrum for other users. GEH's assertions that "no concrete timetable"[18] has been established for iNet is likewise baseless:

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[14] GEH September 18 ex parte at 6.

[15] Panama City, FL as referenced in the U.S. response, and Eglin and Tyndall Air Force Bases as referenced by AFTRCC in its ex parte, are essentially the same.

[16] AFTRCC July 28 ex parte at 5.

[17] *See* AFTRCC July 28 ex parte at 3-4.

[18] GEH September 18 ex parte at 8.

Uplink operations are to be deployed within the next four years, and when they are, they will significantly complicate GEH's optimistic sharing scenario.[19]

GEH argues that the purported low chance of interference to AMT as referenced in its June 11 Reply Comments was "realistic," and that AFTRCC's rebuttal, by contrast, was not.[20] Unmentioned by GEH is the fact that up until its filing of September 18, it had not attempted to make allowance for the presence of more than one BSN -- despite the professed business plan for anywhere, anytime use geared to patient mobility.

GEH cites a draft report by CEPT's Electronic Communications Committee for the proposition that wireless microphones can co-exist with L-band AMT at separation distances of 1.5 and 6.0 km in suburban and rural areas, respectively, and with no separation at all in urban areas. [21]

When viewed in context, these results depend critically on assumptions about building attenuation that are at best speculative, and more likely incorrect. Specifically, GEH cites only the simulation results that assume 30 dB of building attenuation, while neglecting to report the results, contained in the very same table of the report, for attenuation values of 6 dB. The latter provide minimum separation distances for suburban and rural settings of 8 and 28 km, respectively.[22]

Moreover, the report assumes that AMT links have bandwidths of 1 MHz, which might be typical for Europe. AMT channel bandwidths of 5 MHz are typical in the United States. To assess the impact of this difference requires analysis of assumed wireless microphone deployment across L-band (vs. S-band) AMT channels, none of which is addressed in the report. As the APL Report notes, the channel bandwidth difference alone would make for a 7 dB difference between GEH's conclusions based on the report, and the real impact.

Most importantly, the ECC report rests entirely on simulations. By contrast, the test results described in the attached Report are based on real-world measurements.

GEH makes a number of criticisms of the tests conducted previously by Learjet such as that the results exceed theoretical free-space propagation (September 18 ex parte at 13), that no allowance was made for a non-continuous signal a BSN would display (*id*. at 14), and that AFTRCC has mischaracterized the test results (*id*. at 15).[23] However, the recent tests confirm the validity of the conclusions drawn from the Learjet tests; namely, that there is a distinct risk of destructive interference from the proposed co-channel BSN devices. The measurements also

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[19] GEH asserts that omnidirectional high-power uplinks per iNet are "strikingly incompatible with the stringent PFD standards AFTRCC seeks to apply to MBANS devices ...." GEH September 18 ex parte at note 28. Among other things, however, iNet uplinks will typically not operate co-channel with iNet downlinks.

[20] GEH September 18 ex parte at 11.

[21] GEH September 18 ex parte at 12.

[22] See November 7 ex parte, Report at p. 29.

[23] The Learjet tests involved simultaneous measurement of aircraft telemetry signals and interfering signals.

illustrate the well-understood notion that interference is a function of the total received power in the bandwidth of the victim receiver, independent of modulation, for example.

A few additional concerns regarding exclusion zones. While GEH offers to limit use to fixed locations (e.g. "hospitals and health care facilities"),[24] it also suggests that future use would expand beyond health care facilities.[25] While GEH might be prepared to offer further assurances on this point, the record at present suggests such an expansion. This would certainly be consistent with GEH's prior filings which contemplated anytime/anywhere use.

Other problems too arise including a fail-safe means of enforcement to protect both sets of safety-related, co-channel users (AMT and BSNs) such that patients do not wander into exclusion zones and cause interference to AMT, on one hand, or lose medical telemetry vital to their health and well-being due to interference from AMT, on the other hand. Merely writing rules, or requiring coordination/registration, is completely inadequate.

This is particularly the case given that the track record of hospitals in complying with spectrum protocols is not good -- a well-known fact which GEH itself has conceded. Just a year ago, GEH stated that "Licensees familiar with the FCC, its requirements and processes understand the differences between primary and secondary use, healthcare facilities generally do not."[26] GEH went on to argue that, "health care facility personnel will not understand that they have only secondary status on certain frequencies."[27]

With health care providers not understanding what secondary status means for their own protection, it is not difficult to gauge the level of any understanding they might have of an obligation to protect other users. This applies even more so to patients who may be discharged from a hospital with instructions to wear a BSN for a week or so, and who will travel to and from their homes and places of work without any regard for, or means to know, when they are about to enter or leave a keep-out zone.[28]

GEH's analogy to coordination of Wireless Medical Telemetry Service devices at 1.4 GHz is unavailing. Unlike a utility meter, interference to flight test telemetry from a GEH medical device, and the resulting loss of flight test data, can not only require costly re-flights to clear a set of test points, but puts at risk safety-of-flight communications. The converse is also

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[24] September 18 ex parte at 2.

[25] *Ibid* (only the "more important [and] immediate ... use of MBANS devices would be in hospitals and health care facilities") (emphasis added).

[26] Reply Comments of GE Healthcare filed September 11, 2007 in WT-Docket No. 07-100 at page 4 (quoting with favor from Comments of the Land Mobile Communications Council; emphasis added).

[27] *Id.* at page 5.

[28] The fact that GEH has taken pains to disavow any responsibility for compliance by its hospital customers with FCC coordination requirements, underscores these concerns. *Id.* at 2-3 (GEH opposes "a binding obligation on equipment manufacturers" to register the equipment they sell hospitals on the grounds that hospitals should have responsibility).

true inasmuch as AMT interference to patient telemetry can jeopardize what GEH itself has characterized as "life-critical" communications.[29]

* * *

GEH has failed to justify its spectrum requirement. It has also failed to demonstrate compatibility with flight testing. Other bands are available -- AFTRCC has identified some of them -- as viable candidates for GEH's proposal. None of these bands present threats to the safety of test pilots, to the certification of aircraft, or to the productivity of aerospace manufacturers. None involve threats to life-critical patient telemetry. None involve a requirement that two safety services seek to share with each other, or a mismatch between noise-limited systems using high gain antennas, and interference-limited, consumer-based systems.

For all of these reasons, it would be inappropriate and wasteful to adopt an NPRM that considers a secondary allocation for BSNs in any portion of the 2360-2395 MHz band.

Respectfully submitted,
Darryl J. Holtmeyer
by WKK
Darryl J. Holtmeyer
Chairman

cc. The Honorable Michael J. Copps
The Honorable Jonathan S. Adelstein
The Honorable Robert M. McDowell
Bruce Gottlieb
Paul Murray
Renee Crittendon
Angela Giancarlo
Julius Knapp
Bruce Romano
Geraldine Matise
Gary Thayer
Mark Settle

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[29] GEH ex parte Comments filed December 27, 2007 in ET Docket No. 06-135, at 7 ("BSNs must be capable of reliably conveying unprocessed life-critical monitoring data"); *accord* GEH ex parte filed July 25, 2007 in ET Docket No. 06-135 at 14; GEH Comments filed October 31, 2006 in ET Docket No. 06-135 at 8.

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Test Report

Measurements of Co-channel Interference to Aeronautical Mobile Telemetry Systems from Devices Using Nordic Semiconductor Transceiver Chips

By: Daniel G. Jablonski, Ph.D.
Principal Investigator

SPACE DEPARTMENT
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I. Introduction and Summary

In recent months, Johns Hopkins University Applied Physics Laboratory (APL) engineers have conducted further tests designed to ascertain whether there is a risk of interference from Body Sensor Network (BSN) devices proposed by General Electric Healthcare (GEH). The test results validate earlier points made by the Aerospace and Flight Test Radio Coordinating Council (AFTRCC) about the significant risk of interference from BSN-type devices.

- AMT Noise measurements have been made on several days, and at several times of day using a variety of antennas and receivers.
- Interference testing in the laboratory has been performed using the commercial transceiver chips proposed by GEH in their earlier filings. The tests demonstrate the equivalence, in terms of interference measurements, of these BSN devices to the signal generators used in the previous AFTRCC tests at Wichita. As expected, the specific details of the modulation techniques used are of no consequence to the interference measurements, despite GEH claims to the contrary.
- Range measurements of the interference of these BSN devices to AMT ground stations have been performed at the Naval Air Weapons Center, Aircraft Division, at Patuxent River, Maryland on several different occasions. Preparation for these tests required hardware and software changes to enable the BSN devices to operate in the AMT band under conditions that represent accurately the body sensor networks proposed by GEH. To our knowledge, GEH has not performed similar tests.

In summary, the test results reveal that there is in fact a significant risk of interference from co-channel BSN devices to sensitive flight test telemetry receive systems with their low noise receivers and high gain antennas. The test results also confirm and corroborate the results of earlier tests conducted by Learjet and Cessna at the Wichita Mid-Continent Airport.

During the course of this testing, data were also gathered relative to the argument that the flight test spectrum from 2360 MHz to 2390 MHz experiences extensive out of band emissions from, for example, wireless ISM devices located in the band 2400 MHz and up. However, the results obtained by APL indicate that any interference from ISM devices does not raise the noise floor. This is consistent with the long term experience of flight test engineers, which is that any noise from ISM devices is generally limited to the portion of the band from 2390 - 2400 MHz.

With respect to GEH's filed comments, its arguments and data concerning spurious emissions from ISM and other devices into the AMT band do not distinguish between out-of-band emissions and out-of-band spurs. Consequently, its, comments overstate the impact of a finite number of narrowband spurs by suggesting that such spurs represent a broadband increase in the noise floor across an entire 5 MHz AMT channel. Nor does GEH acknowledge that the 500 microvolt per meter maximum allowable electric field from an ISM device into an adjacent band, when equated to an equivalent radiated power level, is fully 40 dB below the 1 milliWatt radiated power proposed by GEH for their BSN devices.[1]

To a first approximation, the propagation conditions between ISM devices and AMT sites, and between BSN networks and AMT sites, are essentially the same (i.e., indoors/outdoors, and urban, suburban, or rural). Thus, claiming that spurious emissions from ISM devices are significant, while co-channel interference from BSN devices operating at a power level that is 10,000 times higher is not, is an oxymoron. Put differently, the same propagation conditions that presumably would favor interference from ISM devices cannot then be claimed to mitigate interference from devices operating at significantly higher power levels. As will be shown, the same contradiction exists when GEH introduces results from a report dealing with wireless microphones operating in a flight test band. Both of these topics are discussed in depth in subsequent sections of this report.

The Monte Carlo analyses presented by GEH do not properly account for the fact that even a short-term interfering signal has a long-term impact on the integrity of the flight test data link. Thus, the arbitrary assumption that 1% interference to AMT is acceptable ignores the fact that 1% interference can result in 10 - 100% loss of service, resulting in the need to abort, then repeat, flight test segments that are complex, lengthy, expensive, and dangerous, such as a “flutter dive.”

Finally, GEH is asking for several tens of Megahertz of new spectrum for what is essentially a low data rate application. When the body of documentation submitted by GEH is considered in its entirety, it becomes apparent that the driving force for the request for this large amount of spectrum is the desire, by GEH, to implement BSN devices using coin-sized batteries that have limited energy capacity.

By its own admission, the 40 MHz requested by GEH will be in use only 25% of the time.[2] Thus, by making a simple adjustment to the bit rate of their proposed BSN devices, from 1 Mbps to 250 kbps,[3] BSN networks can operate at the same level of total network performance, but using only 10 MHz of spectrum.

The increase in duty cycle of individual BSN devices will increase battery drain. However, a slight increase in battery size for a BSN (from a single coin-size cell to a pair of AAAA-size cells) will compensate for this. The remaining 10 MHz of required spectrum for BSN networks can be met by use of the bands 2300 – 2305 MHz and 2395 – 2400 MHz, without the need to use the AMT band. As always, the complete, adjacent 100 MHz ISM band, with no constraints, is also available for unlicensed use by BSN networks.

In the sections that follow, laboratory and range testing of BSN devices is described in detail. Noise floor measurements are presented. The interpretation of the Monte Carlo

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[1] FCC Rule 15.209 limits the maximum electric field in a 1 MHz bandwidth for spurious emissions from an ISM device into a restricted band to a value of 500 microvolts per meter at a distance of 3 meters. This equates to an effective isotropic radiated power for the device of -70 dBW, which is 40 dB less than the -30 dBW EIRP proposed by GEH for its devices.

[2] September 18, 2008 GEH ex parte, Appendix A, page 3.

[3] This modification requires no change to GEH’s proposed use of currently available commercial wireless devices.

results submitted by GEH to the Commission is refuted. The report concludes with a discussion of the comments by GEH pertaining to the ECC report on wireless microphones, and various and sundry points raised in GEH filings submitted as part of the current proceeding.

II. BSN tests

In response to criticisms of the use of laboratory signal generators, APL has conducted an extensive and time-consuming series of tests. These have involved numerous laboratory and field trials, conducted over several months in different locations, under different conditions, and using a variety of AMT antennas and receivers. Support from multiple test engineers was required, and there were extensive practical challenges, including the fact that test points separated by the Chesapeake Bay are 12 miles apart by air, but 150 miles apart by automobile.

Furthermore, testing had to be conducted around busy flight test schedules and with deference to winter weather conditions, which in this region are often unfriendly to those working outdoors.

The tests required obtaining, then modifying hardware components and software modules in order to develop practical BSN devices using the technology previously suggested by GEH, namely the transceiver chips manufactured by Nordic Semiconductor. A thorough review of the technical literature was undertaken in order to identify processors, programming language modules, compilers, suitable surface mount crystals, programming devices, bootloader software, reverse polarity connectors, and other specialized apparatus and equipment needed to conduct the trials. Procurement, programming, and debugging activities required the usual extended periods of time typical of a test and measurement effort. In particular, hardware and software modifications were made to enable operation in the 2360 – 2390 MHz AMT band of devices designed for use in the 2.4 GHz ISM band. (Although in recent filings, GEH refers to as yet un-built devices to be marketed by Texas Instruments, the Nordic NRF24L01 family of devices seems quite appropriate for conducting the tests at hand, and there is no reason to think that the physics of the situation will change if and when TI devices become available.)

Using the modified Nordic devices, interfaced to personal computers via microcontrollers from the Microchip Technology, Inc. “PIC” family of devices, BSN-like transmitters and receivers were built, implemented, and tested. The tests include laboratory measurements to verify that, as expected, the specific modulation techniques are of little consequence -- contrary to GEH’s prior arguments.[4] In particular, the BSN circuits modulated at 1 MBPS produce the same interference to an AMT receiver as does a continuous wave (CW) signal of the same power produced by a laboratory generator. Aggregate effects of multiple BSN transmitters operating simultaneously at different frequencies within a single 5 MHz wide AMT channel obey the laws of superposition. Again, this is the expected result.

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[4] See September 18, 2009 ex parte at 14 (referencing technical incorrectness of AFTRCC statement).

APL then undertook additional field tests to measure the interference of these devices to real AMT systems with BSN-to-AMT separation distances of several miles; with BSNs operating inside buildings and automobiles; and with BSNs separated from the high gain, AMT receive antennas by foliage, varying terrain, and even open water. The interfering devices used in the tests have the performance characteristics of the BSN devices proposed by GEH (1 Megabit per second, low duty-cycle bursts at 1 mW to model an individual BSN device, and higher duty cycle operation to model an ensemble of BSNs).

BSN Baseline Test Measurements

In order to address concerns by GEH about the setup of previous test and interference measurements conducted by AFTRCC Member Companies, APL engineers constructed prototype Body Sensor Network (BSN) devices using the Nordic Semiconductor transceiver chips identified by GEH in an earlier filing as a candidate BSN technology. These chips exhibit the same power, modulation, bandwidth, duty cycle, and burst transmission features identified by GEH as being representative of their proposed BSN devices. Because of the *spectral re-growth* typical of low cost consumer wireless devices, the Nordic transceivers do not exhibit the spectral characteristics that GEH identifies for BSNs in Appendix C of its filing of September 18, 2008. However, as shown below, this is of no consequence to the test results presented herein, or to the previous analyses and tests performed by AFTRCC representatives.

The Nordic devices were implemented using commercially available evaluation kits that included antennas and microprocessors. APL modified the circuits to operate in the 2360 – 2390 MHz AMT band rather than in the 2.4 GHz ISM band. APL programmed the devices to generate data content that permitted the signals from the devices to be identified remotely, thus to address GEH's notion that some sort of rogue transmitter may have been responsible for the interference demonstrated in the Learjet Tests.[5] APL also made hardware modifications to permit a BSN transceiver to operate in receive mode while connected to a 15 foot diameter AMT ground station antenna.[6]

When connected to a microcontroller chip, Nordic transceivers behave as software defined radios. This permits software definition of the operating parameters of the Nordic devices. For example, operating frequency, power level, transmit/receive switch, error correction, use of data-bursting at 1 Mbps, etc., are controlled in software that is downloaded to the microcontroller from a host computer. The microcontroller is programmed using code written in the "C" programming language and compiled using the open-ware CC5X compiler.

An evaluation board that uses a Nordic nRF2401 chip is shown in Figures 1a and 1b. A similar system using the nRF24L01 was also built and used. The architecture of the devices, and the set-up under which they were tested on a flight test range, are shown in

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[5] Page 20, Technical Appendix of GEH filing of September 10, 2008, ("Was the signal being measured actually a distinct and unrelated signal from an unknown radiator (*e.g.*, Part 15 or Part 18 OOBE) that was not part of the intended test?").

[6] While AFTRCC has previously called the Commission's attention to the fact that the manufacturer recommends against use of the Nordic chip for contention-based sensing (July 28, 2008 AFTRCC ex parte at note 17), its use is this context, in order to evaluate the interference risk from the device, is quite different.

Figures 2a and 2b. The Figures also illustrate the manner in which two devices, one in transmit mode and one in receive mode, can communicate at a distance of two miles by connecting the receiver to a 15 foot diameter parabolic dish AMT receive antenna and low noise amplifier combination at Patuxent River. This permits, as shown later, the AMT system not only to detect the interfering signal, but to read its content.

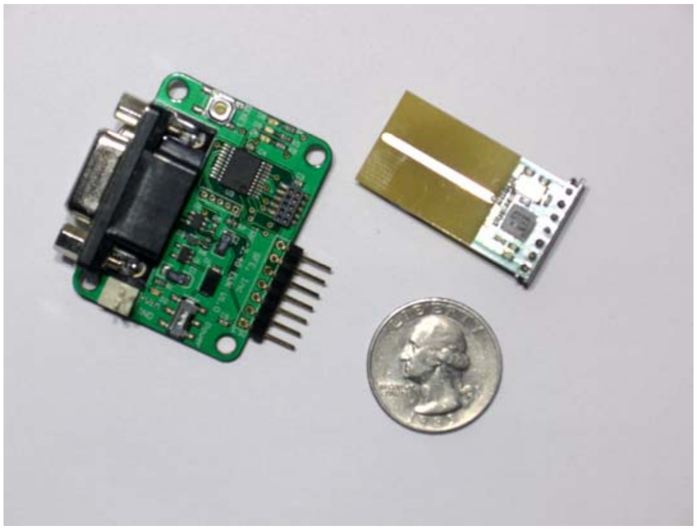


Figure 1a. The prototype BSN device shown in the figure consists of a Nordic nRF2401 chip, a quartz timing crystal, and a microstrip antenna on the right-hand board. The left-hand board contains a PIC microcontroller, a DB-9 RS-232 connector, and various glue chips and interface components. A personal computer is used to download the compiled code into the PIC device, and to perform high level I/O operations and data processing.

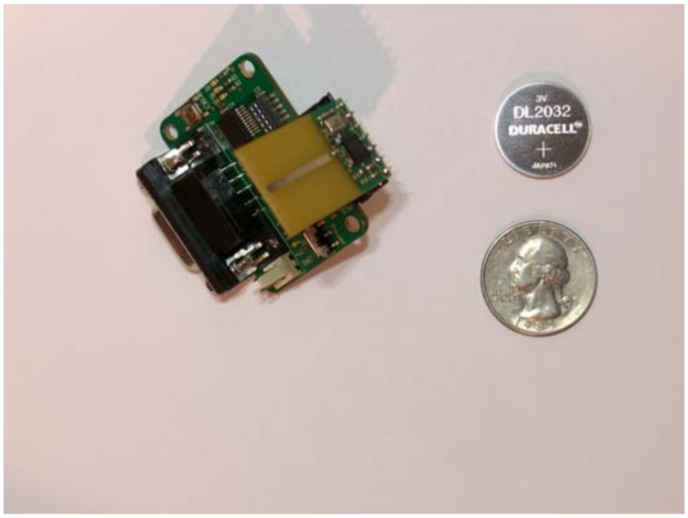


Figure 1b. The nRF2401 is shown assembled, with a Duracell 2032 three volt lithium-ion battery shown for comparison. This combination of devices, with battery, is also available packaged as a “key fob”.

The prototype system shown in Figures 1a-b includes of a circuit board containing a Nordic nRF2401 chip and micro-strip antenna, along with a quartz crystal used as the master clock. This is shown in Figure 2a. The actual transmitter frequency depends on the frequency of this crystal. A 16 MHz crystal is typically used to map the operating frequencies of the Nordic system into the 2400 – 2525 MHz ISM band. Although the band 2500 – 2525 MHz is not used for ISM purposes in the United States, it is an ISM band in Japan, and the nRF2401 and its sister chip, the nRF24L01, can both operate at these higher frequencies.

Figure 2a. Architecture of the Body Sensor Network transceivers used for interference testing.

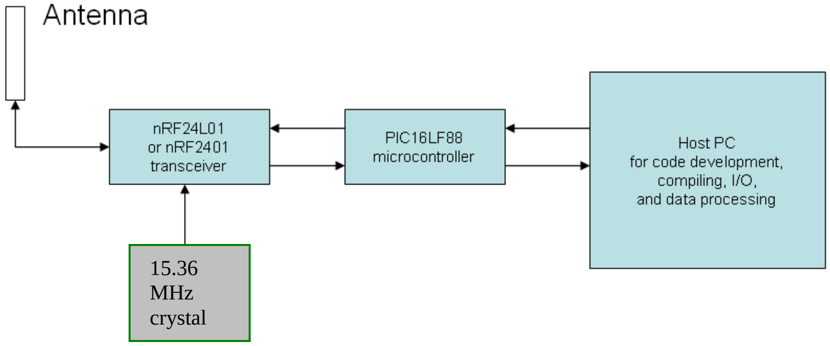
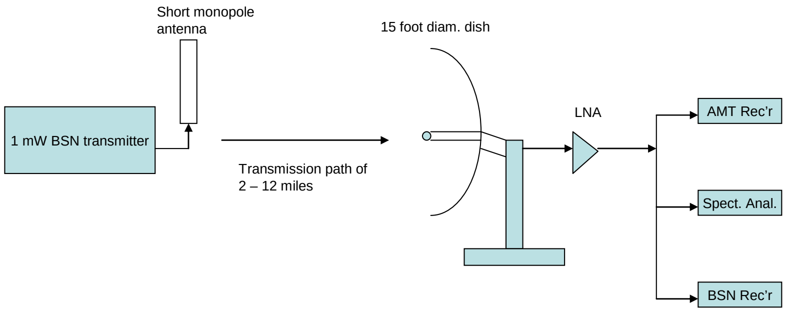


Figure 2b. Architecture used for end-to-end interference testing between BSN transmitters and AMT ground station receivers. The BSN receiver is identical to the BSN transmitter, except that it is programmed to receive rather than transmit, and is connected to the high gain AMT antenna through the low noise amplifier and related components (splitter with gain compensation so that there is no power loss due to splitting the signal; coaxial cables, etc.)



To permit the Nordic chips to operate in the AMT band, the 16.00 MHz surface-mount crystal was replaced by a 15.36 MHz crystal. This shifts the operational frequency range of the Nordic transceiver from 2400 – 2525 MHz to approximately 2300 – 2425 MHz. With no further hardware changes whatsoever, the prototypes can operate at any frequency within this 125 MHz band.

A Microchip "PIC" 16LF88 microcontroller is located on the adjacent board. Programmed in "C", the board sets the transceiver characteristics (operating frequency, power level, transmit/receive switch, etc.) of the Nordic transceiver. It also interfaces the prototype BSN to a personal computer, which manages the higher level I/O and data processing functions. The non-volatile software on the microcontroller can be programmed using either a boot-loader, or a "programmer". The latter provides the high signal voltages needed to re-program the EEPROM on the microcontroller. The boot-loader program circumvents the need for these higher voltages. In any case, re-programming the device is accomplished using traditional microcontroller techniques and skills.

Figure 2b shows the relationship between the BSN transmitter and the AMT receive equipment during the field tests. Note that the received signal could be directed to a multichannel AMT receiver, and/or a spectrum analyzer, and/or a BSN device configured to act as a receiver. The BSN device used the architecture shown in Figure 2a to permit the received data to be displayed on, and recorded by, a laptop computer, as shown in subsequent figures.

Figure 3 shows the spectrum of the Nordic device when operated at 1 Mbps in its "Shockburst" mode using shaped-FSK (SFSK) modulation. An ASCII test message is being broadcast (cf. Figure 9). The duty cycle is quite low (~3%), resulting in long battery life.

Note that the spectrum does not exhibit the $\sin x/x$ behavior predicted by theory for SFSK modulation. The $\sin x/x$ envelope is also presented by GEH, in Figure 1 of Appendix C of the GEH filing of 18 September 2008, as being the measured spectrum of an actual BSN device. GEH does not identify the specific BSN device used to generate the spectrum shown in the Figure.

In any case, the measured spectra of the nRF24L01 shown in Figure 3 is not unusual for small consumer devices in which the modulation and transmitter stages within the transceiver chip are poorly isolated from each other, and spectral "re-growth" occurs. The point is that conclusions should not be drawn about GEH comments regarding the spectra of BSN signals until GEH presents a complete design for such a device.

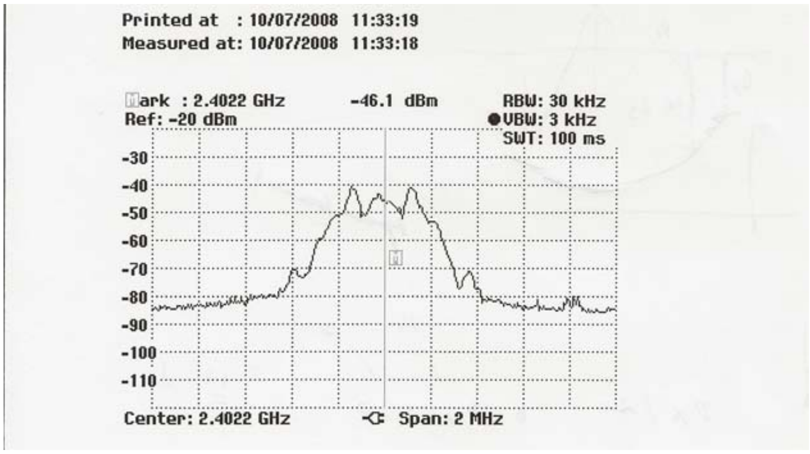


Figure 3. Spectrum of a Nordic nRF24L01 transceiver broadcasting a 1 Mbps test message in the 2.4 GHz ISM band.

In its September 18th filing (at page 14), GEH states:

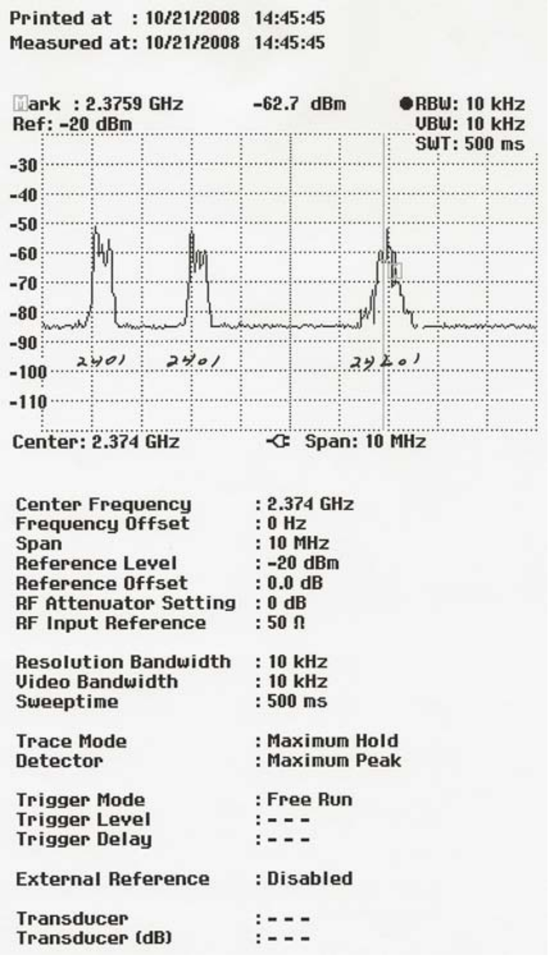
> "In addition, AFTRCC's assertion that these continuous narrowband signals were equivalent to MBANS signals because both signals fit into the AMT receiver bandwidth is technically incorrect. AFTRCC considers only the gross C/I interference mechanism and not the actual behavior of the tracking antenna, automatic gain control ("AGC"), or demodulator. (For many practical real-world receivers, a narrow-band signal often produces a worse jamming effect than a wider-band more noise-like signal of the same received power.)"

However, it is to be noted that the antenna tracking loop and AGC circuits in AMT receivers use incoherent peak detectors with built-in integrators that do not distinguish between unmodulated and modulated signals. They respond to the total power in the signal, which is independent of its modulation. It is further noted that gain compression and intermodulation effects due to preamplifier saturation, which, in a footnote to the above quoted material, GEH suggests was occurring, was not a factor for either the Learjet tests or the tests described below.

Returning to GEH's claims concerning modulation, AMT receivers have video detectors after the Intermediate Frequency (IF) amplifier/filter stage. Like the AGC and tracking loop circuits, the video detection stage uses an incoherent process. Thus, the video detector responds to the total power in the interfering signal, which is independent of its modulation.

Figure 4 shows the spectrum of an ensemble of three Nordic devices, modified to operate in the AMT band, transmitting in different channels within two adjacent 5 MHz AMT channels. The nRF2401 chips are transmitting at a 35% duty-cycle at a bit rate of 650 kilobits per second. The data rate is reduced from the 1 Mbps rate, ~3% duty cycle of the nRF24L01. This is because the data is being read into the transceiver chip from the micro-controller continuously, rather than using the cached, burst mode of the nRF24L01. In this case, the microcontroller limits the rate at which data is fed to the Nordic chip for immediate transmission.

By using a high duty cycle in the range experiments, a single BSN chip emulates the behavior of an ensemble of BSNs operating on the same channel, but in different time slots. It might be suggested that GEH does not propose to fill time slots in a BSN network to an aggregate level of 35%.[7] Indeed, the repeated mention in numerous filings of “frequency hopping” suggests that GEH proposes to use the spectrum even less than the 35% level used for the 2401 chips in the range tests, with a consequent increase in the total amount of spectrum that needs to be allocated to BSN networks.



```
Printed at  : 10/21/2008  14:45:45
Measured at: 10/21/2008  14:45:45

Mark  : 2.3759 GHz        -62.7  dBm      ●RBW: 10 kHz
Ref: -20 dBm                               VBW: 10 kHz
                                           SWT: 500 ms

Center: 2.374 GHz            Span: 10 MHz

Center Frequency        : 2.374 GHz
Frequency Offset        : 0 Hz
Span                    : 10 MHz
Reference Level         : -20 dBm
Reference Offset        : 0.0 dB
RF Attenuator Setting   : 0 dB
RF Input Reference      : 50 Ω

Resolution Bandwidth    : 10 kHz
Video Bandwidth         : 10 kHz
Sweeptime               : 500 ms

Trace Mode              : Maximum Hold
Detector                : Maximum Peak

Trigger Mode            : Free Run
Trigger Level           : - - -
Trigger Delay           : - - -

External Reference      : Disabled

Transducer              : - - -
Transducer (dB)         : - - -
```

Figure 4. Spectra of three 1 mW Nordic devices transmitting simultaneously at different frequencies.

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[7] APL’s tests using the nRF2401 chip were conducted with a 35% vs 25% duty cycle since the microcontroller was already set to the 35% level. On the other hand, the nRF24L01 chip was re-programmed to operate in the “Shockburst” mode at a duty cycle of about 3%.

Figures 5a and b show the *carrier-enable* signals of the two nRF2401 chips and the received signal strength output of an AMT receiver. The purpose of the Figures is to demonstrate how superposition of signals with low duty cycles affects the aggregate signal strength as detected by the AMT receiver. The receiver signal is logarithmic, meaning that a 3 dB increase in received power does not double the amplitude of the signal. Note that when the interfering signals arrive simultaneously at the AMT receivers, the total interference, as expected, reflects the non-coherent addition of the power from the two uncorrelated signals.

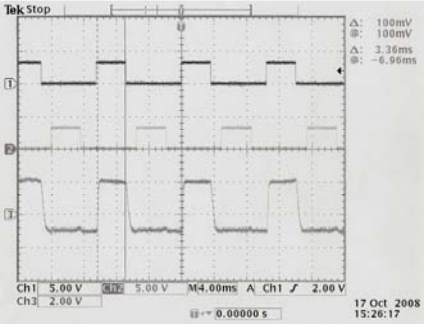


Figure 5a. The top two traces are the carrier-enable signals from the two Nordic 2401 chips. The bottom trace represents the logarithm of the total received signal strength measured by an AMT receiver (a Microdyne 1400 MRA).

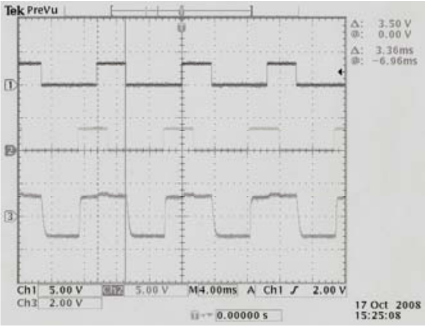


Figure 5b. As before, the top two traces in each graph are the carrier-enable signals from the two Nordic 2401 chips. The bottom trace represents the logarithm of the total received signal strength measured by the same AMT receiver.

Note: When the *carrier-enable* signals are high, the Nordic devices are transmitting. When the two transmitters happen to be transmitting simultaneously, they do not interfere with each other, as they are operating on different frequencies. In Figure 5a, the receiver is tuned in a 1 MHz wide bandwidth that receives the signal from one, but not both, BSNs. In Figure 5b, the bandwidth of the receiver has been increased to permit simultaneous reception, within a single AMT channel, of both BSN devices. When the BSNs are simultaneously active, the amplitude of the AMT received-signal strength voltage increases by an amount that corresponds to 3 dB.

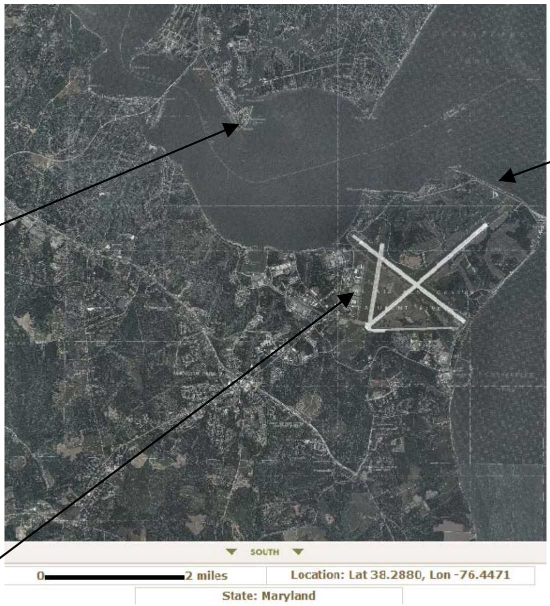
All that remains to be said about the laboratory testing is that a 1 mW signal from a BSN device, whether modulated at 650 kbps or 1 Mbps, yields the same interference, as measured at the signal strength output of a telemetry receiver, as a 1 mW *CW* source from a signal generator. For signals that are incoherent with respect to the local oscillator in the AMT receiver, it is the total power that is down-converted into the Intermediate Frequency (IF) filter within the receiver that counts. Power spectral density, provided it is not high enough to drive the receiver front-end into saturation, is irrelevant.

Again, it is the total power (i.e., the *integral* of the power spectral density) that matters. The concern expressed by GEH in an earlier filing that a continuous wave (CW) signal has infinite power spectral density is a mathematical artifact of Fourier theory. Specifically, the periodic signal $[A \cos \omega t]$ is completely bounded in the time domain. However, since the amplitude of this periodic signal does not go to zero as t approaches infinity, its power spectral density is represented by a Dirac Delta function $\delta(t)$. Although the amplitude of $\delta(t)$ is infinite, its integral (i.e., the area under the curve) is bounded. Thus, the fact that a CW signal has an infinite power spectral density is of no practical consequence.

Range Testing

Range testing was conducted at the Patuxent River Naval Air Warfare Center on numerous occasions using both 8 foot and 15 foot diameter antennas. The results are summarized succinctly below.

Figure 6 is an aerial representation of the Patuxent River facilities. Depending on one's choice of azimuth angle with respect to the AMT antenna site, one can measure the effects of propagation over water, across flat runways, across rolling terrain, from buildings, and through foliage. In simple terms, for distances less than approximately 2 miles, r^2 propagation is often observed. For larger distances, $r^{2.4}$ is sometimes reasonable. Building and vehicle attenuation factors range from nothing (through 1950's era windows) to ~30 dB (through modern thermally insulating windows), to 5 dB (from inside a vehicle).



Location of BSN xmitter in the visitor's center of the Chesapeake Biological Laboratory, Solomons MD

Location of the BSN xmitter for the in-vehicle testing

Location of the telemetry receive antenna

Figure 6. AMT Antenna and BSN Transmitter Locations at Patuxent River and Solomons, Maryland for the results shown in Figures 7 and 8.

Across open water, as seen from Patuxent River, Maryland to Solomons, Maryland, much depends on the sea conditions at the time. During heavy sea-states encountered for one series of tests, two BSNs, operating at different frequencies, were co-located at the river front at Solomons and detected simultaneously using a single AMT antenna and a two-channel receiver. The time-dependent fades were 20 to 30 dB in magnitude. This means that a signal from one BSN would be as much as 30 dB above the receiver noise floor at one moment, while the signal from the other BSN was lost. A few seconds later, the situation would reverse.

What GEH regards as excessive link margin is mandatory in flight test telemetry to compensate for these fades, which are manifestations of long-path delay multipath. Across a 5 MHz telemetry channel, these fades "present" as frequency-selective fades, in which portions of the channel experience 30 dB signal cancellation due to multipath, while other portions of the same channel simultaneously exhibit 3 dB signal enhancement. Similar fades were seen in the Learjet testing as the signal generator used in the testing was moved across a distance of several miles.[8]

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[8] With regard to the Learjet testing, APL understands that the low noise amplifier in use was built by Miteq and installed by Electro-Magnetic Processes Inc. in their antenna, in this case a Model 100 Series, two-axis automatic tracking system with 8 foot diameter parabolic dish with S-band antenna gain of 31.5 dB, including the LNA with a gain of 36 dB minimum and a noise figure of 1 dB maximum. After a Heliax cable loss of approximately 2 dB, the signal is converted into an optical signal for transmission over fiber, and reconversion to microwaves for processing

A second source of fading, when the received signal originates from an aircraft, is due to masking of the aircraft antennas, as seen from the AMT ground station, during flight maneuvers. This is shown in Figure 7, a telemetry read-out in which the aircraft is transmitting at L band over the Chesapeake Bay at close range (twenty miles), but at low altitude (~4500 feet).[9]

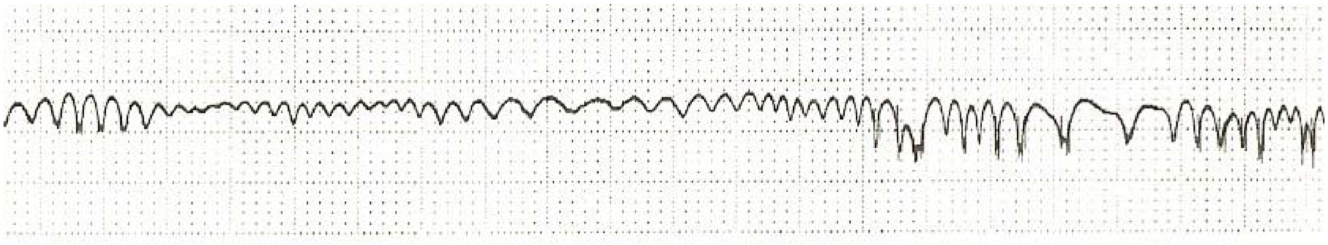

Figure 7. Received signal strength, in dB, as a function of time for a jet aircraft operating at L band (1522.5 MHz) 20 miles from a telemetry ground station. Each large division is 20 dB on the vertical axis, and 1 second on the horizontal axis. An 8 foot diameter parabolic receive antenna, operating between plus and minus 2 degrees elevation, is used. This antenna is mounted on an aircraft hanger approximately 75 feet above the ground. The minimum received signal, in this close-in flight scenario, dips to about 30 dB above the noise floor. After accounting for the required 15 dB signal to noise ratio, there is a minimum link margin of 15 dB. Extending the flight range further from the ground antenna would consume this entire margin. The IF bandwidth of the telemetry receiver is set to 12 MHz, and there is an LNA between the antenna and receiver.[10]

The next Figures summarize measurements of the surrogate BSN devices for various conditions. Figure 8 shows a typical BSN Measurement at Patuxent River, Maryland, showing the interference signal from the 1 mW Nordic Semiconductor nRF2401 Transceiver Chip broadcasting an ASCII test message at a 35% duty cycle using SFSK modulation at a data rate of 650 kbps. The Nordic device is located behind a second story window in Solomon’s, Maryland, facing the Patuxent River 8 foot diameter receive antenna located 2.8 miles away across the mouth of the Patuxent River. Of the 2.8 miles, approximately 2.3 miles is across open water, and 0.5 miles across lightly rolling terrain with foliage and buildings. The telemetry receive antenna has a clear line of sight view to Solomons -- including the upper stories of the Asbury Methodist Village assisted living and health care facility that is over four miles away.

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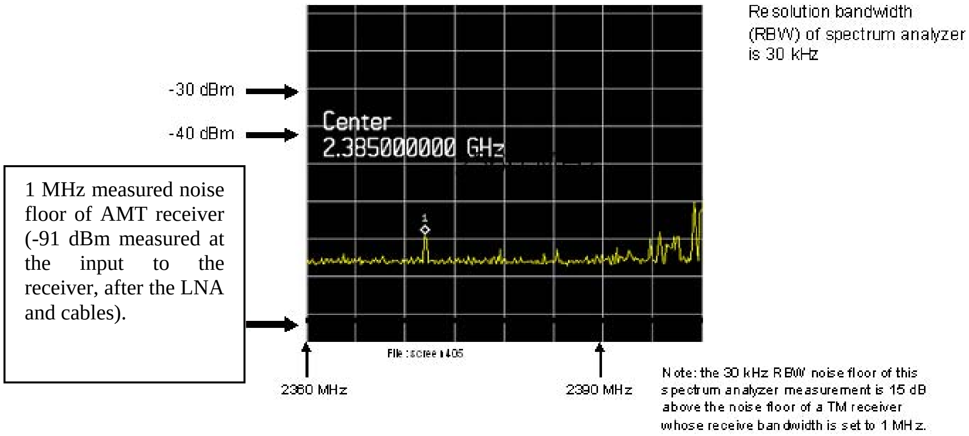
by the AMT receiver at the ground station. Signal strength is further adjusted to lie above the noise floor and within the dynamic range of the AMT receiver.

[9] Statistical details of this are captured in ITU-R Recommendation M.1459.

[10] LNA gains can vary depending on the diameter of the antenna with which they are used, and the site specific details of the individual test range. Data presented herein are measured for systems having 25 - 34 dB amplifier gains.



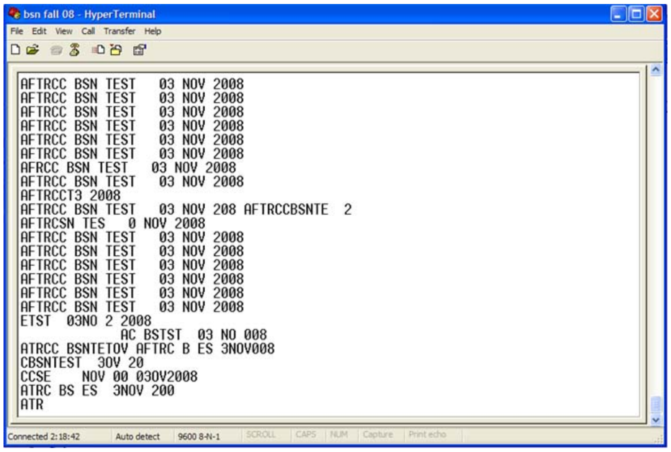
Resolution bandwidth (RBW) of spectrum analyzer is 30 kHz

1 MHz measured noise floor of AMT receiver (-91 dBm measured at the input to the receiver, after the LNA and cables).

Note: the 30 kHz RBW noise floor of this spectrum analyzer measurement is 15 dB above the noise floor of a TM receiver whose receive bandwidth is set to 1 MHz.

Figure 8. Typical BSN Measurement at Patuxent River, Maryland, showing interference signal from a 1 mW Nordic Semiconductor nRF2401 Transceiver Chip broadcasting an ASCII test message at a 35% duty cycle using SFSK modulation at a data rate of 650 kbps. The Nordic device is located behind a second story window in Solomon's, Maryland, in the visitor's center of the Chesapeake Biological Laboratory, facing the Patuxent River, Maryland 8 foot diameter receive antenna located 2.8 miles away across the mouth of the Patuxent River.

Figure 9 was obtained by measurement of a BSN device transmitting at low duty cycle at 1 Mbps. The BSN was located in a vehicle parked 1.9 miles away, separated from the AMT receive site by rolling terrain with moderate foliage. A companion BSN transceiver, configured to act as a receiver, decodes the signal from the BSN after it is received by the 15 foot diameter telemetry receive antenna and amplified by the antenna's low noise amplifier. Note that there is no possibility of confusing the received data with signals from an unknown device, as suggested by GEH regarding the Wichita tests.



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AFTRCC BSN TEST   03 NOV 2008
AFTRCC BSN TEST   03 NOV 2008
AFTRCC BSN TEST   03 NOV 2008
AFTRCC BSN TEST   03 NOV 2008
AFTRCC BSN TEST   03 NOV 2008
AFTRCC BSN TEST   03 NOV 2008
AFRCC BSN TEST   03 NOV 2008
AFTRCC BSN TEST   03 NOV 2008
AFTRCCT3 2008
AFTRCC BSN TEST   03 NOV 208 AFTRCCBSNTE  2
AFTRCSN TES   0 NOV 2008
AFTRCC BSN TEST   03 NOV 2008
AFTRCC BSN TEST   03 NOV 2008
AFTRCC BSN TEST   03 NOV 2008
AFTRCC BSN TEST   03 NOV 2008
AFTRCC BSN TEST   03 NOV 2008
AFTRCC BSN TEST   03 NOV 2008
ETST  03NO 2 2008
             AC BSTST  03 NO 008
ATRCC BSNTETOV AFTRC B ES 3NOV008
CBSNTEST  30V 20
CCSE    NOV 00 030V2008
ATRC BS ES  3NOV 200
ATR
```

Figure 9. The ASCII message transmitted by the BSN when the signal is received and decoded by a second BSN device connected to a high gain telemetry

receive antenna. Some data dropouts, not present in short range testing, occur, as seen by the degraded ASCII text message, which is generated repeatedly and continuously by the source BSN, but transmitted in 1 MHz bursts.

To further explore the impact of BSN devices on AMT operations, an ensemble of BSNs was deployed on the far side of the Chesapeake Bay from Patuxent River, Maryland at Hooper Island, Maryland. This is shown in Figure 10. The arrow points from the AMT receive antenna to the location of the transmitters, almost 12 statute miles away. Of this distance, over two miles is across the slightly rolling terrain at Patuxent River. Furthermore, the line of sight from the AMT receive antenna across the bay is blocked by trees.

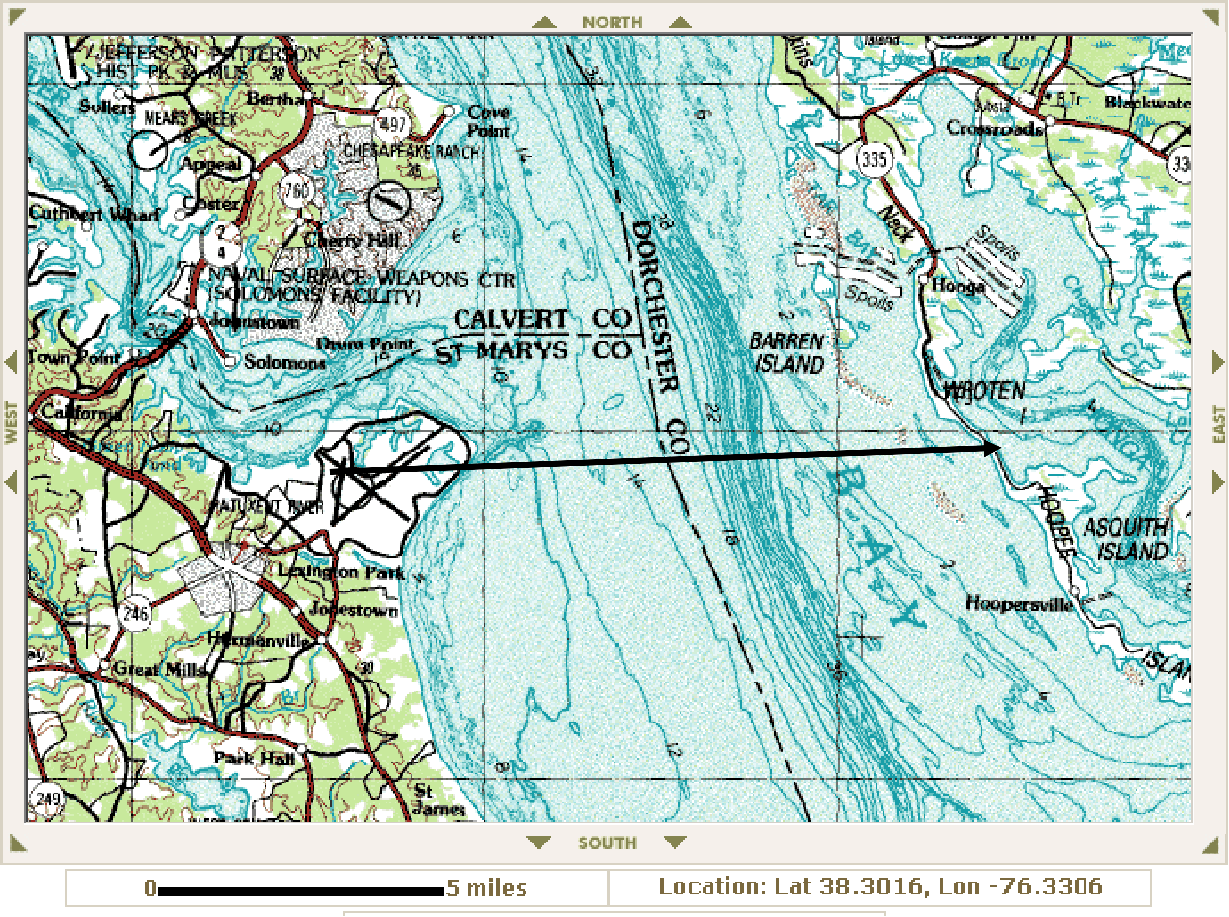


Figure 10. Relative Geometry of the Twelve Mile Patuxent River-to-Hooper Island Interference Test.

Figure 11 shows the arrangement of BSN devices, in this case an ensemble of 2401 chips set to broadcast a random test message at 650 kbps and a 35% duty cycle at carrier frequencies of approximately 2370, 2372, and 2373 MHz, respectively. All three signals lie within the 6 MHz Intermediate Frequency (IF) bandwidth of the RC-600A telemetry receiver in use at Patuxent River. The devices, located both inside and on top of a car during the tests, are shown with a portable Rhode and Schwarz spectrum analyzer.

Figure 11. Three Nordic nRF2401 devices operating inside a passenger car at Hooper Island, Maryland.

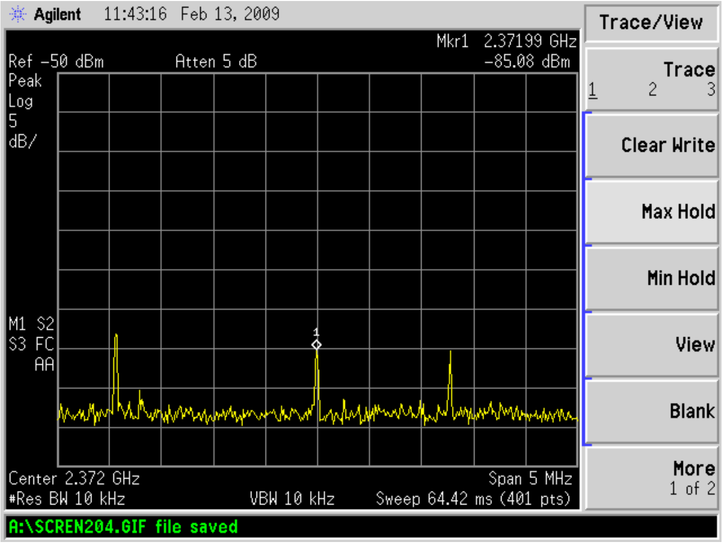
Figure 12 is a view across the Chesapeake Bay towards Patuxent River, Maryland. Except for the fading effects of whitecaps, the propagation characteristics, when taking into account the final two miles of land, terrain, and trees at Patuxent River, are not unlike those expected for ranges at locations like Wichita, Phoenix, Dallas, Palmdale, etc.

Figure 12. View of the Patuxent River Naval Air Station from Hooper Island looking west across the Chesapeake Bay.

Figure 13 shows a nearby bridge with a clearance of 35 feet above the Bay. Being on the bridge is comparable to operation of BSNs on the third floor of a building facing an AMT receive site.

Figure 13. The Bridge between Middle and Lower Hooper Islands.

Figure 14 shows the signals received at Patuxent River from the three BSN devices when operated inside a car parked on the bridge. Note the significant strength of the received signals.



Agilent 11:43:16 Feb 13, 2009

Mkr1 2.37199 GHz
-85.08 dBm

Ref -50 dBm Atten 5 dB
Peak
Log
5
dB/

M1 S2
S3 FC
AA

Center 2.372 GHz Span 5 MHz
#Res BW 10 kHz VBW 10 kHz Sweep 64.42 ms (401 pts)

A:\SCREN204.GIF file saved

Figure 14. Received signals from BSNs operated inside an automobile located on a bridge 35 feet above sea level measured at a distance of twelve miles.

Figure 15 shows the same signals, but with the BSNs placed on the roof of the car. The received signal strength increases by several dB, and the modulation sidebands are clearly visible.

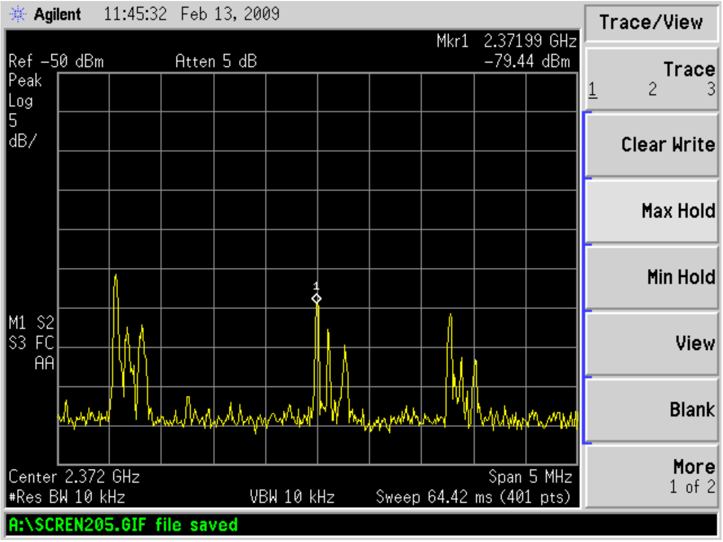

Agilent 11:45:32 Feb 13, 2009
Mkr1 2.37199 GHz
-79.44 dBm
Ref -50 dBm Atten 5 dB
Peak
Log
5
dB/
M1 S2
S3 FC
AA
Center 2.372 GHz Span 5 MHz
#Res BW 10 kHz VBW 10 kHz Sweep 64.42 ms (401 pts)
A:\SCREN205.GIF file saved

Figure 15. Roof-top BSNs Measured at a Distance of Twelve Miles.

Figure 16, for reference purposes, shows the spectrum measured at a distance of twelve miles when the nRF2401 devices are turned off.

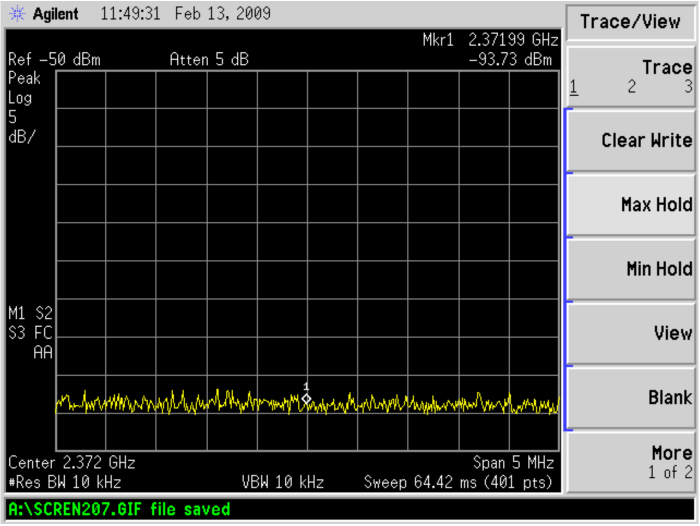

Agilent 11:49:31 Feb 13, 2009
Mkr1 2.37199 GHz
-93.73 dBm
Ref -50 dBm Atten 5 dB
Peak
Log
5
dB/
M1 S2
S3 FC
AA
Center 2.372 GHz Span 5 MHz
#Res BW 10 kHz VBW 10 kHz Sweep 64.42 ms (401 pts)
A:\SCREN207.GIF file saved

Figure 16. Measured Noise floor of Spectrum Analyzer at Patuxent River, Maryland.

Figure 17 shows the spectra from the same BSNs, but measured using a portable spectrum analyzer located in the car. The point is to demonstrate that there are no unknown, rogue devices that are corrupting the data. (Note that the frequency span of the portable spectrum analyzer is set to 10 MHz, versus 5 MHz in the previous figures.)

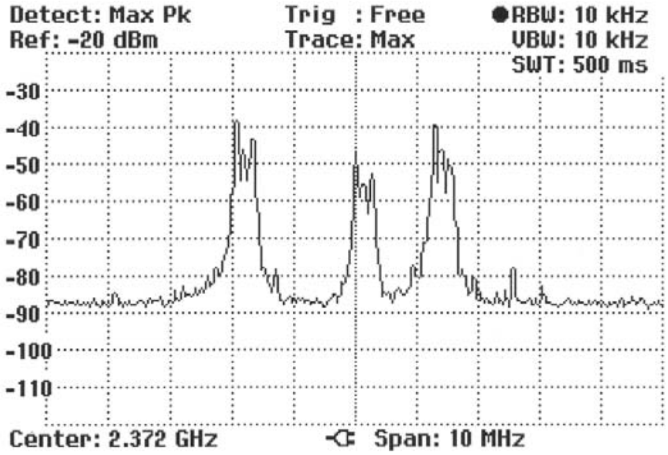


Figure 17. Local Measurement of the BSN spectra obtained using a portable spectrum analyzer in the test vehicle at Hooper's Island.

	Horizontal Polarization	Vertical Polarization
all BSNs turned OFF	-87 dBm	-84 dBm
3 BSNs turned ON	-84 dBm	-76 dBm

Table 1. Effect of three 1 mW BSNs, operating at a duty cycle of 35% at a distance of 12 miles, on the measured noise floor at the input to the RC-600A telemetry receiver. A polarization diversity system is used to feed the horizontally and vertically polarized components of the received signal into separate channels of the telemetry receiver.

Finally, it is important to measure directly the impact of the BSN devices on the RC-600A telemetry receiver. When set to an IF bandwidth of 6 MHz at a center frequency of 2372 MHz, the measured noise floor at the input of the RC-600A receiver (i.e., after the LNA at the antenna), for vertical polarization, is -84 dBm. When the three BSNs are turned on, the noise floor increases to -76 dBm, an 8 dB increase!

Thus, BSN devices are readily detected, at very considerable distances , as signals that are well above the noise floor of the AMT receive system. At a distance of 12 miles, across terrain, through foliage and over water, the measured noise floor of the AMT receiver, due to operation of 1 mW devices at 35% duty cycle at 3 different frequencies within the AMT receiver bandwidth, is raised 8 dB. And, at a distance of almost 2 miles, across rolling terrain and through foliage, the data content of a transmission from a BSN operating in an automobile can be easily read.

Impact and Conclusions

The impact of this on flight test operations is considerable. In addition to the long range data measured using the 15 foot dish, consider the received interference power of the signal shown in Figure 8, which was measured using an 8 foot dish. This measurement was repeated on a separate occasion (a different month, day, and time of day) under different weather conditions and with the BSN located outdoors.[11] With the IF bandwidth of the telemetry receiver set to 700 kHz and using the 15 foot dish, rather than the 8 foot dish used to obtain the data in Figure 8, the received BSN power measured after the LNA of the receive antenna was -76 dBm. The corresponding noise floor of the receiver, measured by simply turning the BSN off, was -96 dBm.

As noted before, the BSN device used in this test utilized a transceiver chip suggested by GEH as being typical of the technology it plans to use for implementation of its system. Its transmit power, spectrum, and duty cycle are representative of the composite signal GEH suggests one would see from a ensemble of seven co-channel BSN transmitters each operating at a duty cycle of 5%. But, the Interference to Noise ratio from this composite signal is 20 dB -- a significant departure from the -3 dB aggregate limit specified in Recommendation M.1459 that GEH claims one would expect (cf. Table 2 at page 6 of Appendix A of the GEH filing of 18 September 2008).

From the GEH point of view, the impact of this interference source on AMT is to increase the percentage of time that the flight test link operated at a fixed distance experiences signal dropouts. However, from a flight test operator's point of view, the effect of the interference signal is to reduce -- by a factor of ten -- the maximum distance at which flight test aircraft can operate at a given level of performance. For an aircraft downlinking telemetry successfully at a range of 200 miles, for example, the 20 dB increase in noise floor due to interference reduces the maximum operational range of the AMT telemetry link to 20 miles.

This corresponds to a 99% reduction in the amount of airspace at this azimuth angle that is available for flight test. When one accounts for the fact that a short term link failure can also yield a long-duration telemetry system failure, the range of affected azimuth angles increases dramatically. That is, flight test aircraft cannot fly, even momentarily, across the wedge of airspace centered about a line between the AMT receive site and the BSN location.

When added to existing air traffic control constraints and the need to test multiple aircraft simultaneously at the same flight test range, the interference from a cluster of BSNs located at even a single azimuth angle with respect to the AMT receive antenna will impact not only the aircraft that flies across that azimuth direction, but all of the aircraft operating at the test range. Furthermore, a civil test aircraft can travel the entire 200 mile radius of a flight test area in less than 25 minutes, which is the duration of many types of tests, such as flutter tests, which require completely uninterrupted streams of telemetry data lasting

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[11] The BSN was located on top of a vehicle parked in front of the Biological Research Laboratory visitor's center, rather than behind a window in the building.

several tens of minutes. Military aircraft operating at supersonic speeds can travel the same distance in a fraction of that time.

III. Noise Floor Measurements and Regulatory Considerations

Noise Floor Measurements

GEH has argued that AMT is coexisting with millions of devices that "violate, by substantial margins, the protection criteria AFTRCC has put forth in this proceeding to argue against the proposed MBANS allocation." In support, GEH has supplied test results originally filed by equipment manufacturers with the Commission for numerous wireless devices operating in the 2.4 GHz band. (October 30, 2008 ex parte at 3d page and Exhibit B). On this basis, GEH claims that there are substantial out of band and spurious emissions into the flight test spectrum.

However, one must consider propagation effects when relating the emissions from a device, measured 3 meters from the device in accordance with Part 15.35 and 15.209 regulations, to the signal received at a distant antenna. As shown in Figure 18, the measured reality at Patuxent River is that the noise floor is not increased by spillover and spurs from ISM devices, even though the Test Center is located in a densely-populated and built-up area.[12] To claim that there must be an increase in the noise floor is not supported by the field tests.

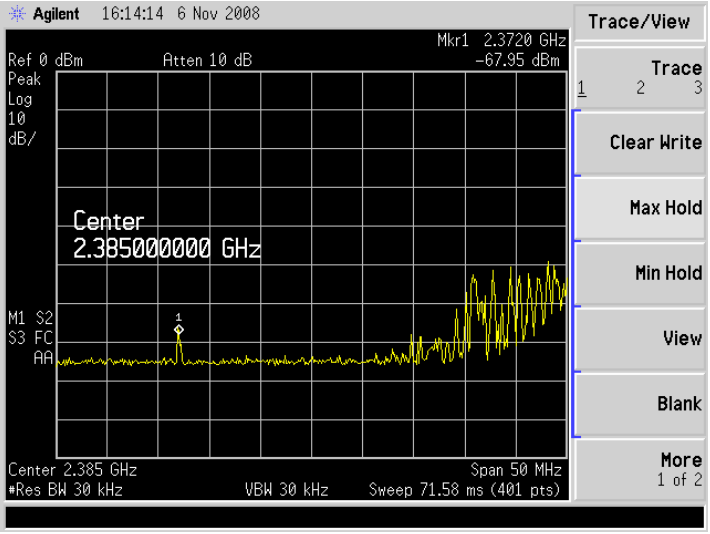

Figure 18. Similar data to that in Figure 8, but with the horizontal scale extending into the lower 10 MHz of the 2.4 GHz ISM band.

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[12] Planners Look to Pax River as Guide Ahead of Military Base Expansions, by Ashley Halsey III, Washington Post Staff Writer, Monday, January 5, 2009; page B01 "Where once there were trees and fields there stand office buildings adorned with the names of giant military contractors: Northrop Grumman, Sikorsky, Raytheon and more. The road leading to the Patuxent River Naval Air Station has widened from two lanes to six and become lined for miles with shopping centers and big-box stores. In a county where tobacco once ruled, the defense industry has become king."

Note that the 10 MHz de facto guard band from 2390 MHz to 2400 MHz provides effective protection against spillover from unlicensed devices operating in the 2400 – 2500 MHz ISM band. For the data shown in Figure 18, the noise floor as measured at the input to the telemetry receiver is -91 dBm in a 4 MHz IF bandwidth. The system includes a high gain (~34 dB), low noise amplifier following the feed element, a common configuration found in most AMT receive antennas. A power splitter and cable losses introduce ~10 dB of attenuation before the input to the SIMCO RC600A telemetry receiver. The effective AMT system noise temperature under these conditions is comparable to the figure of 250 Kelvin used in ITU-R Recommendation M.1459.

In general, AMT operators do not experience noise from ISM devices in the 2360 – 2390 MHz portion of the AMT band. Where any OOBE is observed, it is generally in the 2390 - 2400 MHz portion of the band, of which AMT is allocated only the 2390 – 2395 MHz channel. Because of co-allocation with amateur radio, this spectrum is seldom used for flight test.

Furthermore, there is a difference between spurious emissions, which are relatively narrow in bandwidth and are located at specific frequencies within the victim band, as opposed to out of band emissions, which are continuously distributed and can be described using a well-defined power-versus-frequency mask. GEH has used the term *spurious* and the phrase *out of band emission* as though they are interchangeable, which they are not.

Spurious emissions depend on the unique features of devices that vary from model to model, and from manufacturer to manufacturer. When averaged over an entire 5 MHz AMT channel, their impact on wideband AMT operations is considerably reduced..

Thus, the argument that the ITU-R M.1459 protection criteria "must be flawed" (Nov. 7 ex parte at third page) is not supported by data, such as that provided above, which is characteristic of the noise floor of other flight test ranges. Indeed, if the noise floor were corrupted, it would be impossible for flight tests to operate at the distances of 200 miles typically used.

Actual deployment densities and locations of ISM devices, combined with propagation considerations (geographic separation, line of sight blockage, building attenuation, the radio horizon, etc.) make it simultaneously possible for Part 15 devices to operate at the electric field limits specified in 15.209 (i.e., 500 microvolts per meter at a distance of 3 meters), while meeting the protection criteria of Recommendation M.1459 (-180 dBW per square meter in 4 kHz at the aperture of the AMT receive antenna).

The notion that spillover from ISM devices into the AMT band makes it permissible for BSN devices to operate co-channel within the AMT band is fundamentally flawed. The 500 microvolt per meter at 3 meters electric field limits of the Part 15 regulation pertaining to this Restricted band correspond to an EIRP level, per megahertz, of -70 dBW. Most importantly, GEH proposes to operate BSNs, under propagation conditions essentially identical to the deployment of ISM devices, at power levels of 1 mW, or -30 dBW. Per device, BSNs are 40 dB more powerful than the maximum spurious and out of band emissions of their ISM counterparts.

Regulatory Considerations

At this point, it may be useful to comment on assertions that Recommendation M.1459 is overly protective.

As GEH notes, Rec. M.1459 permits an aggregate I/N ratio of -3 dB. Other services, such as the Globalstar Mobile Satellite System, are protected at a level of $\Delta T/T = 6\%$, where T is the baseline system noise temperature and ΔT the total additional degradation caused by interference from other systems. $\Delta T/T$ of 6% corresponds to a maximum I/N ratio of -12.2 dB, a level that is over 9 dB more protective than that in Rec. M.1459.

As AFTRCC has stated in earlier filings, the problem is not that Rec. M.1459 is overly protective. The problem is that GEH is trying to share with a noise-limited service, which involves safety of life, utilizing large diameter, high gain parabolic dish antennas.

The protection levels of M.1459, have been carefully vetted at the ITU, and are referenced in international treaty agreements (i.e., the final acts of the 2003 and 2007 World Radio Conferences), to which the US is a signatory.

It is also noteworthy that GEH apparently has no difficulties with analyses that depend on other ITU Recommendations, which claim the same level of approval, no more and no less, that Rec. M.1459 has. For example, the SEAMCAT software (discussed in section IV, below), includes the propagation model described and validated in ITU-R Recommendation P.1456.[13] The CEPT Report that GEH also leans heavily on (discussed in Section V, below) acknowledges and uses ITU-R Recommendations F.1334, F.1245, RS.1166-3, M.1388, and M.1731, as well as Rec. M.1459.[14]

IV. The GEH Monte Carlo Analysis

GEH has presented the results of a Monte Carlo analysis implemented using the SEAMCAT software package based on a 1% probability of interference to AMT. It does this in connection with criticism of what it refers to as the "minimum static coupling" model utilized by AFTRCC. There are basic problems with GEH's probability analysis.

First, contrary to its contentions, a static case analysis is entirely appropriate for assessing the compatibility of two safety services sharing on a co-channel basis. The Commission itself used the static case approach in evaluating the risk of interference from AWS-3 devices as noted in the letter attached hereto -- and that was simply for two cellular services rather than two safety services.

Second, GEH admits (October 20th ex parte at page 4) that BSNs will cause interference to AMT systems. But, although GEH admits there will be interference, it does

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[13] see, for example, http://seamcat.iprojects.dk/wiki/Manual/PropagationModels/P1546

[14] Recommendations are available at www.ITU.INT. The CEPT Report is, "Compatibility Studies between Professional Wireless Microphone Systems (PWMS) and Other Services/Systems in the Bands 1452-1492 MHz, 1533-1559 MHz, also considering the Services/Systems in the Adjacent Bands (below 1452 MHz and above 1559 MHz)," Vilnius, September 2008.

not consider the impact of such interference to AMT systems. Since the effects of even a single outage are severe and damaging, as discussed below, interference to AMT is clearly *harmful* within the meaning of the Commission's rules.[15] Thus, the premise that there exists a level at which interference can be tolerated, which may be appropriate for a cellular communications system, for example, is flawed at the outset with regard to sharing between BSNs and AMT.

The Impact of Short Term Dropouts on AMT Systems

In many communications link budget analyses, a target value of bit error probability is stipulated. For AMT operations, this would ideally be one part in 10^6 or one part in 10^5. However, this is the beginning, not the end, of the analysis. After data is received by a flight test receiver, two other critical operations take place. The first, a clock recovery operation referred to as "bit synch", is used to align the received data bits to a master clock. After the bit synch operation, a de-commutation process occurs in which data words are grouped into frames and decoded into the aeronautical mobile telemetry data. This requires synchronization of the input signal to the master clock at the bit, word, and frame levels.

When frame and/or bit sync is lost, large amounts of AMT data are lost. Entire flight test segments, such as a high risk "flutter dive", must be re-flown. This entails considerable cost to the aircraft manufacturers and personal danger to the test pilots and aircraft crew.

Onboard recorders are typically not a solution. As AFTRCC has observed previously, the aircraft are often too small to host the necessary equipment. Even where an aircraft is large enough to accommodate digital recorders, the provision of real-time telemetry to ground station engineers is a critical element of the comprehensive flight test safety programs that are in place at all ranges. On-board recording is no substitute for this.

Furthermore, if preamble bits are lost in more than 2 to 3 adjacent data frames, frame synchronization must begin from scratch, a time-consuming process that usually involves re-flying the test segment. This is not an issue for the type of communications systems that GEH is apparently using for reference, but is a critical component of AMT systems. This is because continuous measurements of analog data must be received completely, with no dropouts, to accomplish the data analysis for which the flight testing is being conducted.

It is typically the case that a single flight test on most ranges can be conducted over a period of several hours without loss of bit sync, frame sync, or antenna tracking. However, as long as GEH continues to regard AMT systems as commercial communications systems in which the effect of a short term dropout is essentially nil, its analyses will not provide accurate estimates of the impact of co-channel BSN operation on flight testing.

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[15] Flight testing “involves the safety of life and property,” and the Commission has taken action to “protect this safety service from harmful interference that could result in loss of life.” In the Matter of Amendment of Part 2 of the Commission’s Rules Regarding Implementation of the Final Acts of the World Administrative Radio Conference, Geneva, 1989. FCC 84-306, July 2, 1984. See also Second Notice of Inquiry in Gen. Docket No. 89-554, 5 FCC Red 6046, 6060, para. 101 (1990). Harmful interference to a safety service is that which endangers its functioning, rather than how often, as is the case with non-safety services. See Rule 2.1.

The notion that AMT operations are limited by a baseline outage rate due to the presence of noise, upon which GEH's Monte Carlo analyses depend, is simply not the case. Uncorrupted telemetry without outages is possible even in the presence of receiver noise. The GEH assertion that because of this noise AMT operators perform flight tests at a baseline dropout rate of 1.5 x 10^{-3} is not correct (GEH Sept. 18, 2008 at Appendix A). Thus, this assertion cannot be used as a basis for determining an acceptable level of interference. The acceptable level of interference is the level specified in Rec. M.1459 in terms of a pfd level at the aperture of the AMT receive antenna.

For the reasons stated above, the "no interference" conclusion based on Monte Carlo analyses is entirely unfounded: Probability analyses are inappropriate for analyzing the interference to AMT.

In any case, the interference susceptibility of AMT systems is more like that of a radar system than of a communication system.[16] SEAMCAT, for example is probably quite good at showing that certain cellular networks "have the fewest dropped calls." In the AMT world, even a single "dropped call" is unacceptable.

V. Professional Wireless Microphone Systems

GEH has made claims based on a CEPT report on interference to aeronautical telemetry systems by professional wireless microphone systems (known as PWMS devices).[17] However, the GEH claims based on this report are over-reaching, use non-representative data, and generate misleading conclusions.

With regard to the CEPT report's predictions for the separation distances required to prevent interference from PWMS devices to AMT sites, GEH argues that the interfering devices can coexist with aeronautical telemetry "given only relatively modest separation distances of as little as 1.5 km".[18] However, this conclusion depends critically on the building attenuation factor that is presumed when obtaining this result. For the reader's benefit, the conclusion of this relevant section of the ECC report is presented below:

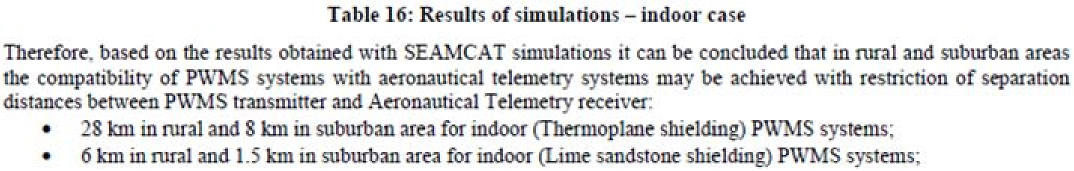

Table 16: Results of simulations – indoor case

Therefore, based on the results obtained with SEAMCAT simulations it can be concluded that in rural and suburban areas the compatibility of PWMS systems with aeronautical telemetry systems may be achieved with restriction of separation distances between PWMS transmitter and Aeronautical Telemetry receiver:

- 28 km in rural and 8 km in suburban area for indoor (Thermoplane shielding) PWMS systems;
- 6 km in rural and 1.5 km in suburban area for indoor (Lime sandstone shielding) PWMS systems;

GEH uses the second bullet of the table, the limit applicable to suburban buildings with the assumption of 30 dB of "Lime sandstone" shielding, to imply that wireless microphones, and hence BSNs operating at a fraction of the power, will not cause

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[16] A similar situation arose at the 2003 World Radio Conference, when the United States opposed the use of statistical techniques for quantifying interference to radar systems.

[17] ECC CEPT Report, "Compatibility Studies between Professional Wireless Microphone Systems (PWMS) and Other Services/Systems in the Bands 1452-1492 MHz, 1533-1559 MHz, also considering the Services/Systems in the Adjacent Bands (below 1452 MHz and above 1559 MHz)," Vilnius, September 2008.

[18] September 18 GEH ex parte at 12.

interference to AMT. However, the first bullet makes clear that some buildings, and perhaps the majority of modern buildings (i.e., those with “Thermoplane” shielding) present only 6 dB of wall attenuation.

The measurements at Patuxent River make clear that there are dramatic (>30 dB) variations between the observed attenuation of BSN signals from different types of buildings. Thus, it is inappropriate to cite only part of the conclusion shown above. One cannot assume building attenuation factors are 30 dB, when indeed many modern buildings have been built or updated to “thermoplane shielding”.[19]

Furthermore, the report assumes that AMT channels have a bandwidth of 1 MHz. The typical AMT channel bandwidth used in the United States is 5 Megahertz, so that an extra 7 dB of interference must be considered when drawing any inferences from the ECC report.

Most importantly, however, the Report relies entirely on simulations. The field tests reported upon here, and previously, demonstrate that the interference risk is much more substantial than the simulations suggest.

Finally, GEH relies on the CEPT report for the notion that there are separation distances beyond which interference from BSNs to AMT is not material. However, the CEPT report is about Europe, not the United States. There are no flight test ranges in Europe that exhibit the vast expanses of flat, often tree-less terrain that characterize major flight test centers in the United States.[20] Other countries routinely test their aircraft in the United States for this reason. This includes Bombardier, a Canadian company and member of AFTRCC, that uses the Wichita range for all their flight testing (cf. the Learjet tests).

Unless an additional 40 dB of mitigation from BSNs to AMT ground stations is provided, free-space separation distances within the radio horizon of AMT ground stations are not practical. Building attenuation and terrain masking can be important and significant effects. However, as shown by the results in Section II of this report a single BSN operating at 35% duty cycle located inside a building at a distance of 2.8 miles (4.5 km) is detected as an interference signal that is well above the noise level of the AMT receive equipment. When this result is extended to account for aggregate effects of as many as 50 BSN devices, even with low duty cycles taken into account, the distance at which the same, substantial level of interference is experienced will more than double. Thus, a separation distance of “as low as 1.5 km” as suggested by an out-of-context and incorrect interpretation of the CEPT report, is certainly not practical.

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[19] “Thermoplane” refers to double layers of wall or window separated by an air gap and/or air-filled insulating material, such as Styrofoam.

[20] Much flight testing in Europe is conducted over the ocean for this reason.

VI. Remarks on Spectrum Requirements and Other Bands

It is important to revisit the possibility that other spectrum exists that can meet the needs of the proposed Body Sensor networks. To address this question, one must first review the amount of baseline data to be captured and relayed by a BSN device.

GEH has stated, in its filing of October 31, 2006, in Docket 06-135 at page 9, that "in order to be generally applicable throughout the range of clinical acuities, BSNs would have to support application data rates of several tens of kilobits per second".

GEH then states (at page 10) that BSNs could be deployed in densities that "approach or exceed one BSN per 10 square feet." However, for their SEAMCAT simulations, the number of BSNs expected to be visible to an AMT receive antenna at one time is estimated to be no more than 50.

Fifty devices operating with a spectral efficiency of 1 bit/Hz yields a total spectrum requirement for 50 channels of approximately 50 kHz each (including guardbands). This equates to a total baseline spectrum need of 2.5 MHz, which is less than the 3 MHz "center portion of the MedRadio band, at 402-405 MHz" identified by GEH in their filing of October 31, 2006 in Docket 06-135 at page 9. Thus, with careful attention to network design, BSN networks could be deployed successfully within this band. This band offers further improvements in terms of body-mounted antenna design, signal propagation characteristics, and ease-of-use.

Apparently the need for tens of megahertz of spectrum is motivated, as GEH states in the same filing, by the need to conserve battery life.[21] However, by increasing the duty cycle of individual BSN devices, at a manageable increase in battery drain, the total spectrum requirement can be decreased significantly.

The Nordic devices or comparable chips from other manufacturers can be operated, with no hardware modifications whatsoever, at 250 kbps instead of 1 Mbps. By using slightly larger batteries, the entire 40 MHz BSN architecture proposed by GEH could be implemented in only 10 MHz, such as the 2300 – 2305 MHz and 2395 – 2400 MHz bands.

Alternatively, GEH can revisit the use of the bands that were referenced as candidates in its earlier filings. Application of Monte Carlo techniques might well be appropriate for analyses of the potential for sharing between BSNs and incumbent services in these bands. To our knowledge, GEH has not performed Monte Carlo analyses using SEAMCAT for these bands.

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[21] In its October 31, 2006 filing in Docket 06-135 at page 9], GEH states, "GEHC expects BSN devices to use channels of approximately one megahertz, which allows the relatively low duty cycle needed to achieve necessary battery life. With relatively low duty cycles, of course, several BSN devices could operate on the same channel using TDMA technology. However, given that the ability to obtain perfect synchronization of distributed autonomous BSNs is unlikely, there is a limit to the amount of efficiency that can be gained from channel sharing."

VII. Conclusion

The results of this engineering study are summarized as follows:

1. New tests conducted using devices that accurately model the behavior of the BSN devices proposed by GEH demonstrate that these devices cause harmful interference to AMT at long distances. For example, at a range of 2.8 miles, a single 1 mW device operating outdoors at a 35% duty cycle produces an interference to noise ratio at an AMT receive site of 20 dB. In the absence of additional line-of-site blockage, a factor of more than fourteen increase in separation, i.e. to 40 miles, or 64 km, would be required to reduce the I/N ratio caused by this single device to the -3 dB aggregate level stipulated in Rec. M.1459. The 8 dB measured increase in noise floor due to three of these BSN devices operating at a distance of twelve miles from the AMT receive antenna supports this conclusion.
2. Blockage due to terrain and buildings will reduce the interference received at long distances. But at flight test ranges in which the terrain is flat and AMT receive antennas are located on towers and rooftops (as is usually the case), one cannot assume that terrain, foliage, or buildings will provide the blockage required to permit co-frequency sharing between BSN devices and AMT operations.
3. The measured noise floor in the band 2360 – 2390 MHz is not affected by spillover from unlicensed devices operating in the 2.4 GHz ISM band.
4. The Monte Carlo analyses presented by GEH presume a 1% outage rate is acceptable to AMT operators. Not only is this not the case, but the entire probability approach is irrelevant.
5. Body Sensor Network design options are available to GEH that would preclude the need for a co-channel spectrum assignment in the AMT band 2360 – 2390 MHz, and would render much more feasible other spectrum bands.

My qualifications to offer this statement, including substantial experience in the design and development of RF circuits, are set forth in the attachment.

Daniel G. Jablonski

Daniel G. Jablonski

Dated: February 23, 2009

JOHNS HOPKINS
UNIVERSITY
Applied Physics Laboratory
Laurel MD 20723-6099

Attachment

Daniel G. Jablonski
Physicist and Electrical Engineer
Principal Professional Staff
SEA
Space Department

1 SUMMARY

Dr. Jablonski joined the staff of the Johns Hopkins University Applied Physics Laboratory (APL) in 1991, working initially on the systems engineering of space-based early-warning systems for theater ballistic missile defense. He is now the supervisor of the Navigation Systems and Technologies section of the Space Systems Applications Group. Dr. Jablonski's research interests involve the use of electromagnetic systems for guidance and navigation, with emphasis on microwave and RF systems (GPS, Cospas-Sarsat, etc.) and X-rays (X-ray navigation and X-ray communication in space). He is active in spectrum management and policy issues related to flight test telemetry, and helps represent the country's flight test interests at the International Telecommunications Union in Geneva. Dr. Jablonski's experience prior to joining APL includes the design, manufacture, and deployment of numerous microwave and electromagnetic sensors and systems; research in superconducting electronics, information theory, and supercomputing; and the investigation of materials for micro- and millimeter wave applications.

Dr. Jablonski has been a member of the adjunct faculty at Capitol College, in Laurel, Maryland for over 20 years, and is a member of the adjunct faculty of the Whiting School of Engineering of the Johns Hopkins University. He teaches courses in microwaves, telecommunications, navigation, and electronics, and is a licensed Professional Engineer in the state of Maryland.

EDUCATION

Ph.D., Physics, Cambridge University, 1982
M.S.E.E. and C.S., Massachusetts Institute of Technology, 1977
B.S.E.E., Massachusetts Institute of Technology, 1976

WORK EXPERIENCE

1991 - Present: Staff Member, Johns Hopkins University Applied Physics Laboratory, Laurel, MD

1986 - 1991: Research Staff Member, Supercomputing Research Center, Institute for Defense Analyses, Bowie, MD

Conducted research on supercomputing, parallel processing, information theory, neural nets, models of computation, thermodynamics and cryptography; evaluated performance of Connection Machine and Cray-2 using prototype parallel processing languages.

1974 - 1986: Coop Student (1974 - 1977), Electrical Engineer/Physicist (1981 - 1986), Naval Surface Warfare Center, White Oak, MD

Worked on radar fuze design, electromagnetic pulse (EMP) studies, mine and anti-mine warfare; served as design engineer for Arctic research buoy; principal investigator in research on superconducting electronics, microwave properties of materials, and special sensors for explosive ordnance demolition applications; provided part-time engineering and management support to Electronics Division of Office of Naval Research, Arlington, VA.

1999 - Present: Instructor, part-time Programs in Engineering, Whiting School, Johns Hopkins University

Course instructor in microwave engineering, antennas, and avionics systems.

1985 - Present: Adjunct Professor, Capitol College, Laurel, MD

Professor, Electrical Engineering; course instructor in analog circuit design, control theory, fundamentals of communication, microwave circuits and devices, etc. Key participant in development of a new, ABET accredited EE degree program.

1978 - 1980: Consultant, Hirst Research Center of General Electric Company, Ltd, Wembley, England

Consultant on superconducting electronics.

2 SKILLS AND CAPABILITIES

Electromagnetics, GPS, superconductivity, solid-state physics, microwave engineering, circuit design, satellite communications, telecommunications engineering, evaluation of flight test telemetry systems, regulatory aspects of spectrum management.

MAJOR PUBLICATIONS/PATENTS

Patents

1. Semi-Active Notch Filter, No. 4,464,637, 2 August 1984.

2. High Output Bipolar Miniature Battery-Operated Programmable Current Source for Oceanographic Applications, with R. W. Watkins, No. 4,613,810, 23 September 1986.

3. Millimeter Wave Dielectric Waveguide Having Increased Power Output and a Method of Making Same, with A. D. Krall, No. 4,665,660, 19 May 1987.

4. Apparatus for and a Method of Determining Compass Headings, No. 4,881,080, 14 Nov 1989. (Cited by approx. 25 other patents; Dr. Jablonski holds an exclusive license to this patent pursuant to the Technology Transfer Act of 1995.)

5. Jablonski, et. al, "System and Method of Radar Detection on Non Linear Interfaces," No. 6,765,527, 20 July, 2004.

6. with others, "Lorentz Force Driven Mechanical Filter/Mixer Designs for RF Applications," No. 6,819,103, November 16, 2004.

7. "The Three Axis Antenna," disclosed within APL, September 2006.

8. Jablonski, et. al, “Technique for gravity gradient measurements for remote mass estimation of asteroids during non-orbital Fly-bys,” disclosed within APL, June 2007.

Sample Publications and Presentations

Photoconductive Damping of a Microwave YIG Filter, Bachelor’s thesis, Massachusetts Institute of Technology (1976).

Investigation of Dielectric Waveguide at 70 GHz, Master’s thesis, Massachusetts Institute of Technology (1977).

Superconducting Tunnel Junctions and Their Electronic Analogues, Ph.D. Thesis, Cambridge University (1981).

“Attenuation Characteristics of Circular Dielectric Waveguide at Millimeter Wavelengths,” IEEE Trans. Microwave Theory Tech. 26(9), 667-671 (1978).

“High Frequency Impedance of Superconductive Tunnel Junctions,” J. Low Temp. Phys. 51(3/4), 433-451 (1983).

With A. D. Krall and J. Coughlin, “Radiation Properties of a Gaussian Antenna,” Microwave J. 27(5), 283 and 288 (1984).

“Power Handling Capabilities of Circular Dielectric Waveguide at Millimeter Wavelengths,” IEEE Trans. Microwave Theory Tech. 33(7), 85-89 (1985).

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