Before The
FEDERAL COMMUNICATIONS COMMISSION
WASHINGTON, DC 20554

In the Matter of	)	
	)	
Amendment of the Commission's Rules to Provide Spectrum for the Operation of Medical Body Area Networks	)	ET Docket No. 08-59
	)	
	)	
To: The Commission	)	

COMMENTS OF AEROSPACE AND FLIGHT TEST RADIO COORDINATING COUNCIL

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SUMMARY

The Commission has long recognized, and protected, the 2360-2390 MHz band for flight testing due to its safety-related purposes. The use of S-band telemetry enables ground engineers to monitor the conduct of tests on a real-time basis, warn the aircrew in the event anomalous conditions are detected, diagnose the problem and provide instructions to the aircrew. If disaster strikes, real-time telemetry enables engineers to reconstruct the cause of the accident. This is true for all flight testing, whether civil or government (military and NASA). Any interference to this telemetry is harmful; and will significantly hurt the US aerospace industry, the US taxpayer, and the flying public in terms of dollars, global competitiveness, and, potentially, human lives.

Test conducted by Johns Hopkins University Applied Physics Laboratory and Learjet have confirmed that MBANS devices will cause significant interference to sensitive AMT receive antennas. Moreover, it is likely that flight test aircraft on taxi, on take-off, on landing and transit, for example, will cause interference to MBANS devices.

This mutual interference scenario should be avoided, and the Commission should not seek to mix a safety-related service and medical telemetry applications in the 2360-2390 MHz band.

The probability (aka Monte Carlo) analysis presented by MBANS proponents should be discarded as unreliable. The technique is notorious for producing results that underestimate worst-case risk. Moreover, as utilized by the proponents, the technique minimizes the effects of one of the most salient characteristics of aeronautical mobile telemetry ("AMT"), i.e. deep fades in the received signal. It does this by disregarding the key criterion in the internationally accepted Recommendation, i.e. the interference-to-

noise ("I/N") ratio, in favor of the more liberal carrier-to-interference plus noise ("C/(I+N)") ratio. In so doing, it is able to posit an outage rate of 1.7 percent which, while still harmful for AMT communications, is a far cry from the 20 percent outage rate produced by use of the correct criteria.

MBANS proponents are wrong in their assertion that the band is already subject to significant out-of-band interference. Noise-floor studies being submitted by Cessna and Boeing confirm that the band is noise-, not interference-, limited.

Nor are mitigation measures, such as exclusion zones, practical. Any such zones would have to be line-of-sight based, i.e. very large. There is no way of enforcing such zones since MBANS devices are intended to operate autonomously. And exclusion zones could not work given the aerospace need for mobile AMT facilities.

Frequency coordination is not an option either: It is unrealistic to expect an MBANS-equipped hospital to shut down its devices when a new, fixed or mobile AMT system, seeks to operate in the same area as a hospital. It is unlikely that the Commission would be able to enforce a timely shut-down, even if it were of a mind to do so.

Putting the above aside, and strictly for the sake of discussion, it is also clear that the Commission should not, under any circumstances, allow MBANS usage for life-critical/or time-sensitive applications. While nominally secondary, medical telemetry devices have been treated as super-primary in prior interference disputes. The Commission does its entire regulatory regime a gross disservice if it does not require a non-life-sensitive/non-time-critical restriction -- as well as bold consumer warnings on MBANS devices to back it up.

There are alternative proposals which avoid all of these problems, for example, an allocation for MBANS in 2300-2305/2390-2400 MHz, where MBANS users could also access 2.4 GHz frequencies if needed. Indeed, of the alternative bands which might be considered (bands including 5.1 GHz), this particular solution offers the potential for a primary or co-primary allocation.

For these and the other reasons set forth in these Comments, an MBANS allocation in 2360-2390 MHz should not be pursued.

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TEST RADIO COORDINATING COUNCIL

Aerospace and Flight Test Radio Coordinating Council ("AFTRCC"), by its counsel, hereby submits its opening comments on the Notice of Proposed Rulemaking, FCC 09-57 (the "Notice" or "NPRM") in the above-captioned proceeding.

The Notice proposes to create a spectrum allocation for Medical Body Area Network ("MBAN") devices. It asks for comment on various allocation options including 2360-2390 MHz, which is used exclusively for flight testing aircraft and missiles; 2300-2305/2390-2400 MHz; 2.4 GHz; and 5.15 GHz. An allocation in the first band (2360-2390 MHz) would be secondary, while an allocation in the second set of bands (2300-2305/2390-2400 MHz), and perhaps others, could be primary. The Notice also asks for comment on compatibility issues, on licensing regimes, and on service rules, including whether MBAN devices should be limited to non-life-critical, non-time-sensitive functions.

In AFTRCC's view, MBAN devices could serve a useful purpose as a secondary allocation, but only if they do not cause interference to, or otherwise constrain, the primary service, flight test telemetry, and only if they themselves are not subject to interference from

flight test operations.[1] Based on the record developed to date, and the points discussed herein, it is clear that those conditions cannot be satisfied by an allocation in the 2360-2390 MHz band. Accordingly, should the Commission take any action to support MBANS it should not include an allocation in 2360-2390 MHz.

I. INTRODUCTION

As the Commission's records reflect, AFTRCC is an association of the nation's principal aerospace manufacturers. AFTRCC was founded in 1954 to serve as an advocate for the aerospace industry on matters affecting spectrum policy. Among its many accomplishments is AFTRCC's role in obtaining allocations of spectrum for flight test telemetry, including the 2360-2390 MHz band at issue here. A listing of AFTRCC Member Companies is attached as Exhibit A.

AFTRCC is also the recognized non-Federal Government coordinator for the shared, Government/Non-Government spectrum allocated for flight testing. AFTRCC works closely with Government Area Frequency Coordinators, who are responsible for Federal Government use of the spectrum, in an effort to ensure that flight safety is maximized and interference-free flight test operations are protected.

II. BACKGROUND

In earlier filings in this proceeding,[2] AFTRCC has detailed the importance of real-time telemetry to the safe and efficient development of new and modified aircraft and missiles; the sensitivity of the high-gain parabolic antennas used to gather telemetry signals from distant test vehicles; the impending development of new, high-power uplink technologies; and the adverse

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[1] For ease of reference, flight test telemetry is also referred to as aeronautical mobile telemetry, or "AMT," in these Comments.

[2] *See*, e.g., Comments filed May 27, 2008; Reply Comments filed June 11, 2009.

and potentially disastrous consequences of interference for Government and Non-Government aviation programs. AFTRCC sponsored field tests confirming the risk of co-channel interference as predicted by analytical studies and conducted in accordance with the relevant, internationally-approved recommendations. Certain of those tests were performed by Learjet at its test facility in Wichita, Kansas. Others were performed by the Johns Hopkins University Applied Physics Laboratory. The results of these tests show that MBANS will interfere with telemetry signals at distances corresponding to the line-of-sight from the AMT antenna to the MBANS device.

III. DISCUSSION

A. Interference analysis

One of the central issues identified in the Notice are the differing methodologies used by AFTRCC and GE Healthcare ("GEH") to analyze the interference risk from MBANs to flight test telemetry. *Id.* at ¶ 52. The Commission observes that it has not necessarily been persuaded to this point by either analysis, and asks for further comment on the appropriate methodology issue. In order to address this issue, it is critical to first establish the proper foundation.

1. Aviation safety

The Commission has long recognized flight test telemetry as a safety-of-life service, and AMT spectrum as not suitable for sharing with other services.

Flight testing is synonymous with high-risk activity, and the potential for loss of life is ever-present during the conduct of commercial and military aircraft testing. AFTRCC members have encountered life-threatening situations involving flight tests of general aviation, commercial, and military aircraft. These problems have ranged from hydraulic system failure preventing landing gear deployment, to low frequency oscillations in a tail assembly, to foreign object debris jamming elevators during a stall test. In each of these cases, real-time telemetry

was instrumental in detecting and/or diagnosing the problem and in providing instructions on steps to bring the pilot and aircraft home safely.

For example, in one recent incident involving a new model business jet, abnormal vibration was detected in the control surfaces during flutter tests.[3] Ground engineers spotted the problem via real-time telemetry during a dive, and immediately warned the pilot to abort. Thereafter, many days of flying and a multitude of test points were flown to isolate the cause. A team of engineers on the ground carefully monitored the vibration data in real time, and repeatedly were required to warn the pilot to abort specific maneuvers based upon the live telemetry data. The aircraft had to be pushed hard enough for the oscillation to manifest itself and data taken, but not so hard that a catastrophic failure was risked. Monitoring this balance would not have been possible without the continuous and uninterrupted receipt of telemetry. Ultimately, enough data was collected over numerous flights and test points to identify the cause of the oscillation. The aircraft design was modified, and subsequent testing verified that the modification had eliminated the problem.[4]

The use of real-time telemetry enables test operators to minimize the number of personnel on board aircraft during these necessary and risky flights. If disaster strikes and the aircraft is lost, recordings of the real-time telemetry enables engineers to reconstruct conditions aboard the aircraft just prior to the failure and more readily identify the cause, information which can then be applied to fix the problem. Of course, with missile tests, the only practical means of

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[3] A test where the wings, tail assembly and control surfaces are stressed to the maximum in order to determine points of harmonic resonance that can cause airframe failure

[4] In one incident, the prototype of a tactical aircraft now in standard use with the military was saved enroute from the manufacturer's facility to Patuxent when engineers on the ground detected overheating in certain components by means of the real-time telemetry stream. They were able to warn the pilot, and provide instructions to avert the problem.

gathering data during test flights is by means of real-time telemetry since such flights are, by definition, one-way.[5]

It is against this background that the Commission has long characterized flight test telemetry as supporting safety-of-life. For example, 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."[6]

In 1989, the Commission determined that the telemetry bands should be classified as "Restricted" and protected from fundamental emissions of unlicensed devices (such as, in effect, MBANS devices were they to be licensed merely by Rule). In so doing the agency stressed that the telemetry band "involv[es] safety of life."[7]

In 1990, the Commission declined to reallocate flight test telemetry spectrum for broadcast auxiliary operations, even on a secondary basis, explaining:

> "In short, sharing of these frequencies with unlike services is difficult at best because schedules of telemetry flight tests are unpredictable and delays costly. Further, interference cannot be 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."[8]

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[5] The presence of real-time telemetry also greatly improves the efficiency with which a flight test program can be conducted in contrast to other data collection methods such as on-board recording. Aircraft can be cleared for multiple test points during a single flight, instead of having to return to base for data analysis before being allowed to progress to the next set of test points. This saves time and money, and enhances global competitiveness.

[6] *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.

[7] *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).

[8] *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).

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."[9]

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." [10]

The Commission even went on to say that "[w]e 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."[11] Nothing has changed in the years since to alter the soundness of these conclusions; on the contrary, they are even more germane in the light of the instant co-channel sharing proposal.

To be sure, not all flight testing involves the highest risk maneuvers, such as "flutter" testing or spin tests.[12] But even "ordinary" flight tests such as envelope expansion[13] involves significant risk to the pilot and persons on the ground. It is for this reason that AFTRCC Member Companies strictly limit the number of persons who can be on board aircraft during

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[9] *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).

[10] 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).

[11] *Id.* at 6061 para. 102.

[12] Tests which determine the conditions which can cause a spin and the best means of recovering.

[13] Determining the characteristics and performance of the aircraft at a large number of attitude, power, and control surface combinations.

such tests.[14] Moreover, from day-to-day, even hour-to-hour, the same spectrum used for a simple avionics test, for example, can be, and often is, used for a more dangerous spin test. In other words the entire spectrum resource supports safety-of-flight.

2. The Monte Carlo analysis is fatally flawed.

The probability (aka Monte Carlo) analysis in the record does not take proper account of the realities of flight test operation. On the contrary, the analysis artificially diminishes the apparent risk to flight safety by focusing on average, rather than worst-case performance of aeronautical telemetry systems. The Engineering Statement of Daniel G. Jablonski, PhD., attached hereto as Exhibit B, analyzes these shortcomings.

At the outset, the Statement observes that the use of the Monte Carlo techniques, in lieu of a deterministic method, is unnecessary. Given the relatively simple mathematical models of the probability distributions assumed (uniform spacing in azimuth, an analytic expression for fades in the AMT budget, and a constant BSN duty cycle, for example), direct computation is quite practical. However, use of the Monte Carlo approach does capitalize on one element, namely the well-known tendency of this methodology to understate worst-case results by reducing the predicted likelihood of extreme and "hot spots."

For example, because it obscures the potential for extreme results, the Wall Street reliance on Monte Carlo simulations has been widely criticized as having contributed to a false sense of security in assessing the risk of the increasingly aggressive investment strategies at the heart of the meltdown earlier this year.[15]

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[14] In one instance a few years ago, seven Airbus engineers were killed when an Airbus 330 crashed during acceptance testing.

[15] Eleanor Laise, "Odds on Imperfection: Monte Carlo Simulation; Financial Planning Tools Fail to Gauge Extreme Events," *The Wall Street Journal*, May 2, 2009, http://online.wsj.com/article/SB124121875397178921.html

In addition to the tendency of the model to understate worst case results, there are a number of specific deficiencies in the GEH analysis detailed in the Engineering Statement.

For example, the analysis minimizes the effects of fades in the AMT link due to aircraft maneuvers and the resulting changes in antenna aspect angles, and multipath. In particular, it uses a carrier to interference plus noise ("*C/(I+N)*") ratio, rather than the interference to noise ("*I/N*") ratio prescribed by ITU-R Recommendation M.1459. The Recommendation avoids use of the *C/(I+N)* ratio precisely because the power level, "C," of the telemetry signal, as measured at the telemetry ground station, is significantly affected by fades, whereas the ratio *I/N* is independent of this highly variable factor and provides a more realistic understanding of the effect of fades on the telemetry signal path.[16] Furthermore, it is essential that worst case fades be anticipated and measures taken to protect against such phenomena.

In addition the scenarios presented by the analysis are contrived. Specifically, the GEH Monte Carlo simulation provides results for 10 scenarios. Scenarios 1-6 and scenario 9 in effect assume test aircraft fly in a circle of radius 320 km while MBANs devices, operating at various transmit frequencies and duty cycles, pop into the field of view of the telemetry receive antenna's main lobe. As the Engineering Statement explains, these seven scenarios, while seemingly conservative, in fact minimize the chances that a medical device would be in direct view of an AMT receive antenna, as well as the number of MBANS devices operating in a 5 MHz channel. These scenarios should be dismissed out of hand.

Test aircraft do not fly in circles around ground stations. Their location in the flight test airspace is dictated by compromises among:

[16] In fact, GEH's Monte Carlo Exhibit exploits the existence of this fade margin by reclaiming it as interference margin to suit its own purpose. If AMT operations didn't need this fade margin, AMT links would be implemented so as to use the margin to transmit more data to the ground in the same bandwidth by using advanced modulation techniques that, unfortunately, are less robust against fades.

- the technical requirements of the tests being conducted (e.g., flutter tests, dives, stall testing).
- FAA air traffic control directives and restrictions (which depend on the use of airspace by non-test aircraft, a probabilistic constraint not accounted for by GEH)
- the need to share airspace with other test aircraft
- local weather conditions
- geographical constraints (mountains, water bodies, etc.)

As noted above, the use of a circle flight pattern with a high gain AMT receive antenna, minimizes the likelihood of interference, and avoids having to deal with worst-case scenarios where the aircraft "dwells" at an azimuth angle populated by BSNs.

The Monte Carlo report includes only one scenario in which both the aircraft and a cluster of its devices remain in main-beam conjunction for the duration of the simulation. When the results of this case, identified as scenario 10, are examined -- with *C/(I+N)* used as the interference criterion -- complete loss of the telemetry link occurs 1.7 percent of the time even by GEH's reckoning, an outage which is harmful.[17] Moreover, that result is obtained only because, by using the carrier/interference plus noise ratio (rather than interference to noise, as discussed above), the analysis discounts the fluctuating characteristic of AMT signals. When the correct values of *I/N* are used as the interference criterion -- even using GEH's own suggested exclusion zone radius of 9.7 km **-- the *I/N* limit of -3 dB is violated fully 20 percent of the time**!

Replacing *I/N* criteria with probabilistic *C/(I+N)* criteria in these bands

- eliminates essential protections for the primary users of these critical bands,
- changes the bands from being noise-limited to being interference-limited, and
- undermines the existing International Radio Regulations by presuming to endorse the use of statistical analyses for the Restricted bands defined in Rule 15.205.

[17] Scenarios 0 and 8 are presented as calibration cases only and do not include any interference sources. Scenario 7 does not accurately model the distribution of MBANS devices across the main beam of the AMT antenna. See Engineering Statement, page 10.

By using *C/(I+N)* criteria, the risk of, and effects from, short-term interference to an incumbent, primary user become seemingly acceptable. However, as the Engineering Statement explains, such interference is in fact harmful since, among other things, a short term interruption in the telemetry stream can cause loss of bit sync, loss of multiple contiguous data frames, loss of antenna tracking, and complete loss of the ability to track an aircraft.[18] For critical flight segments, if even a single bit in a data frame header word is lost, the link is considered to be corrupt until bit sync is re-established and multiple data frames are received with no corrupt headers, during which interval additional data is not received.

Once bit sync and data frames are lost, the next component in the test hierarchy to fail is the control loop of the highly directional AMT antenna since the antenna tracks the aircraft by means of the received signal itself. When aircraft are at distances of 70 miles or more, re-acquiring the aircraft is a time-consuming process during which the aircraft must loiter, burning fuel, or even return to base. In the presence of interfering co-channel signals, it may not be possible to locate and re-establish tracking of the aircraft without first having the aircraft return to close proximity of the receiving antenna. Interference scenarios like this are highly likely given GE's proposal.

In the case of spin recovery testing, for example, the risk of the aircraft entering a non-recoverable "flat spin" puts both the aircraft and flight crew at extreme risk. Re-flying tests is particularly dangerous. The fade margin provided for by ITU-R Recommendations is a critical asset enhancing the safety of flight testing.

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[18] GEH is cognizant of the distinction between interference-limited and noise-limited spectrum. In earlier filings, it has insisted that the 2360 – 2390 MHz band suffers extensive interference from the adjacent 2.4 GHz ISM band. This is the case despite claiming the entire interference budget *I/N* of -3 dB in the Monte Carlo simulations for its devices, notwithstanding the alleged presence of other interference sources in the band.

In short, there is no merit to applying the GEH Monte Carlo methodology to assess the risk of interference to AMT. To the contrary, the deterministic analysis presented by AFTRCC remains the only appropriate approach -- and the only approach consistent with the international Recommendation which the United States labored long and hard to secure, and which it has relied upon to protect AMT spectrum at the last two World Radiocommunication Conferences.[19]

3. Other deficiencies in the MBANS analysis.

GEH has endorsed the use of Nordic chips for MBANS devices, as well as yet-unavailable devices from Texas Instruments. At the same time, the proposed secondary allocation in 2360-2390 MHz has been supported by other filings promoting use of "cognitive radio" techniques. However, as AFTRCC has pointed out previously,[20] the Nordic application notes for the nRF2401 family of devices specifically recommend against their use for the cognitive, frequency-hopping techniques proposed by GEH and its allies.

Separate and apart from unsuitability of Nordic chips in this application, cognitive radio techniques such as contention-based protocol are not capable of detecting the very weak signals characteristic of AMT and other Restricted band services when the aircraft are distant from AMT ground stations. AFTRCC spelled this out in detail in earlier filings in this docket.[21] The limitations of these techniques have been recognized by GEH itself which has argued against spectrum sensing as adequate to protect its medical devices.[22]

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[19] The approach pursued by the proponents here is in stark contrast to that of other medical device proponents. When Medtronic successfully proposed allocation of the 402-405 MHz band for medical implant devices, it specifically relied upon the relevant international Recommendation. See Report and Order in WT Docket No. 99-66, FCC 99-363, released November 29, 1999, at ¶ 8. It did not disregard portions of the Recommendation that it found inconvenient, only to then try to write its own standard.

[20] *See* ex parte filed July 28, 2008 at note 17.

[21] *See*, e.g., AFTRCC ex parte of August 1, 2009 at p. 8.

[22] See GEH Comments filed January 31, 2007 in ET Docket No. 04-186, at 5-6 (GEH "not confident that the still-undefined sensing technology to be incorporated into the TV band devices will be able to provide adequate protection to telemetry users").

GEH has also argued that there are extensive out-of-band interference sources in the AMT allocation at 2360-2390 MHz from Part 15 and other devices operating in, for example, the 2.4 GHz band, which signals are permissible under the Commission's Rules; that the addition of co-channel interference from MBANs devices would not add to this; and that AMT is already subject to significant outages.[23] There is no merit to these arguments.

In the long experience of flight test engineers extraneous signals are confined almost entirely to the 10 MHz above the flight test band, i.e. 2390-2400 MHz, which serves effectively as a guard band for AMT operations. Out-of-band signals below 2390 MHz are infrequent and isolated.[24] This should not be surprising given the fact that 2360-2390 MHz has long been Restricted under Commission and NTIA Rules, i.e. off-limits to fundamental emissions by any operations other than flight testing. 47 C.F.R. Section 15.205.[25]

To further elucidate, AFTRCC Members, Cessna Aircraft Company and The Boeing Company, recently conducted studies of the noise floor at Wichita and Seattle, respectively. The results of their analyses confirm the industry experience that flight test telemetry systems are noise-, not interference-, limited as alleged by GEH.

Commission Rule 15.205 defines Restricted Bands in order to support safety-of-life functions, such as aeronautical radionavigation, military satellite communications, and scientific observation. In the Cognitive Radio Proceeding, the Commission addressed the issue of allowing unlicensed use in the Restricted bands, but determined not to alter its policy prohibiting such operation. On the contrary, even though it allowed the certification of Part 15 devices

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23 GEH ex parte, October 30, 2008.

24 No incidents of interference have been reported from the lower adjacent band, 2345-2360 MHz, where there has been virtually no activity to date.

25 See also National Telecommunications and Information Administration Comments filed February 15, 2005 in ET Docket No. 03-108, at 1 ("Given the large number of Part 15 devices in use today, [National Telecommunications and Information Administration] is unaware of any reports where a compliant unlicensed device has interfered with another authorized spectrum user").

capable of operating in other countries within bands designated at Restricted in the U.S., it required that those devices incorporate features specifically limiting operation to permissible frequencies when in the United States.[26]

B. Exclusion zones

The Notice suggests that sharing between AMT and MBANs could potentially be facilitated "if we establish effective exclusion zones around AMT test flight sites…." *Id*. at ¶ 22. However, the Commission also acknowledges that "use of exclusion zones could frustrate the widespread use of MBANs devices," particularly if the exclusion zones were large, e.g., line-of-sight. *Id*. at ¶ 36; cf. ¶¶ 19, 48.

In its earlier filings, AFTRCC documented the results of Learjet and Johns Hopkins tests. The Johns Hopkins tests confirmed the severe impact that a 1 mW device has on telemetry receivers using the same chips proposed by GEH -- e.g., the fact that significant interference was created at a distance of 12 miles.[27] It was Johns Hopkins' considered view that MBANS devices anywhere within line of site of an AMT receive dish would cause a similar effect. For example, doubling the distance from the MBANS devices to the AMT ground station would decrease the received interference signal by only 6 dB, a condition which still results in an impact to the ground station.

In AFTRCC's view, exclusion zones are neither practical nor enforceable. First of all, as the Johns Hopkins tests demonstrated, any such zones would have to be line-of-sight based, i.e. large -- very large -- in order to ensure that MBANs systems not cause co-channel interference to tower and roof-mounted telemetry receive antennas. This has been established by the Johns

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[26] *See Notice of Proposed Rulemaking and Order* (FCC 03-322) at ¶ 31; *Report and Order* (FCC 05-57), ¶¶ 39, 72, 77.

[27] See AFTRCC ex parte filed February 23, 2009 at Test Report, page 16.

Hopkins tests. Exclusion zones of such size would eliminate entire metropolitan areas such as Los Angeles, California; Wichita, Kansas; Seattle and Everett, Washington; and St. Louis, Missouri to name a few.

Another issue concerns future AMT test sites. See Notice at ¶ 55. Use of mobile AMT facilities is routine today by both Government agencies and aerospace companies. These mobile facilities are used frequently for specialized tests (e.g., icing), and in order to avoid unfavorable weather conditions, air traffic congestion, or other issues that can hamper fixed flight test center operations. There is no practical way to establish exclusion zones in the case of mobile AMT facilities.

As primary users, neither Government nor civil flight test agencies are to be constrained lawfully in their use of 2360-2390 MHz spectrum by secondary devices. Yet, it appears unlikely that the Commission is prepared to issue an order to a hospital to cease MBANs operations which happen to be in a new or temporary exclusion zone. These problems underscore AFTRCC's position that the notion of these two life-critical, but unlike, applications sharing spectrum is fraught with problems for the Commission licensees and the public.

AFTRCC's chief concern with exclusion zones is that of enforceability. The business case for MBANs is heavily predicated on ease of use and enhanced mobility/flexibility.[28] Typical patient monitoring devices are <u>expressly</u> <u>designed</u> to be worn for 24, 48, or more hours by the patient in his or her daily routine, e.g., eating, sleeping, and working. See Exhibit C. It is predictable, if not inevitable, that patients will be instructed to wear MBANs units outside the hospital setting. That is exactly what Philips Healthcare Systems has already envisioned for

[28] See, for example, 08-59, GEH ex parte of March 13, 2009.

MBANs.[29] It is equally predictable that vendor sales reps will be under pressure to sell MBANs units with the widest possible spectrum flexibility. It is unrealistic to expect that these devices will be confined to use outside exclusion zones, or 2390-2400 MHz within exclusion zones.

The exclusion zone problem is exacerbated by the MBANS architectural design which contemplates that the devices would constitute an autonomous broadcast node, rather than a two-way link. There is no mechanism to limit operation to indoor use only by, for example, having a base station/host controller within the healthcare facility which must grant permission for a BSN to transmit. A patient discharged with instructions to wear a device for a day or two to monitor heart function, for example, or simply stepping outside the hospital to have a cigarette, will continue to transmit. As discussed, such signals would be easily seen by tower or building-mounted AMT antennas at line of sight distances, even with nominal foliage blockage and multipath fades.

C. In-Building Use

Beyond this, there are issues even with usage nominally confined to hospitals. Transmissions from MBANS located in the interior spaces of a hospital would likely be attenuated by walls and the like. Notice at ¶ 22. However, MBANS used in exterior patient rooms would offer little attenuation, and upper-story rooms of metropolitan hospitals could have clear line-of-sight to AMT receive antennas. Measurements of typical building attenuation during the Johns Hopkins tests show factors ranging from 0 – 30 dB (in contrast to the 6 – 12 dB values suggested in an early discussion with FCC engineers).

[29] See ex parte statement filed in this docket on May 18, 2009 at page 8 (focusing on scenarios where, via MBANS, a "patient's family [can] identify a failing patient" such that "appropriate radio technology [can] allow sensors to reliably and inexpensively relay their information so that clinicians can respond in a timely fashion").

For all these reasons, AFTRCC sees exclusion zones as being impractical, and unenforceable. Only if there is a technological, fail-safe function built-in such that the devices could not radiate in an established, new, or temporary exclusion zone, would exclusion zones present a meaningful opportunity for AMT and MBANS to share the 2360-2390 MHz band without endangering safety-of-life. For example, a host-controller configuration along the lines of that set forth in Rule 15.202, or perhaps a geo-location capability not unlike that required for TV white space devices, would be essential.

While exclusion zones needed to protect AMT operations must be centered about the location of the AMT ground station, flight test aircraft will potentially interfere with MBANS devices in hospitals while aircraft taxi, take-off, land, and transit to and from test areas (areas where an exclusion zone may not exist). As discussed in the Engineering Statement, there can be no assurance that there will be unoccupied spectrum to hop to, and the impact of hopping on the efficiency of the network will be significant. Take, for example, helicopter tests such as those conducted by AFTRCC Members Bell Helicopter at Fort Worth or Sikorsky Aircraft at West Palm Beach. In these instances, the exclusion zone is determined by line of sight from the aircraft to the affected healthcare facilities, an area that will be a great deal larger than the possible exclusion zones surrounding flight test ground stations. It would take only two helicopters, operating simultaneously in the same flight test range, to occupy the entire 30 MHz of the AMT band.[30]

Furthermore, as the Notice observes, AMT technologies in the development stage look toward the use of high-power, omni-directional uplink transmitters. Notice at ¶23. The S-band spectrum at issue is ideally suited for this technology given its allocation for two-way

[30] It is precisely because of the large interference zones created by aircraft, that numerous bands in the Table of Allocations, even Mobile bands, contain an aeronautical exclusion.

telecommand and telemetry, i.e. uplink and downlink, applications. Given the questions about the efficacy of contention-based technology in this setting, and the fact that it is unproven in the MBANS application, the presence of interfering signals from high-power sources like these further complicates the sharing scenario.

D. MBAN devices should not be allowed for life-critical operations.

The Commission invites comment as to whether its Rules should proscribe life-critical and/or time-sensitive functions for MBAN devices. *Id*. at ¶ 40. Such a policy should be mandatory given the Commission's history with nominally secondary, realistically super-primary medical telemetry applications. An express limitation to non-life-critical applications would be of significant help to the Commission if the agency found that MBANS were causing interference to flight test telemetry operations and the devices needed to be shut down -- a likely scenario under the wholly unrealistic 9.7 km separation proposed by MBANS proponents. Otherwise, the agency invites a Hobson's choice similar to that which it faced in Dallas some years ago when it was compelled to protect a secondary medical telemetry system against a primary television station, namely the medical telemetry at Baylor University Medical Center and Methodist Dallas Medical Center. That episode required the diversion of major OET resources and ultimately led the Commission and the FDA to issue an unusual "Joint Statement ... Regarding Avoidance Of Interference Between Digital Television And Medical Telemetry Devices."[31]

[31] http://www.fcc.gov/Bureaus/Engineering_Technology/News_Releases/1998/nret8003.html ("fortunately no patients were significantly affected."); see also OET Fact Sheet, http://www.fcc.gov/oet/faqs/medical.html.

When the Commission established the Wireless Medical Telemetry Service ("WMTS") in June 2000,[32] the agency recognized the regulatory problems it faced from nominally "secondary" medical telemetry devices, and warned the medical telemetry community that:[33]

> Our goal in this proceeding is to not only provide spectrum where medical telemetry equipment can operate without interference, but also to encourage medical telemetry users to eventually migrate out of the current bands. Despite the fact that medical telemetry has no legal protection from interference in these bands, the fact remains that the Commission has had to take steps to protect medical telemetry from interference because it is used to protect safety of life. The steps the Commission has taken, such as the freeze in the 450-470 MHz band and the requirement for DTV stations to notify nearby health care facilities, affect other parties.

Even GEH has attacked the notion of secondary allocations for medical telemetry, arguing in bolded comments on the 1427- 1432 MHz band in WT Docket No. 07-100 that **"The Commission Should Not Risk Patient Safety By Permitting Secondary WMTS Operations . . ."**[34]

With a prohibition on life-critical use, hospitals will be on notice that MBANS are not to be used for such applications; hence, they should have no standing to object to interference in the likely event that it arises. Moreover, GEH, Philips et al will be on notice that they must warn potential customers that MBANs devices are not to be used for life-critical purposes. And, most importantly, the Commission would have adopted a rule consistent with secondary regulatory status, rather than allowing something to operate nominally on an NIB basis which is anything

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[32] *Report and Order* in ET Docket No. 99-255, 15 FCC Red 11206 (2000). The Commission stated explicitly that "This action addresses consumer concerns that medical telemetry devices are increasingly at risk of harmful interference due to more extensive use of spectrum resources by other applications."

[33] *WMTS R&O*, 15 FCC Red at 11225 ¶ 57 (emphasis added). See also *Notice* at ¶5 ("The Commission established the WMTS because existing medical telemetry devices operating in other frequency bands were receiving interference from incumbent users in those bands.") The *Notice* goes on to reference the fact that since 2000 the agency has refused to issue new equipment approvals for unlicensed medical telemetry equipment operating on an unlicensed basis or licensed under Part 90 (except for 1427-1432 MHz). Instead, all new approvals have been issued under the WMTS in Part 95. *Id.*

[34] Reply Comments of GE Healthcare filed September 11, 2007 in WT Docket No. 07-100 at Section III (emphasis in original).

but secondary in actual practice. This in turn would enable the Commission to avoid the regulatory trap that tolerance for a "life-critical" secondary allocation entails. [35]

In AFTRCC's view there is no need for the Commission to define "life-critical" or "time-sensitive." The medical technology communities are more than qualified to determine what kinds of uses should fall within these limits. But it is the Commission's mandate to regulate the radio spectrum. Indeed, the agency has adopted a host of Rules designed to protect and enhance the safety-related use of radio technologies. Given its unhappy history with the attempted regulation of "secondary" medical devices, anything less in this case (i.e. in the event, *arguendo*, that an allocation were made to 2360-2390 MHz) would be unreasonable, if not irrational. Thus, it is enough for the Commission to simply proscribe life-critical/time-sensitive uses.

Consistent with the above, AFTRCC would urge a user caution much more explicit than that cited in the Notice (*id*. at ¶¶ 75). The advisory cited is as follows:

> "This device may not interfere with stations authorized to operate on a primary basis and must accept any interference received, including interference that may cause undesired operation . . . . Although this transmitter has been approved by the Federal Communications Commission, there is no guarantee that it will not receive interference or that any particular transmission from this transmitter will be free from interference."

Instead, AFTRCC would urge addition of the following sentences in bold, large type:

> **THIS DEVICE SHOULD NOT BE USED FOR LIFE-CRITICAL OR TIME-SENSITIVE FUNCTIONS. ANY SUCH USE IS CONTRARY TO FCC RULES AND POLICY, AND IS AT THE USER'S SOLE AND EXCLUSIVE RISK.**

[35] In the recent *MedRadio Service Report and Order*, FCC 09-23, released March 20, 2009, the Commission declined to adopt non-life-critical/non-time sensitive requirements for 25 microwatt devices. *Id.* at para. 36. However, there the primary incumbents did not involve safety-of-flight communications, but rather meteorological aids and earth exploration satellite. The probability of interference from MBANS to AMT or vice versa, and the absence of the unique core band/wing band technology split available for MICS, warrants the more exacting approach urged here.

Consumers, including hospital personnel, doctors and nurses (let alone patients), cannot be expected to grasp the import of boilerplate FCC advisories written in opaque spectrum-ese; on the contrary, in this context a plain vanilla advisory runs afoul of elementary principles of consumer disclosure law. The Commission's entire thrust in the recent *Truth-In-Billing Notice* of Inquiry (FCC 09-68), released August 28, 2009, is improved consumer information and awareness. Indeed, as the Notice states, "Protecting and empowering American consumers is a core responsibility of the Commission." *Id*. at para. 2. It would be ironic indeed, not to say contradictory, were the agency not to require stronger disclosures in a case where a safety-of-life application is involved.

Furthermore, the warning label should be affixed to the main control unit, as well as the receiver worn by the patient, <u>and</u> displayed prominently in the instruction manual. Of course, the marketing rules should reflect that the device is to be used only for the permitted purposes.

Rules for MBANS should also require that the user make the device available for inspection upon request by a Commission representative, and that the user not just "reasonably cooperate" in resolution of interference problems, but immediately suspend operation upon request by the Commission. *Id*. at p. 28.

E. Alternative Bands

The Notice seeks comment on the MBANs spectrum requirement (*id*. at ¶ 21), and on issues relating to alternative bands, including use of 2300-2305 and 2390-2400 MHz. *Id*. at ¶ 24.

Preliminarily, it should be noted that the 2390-2395 MHz band was allocated to AMT on a co-primary basis with amateurs several years ago. However, the band is of little use for flight testing since there is no way of controlling the risk to AMT of co-channel interference from amateur transmissions. The risks and liability associated with potential interference in this band means it is impaired for flight test purposes. It is for this reason that AFTRCC suggests that this

band, together with 2300-2305 and 2395-2400 MHz, be reallocated for MBANS. This would produce 15 MHz of useful spectrum for MBANs.

GEH has stated that, in order to be effective:

> 5-10 megahertz of spectrum will need to be available for BSN communications at any given location, 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.[36]

If an allocation were made on a primary basis, MBANs would have spectrum rights equal to those of amateurs who make limited use of 2390-2400 MHz for applications like fast-scan TV, and rights superior to those of amateurs at 2300-2305 MHz where the amateur allocation is secondary. If yet additional spectrum were desired, the adjacency to the 2400 MHz band could lend itself to that purpose.

Significantly, the American Radio Relay League, while not dismissing the possibility of MBANS interference to amateur operations, has stated "far more concern[ ]" about the potential for interference that its members might cause to MBANS. [37] But, once again, if the medical technology community is to be believed, contention-based protocols can handle any interfering amateur signals. Indeed, the medical technology community is on record as supporting use of 2390-2400 MHz for MBANs use, even as the sole source of spectrum for the many hospitals which would necessarily be located within line-of-sight AMT exclusion zones.

Besides facilitating use of MBAN devices for wider types of applications (including life-critical applications), a 2300-2305/2390-2400 MHz primary allocation would dispense with the need for exclusion zones -- and any prohibition on life-critical use -- enabling far more hospitals and health care facilities to benefit from the technology, and support the patient-anywhere/anytime use originally envisioned by MBAN proponents.

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[36] Reply Comments of GE Healthcare, filed December 4, 2006 in ET Docket No. 06-135, at p. 6 (emphasis added).

[37] Comments of ARRL, The National Association for Amateur Radio, filed May 27, 2008.

That leaves the question of frequency separation. The Nordic chips proposed by GEH are, in fact, designed to cover the entire frequency range from 2400 MHz to 2525 MHz. As the Engineering Statement observes, limiting those devices to the two bands referenced above entails a straightforward change of the crystal used in the local oscillator/synthesizer on the chip. With this change (15.36 MHz crystals are identical in cost, size, and performance to their 16 MHz counterpart), software control permits operation of the BSN at any frequency, or combination of frequencies, from 2300 MHz to 2425 MHz with no impact whatsoever on cost, size, weight, battery life, or functionality. It should not be surprising, therefore, that GEH itself is on record with the statement that:

> If the allocation is made in separate blocks within a particular frequency band, then the frequency blocks should be separated <u>by no more than 150 megahertz</u>, in order to reduce the cost of component parts and overall manufacturing costs.[38]

Thus, there is no technical or economic reason why the two bands could not be paired for this application, and 2300-2305/2390-2400 MHz would be a very adequate solution.

The Notice invites comment on the use of other bands such as 2400-2483.5 MHz and 5150-5250 MHz. *Id*. at ¶¶ 26-32. These bands, too, could be useful options. See *id*. at ¶¶28, 31. As ARRL has observed,[39] the use of long-range propagation bands such as 2.3 GHz is quite at odds with the short-range communication that MBANS seeks to achieve. And if economies of scale from chip production are a driver, 5.1 GHz wireless local networks would offer some of the same economies with a much more sensible spectrum management solution.

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[38] Reply Comments of GE Healthcare, *supra*, note 31, at p. 6 (emphasis added).
[39] Comments of ARRL, *supra*, at 4.

F. Other Issues

The Commission invites comment as to whether successful sharing in the 2360-2390 MHz band might be accomplished if MBANs systems were licensed under Part 90 vs. Part 95, e.g., if the systems were individually licensed and coordinated rather than licensed on some blanket basis. *Id.* at ¶ 34. Such scenarios could entail exclusive or non-exclusive licensing as among MBANs licensees, or local vs. nationwide licenses as with 3650-3700 MHz wireless licenses, coupled with registration of individual facilities (hospitals) or systems. *Id.* at ¶ 36. With each of these, the Notice asks whether some form of coordination might also be used, e.g., possibly for use inside hospitals, within exclusion zones (*id.* at ¶ 52); and what sort of criteria might be used for determining whether an MBANs system could operate without causing interference. *Id.* at ¶¶ 56-60. For the sake of completeness, AFTRCC offers comments on these and a few remaining issues.

Certainly, as between Part 95 licensing-by-rule, and Part 90 individual licensing, Part 90 provides greater regulatory oversight and enforcement capability. Part 95 licensing is not specific to any particular operating location. It affords a status superior to Part 15 devices, but for all intents and purposes is every bit as uncontrolled.

Part 90, by contrast, ties the license to a specific set of coordinates. Moreover, the operating parameters are reviewed by the Commission prior to grant. However, Part 90 licensing also presumes some sort of coordination, which would be especially challenging in the case of MBANS operation in AMT spectrum.

Neither the Part 90 Wireless Medical Telemetry Service ("WMTS") nor the Wireless Broadband Service ("WBS") at 3650-3700 MHz, as referenced in the Notice, provides a useful analogy for this purpose. With WMTS, coordination is required between and among the medical device users themselves: Primary Government users with which WMTS coordinates are at just a

handful of sites. By contrast, there are a much larger number of primary AMT incumbents, as the Commission acknowledges. *Id.* at ¶ 58.[40]

In the case of the WBS, operation is permitted outside of 150 km protection zones around primary earth station incumbents, subject to direct coordination where any WBS operator seeks to operate within that zone. However, not only is the coordination regime "substantially different" in the case of the flight test telemetry bands (Notice at ¶ 60), but any notion of "coordination" begs a threshold question: Coordination as between a primary user and a secondary user works only as long as the secondary user is prepared to give way on little or no notice. Any other result entails constraints on the operation, growth and deployment of primary facilities, and stands the primary-secondary relationship on its head. *See* Notice at ¶ 23 (seeking comment on techniques medical devices could use to avoid "constraining AMT").[41]

Besides national level coordination conducted by AFTRCC and NTIA, day-to-day scheduling of the spectrum resource takes place between and among neighboring test centers, and aerospace agencies located in the same area. Once a flight test program has marshaled all of the resources required for a test flight, e.g., test engineers, ground equipment, chase aircraft, crash trucks, and the like, and all the test equipment has been calibrated, delays on account of lack of spectrum or co-channel interference are extraordinarily expensive -- seven figures in the case of larger test programs. The Commission itself has recognized this issue. See 5 FCC Rcd at 495 ("sharing of these frequencies with unlike services is difficult at best because schedules of telemetry flight tests are unpredictable and delays costly"). Thus, MBANs systems would have

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[40] The Notice observes that there are inconsistencies in the record regarding the number of AMT sites requiring protection. See *id.* at ¶15 and note 69. AFTRCC records currently show a total of 172 AMT locations, Government and Non-Government, many, if not most of which utilize the S-band, all of which are eligible for S-band assignments. It should also be noted that many of these represent home base for AMT receiver assets which support flight operations in other locations.

[41] If, *arguendo*, licensing were considered, registration should be required for each individual MBANS system, i.e. on a system-by-system basis. *Id.* at page 29. This approach offers greater focus on compliance by hospital personnel.

to be preemptible on little or no notice, especially for mobile AMT facilities, but also to accommodate the expansion of existing fixed AMT facilities or the creation of new fixed AMT facilities.

The Notice proposes definitions of MBAN networks, control devices, and medical body area devices. *Id.* at ¶ 37. In several cases the device is defined as a unit placed on "or in close proximity to the patient's body…." *Id.* Similarly, the Notice asks whether MBANs transmissions to a receiver not body-worn should be prohibited, as is the case for MedRadio Service rules under Section 95.1209(e) (*id.* at ¶ 41); and whether the rules should allow multiple MBANS systems to be controlled by a single remote transmitter. *Id.* at ¶ 42.

AFTRCC strongly supports limitation of MBANs devices, including receivers, to those worn by the patient. Any other approach increases the risk that MBANs transmissions might be used for backhaul to an access point at some distance from the patient. Uses like this would further increase the interference risk.

The Notice asks for comment on whether a 1 mW EIRP level and a 25 percent duty factor, as recommended by GEH, would be appropriate for MBANs units; whether some other power/duty cycle would better protect AMT; or even whether there should be any duty cycle limits at all. *Id.* at ¶ 66.

With respect to duty cycle, the use of pulsed jammers, in which a low duty cycle jammer causes high duty cycle failures in the system being jammed, is well known to the military. Reducing the duty cycle from 100% to 25% does not necessarily reduce the impact of the interference.

The Notice goes on to ask a variety of other questions concerning possible technical rules for MBANs such as bandwidth limitations, unwanted emission levels, antenna locations, and RF

safety. *Id.* at ¶¶ 67-71. Among other things, it asks whether any MBANs in 2360-2390 MHz should be limited to indoor use within healthcare facilities, or whether "temporary outdoor antennas" could be used for MBANs in other bands (*id.* at ¶ 70); and whether MBANs should be deemed portable devices for purposes of the RF safety rules. *Id*; see also ¶ 52.

Again, for completeness, for any MBANs allocation in the 2360-2390 MHz band the devices would have to be limited to health care facilities and indoor use only, whether inside or outside an exclusion zone. Only such use provides even a minimal level of protection for AMT -- but at a level far from sufficient. By contrast, the AFTRCC proposal that uses bands outside of 2360 MHz – 2390 MHz would permit indoor and outdoor, anytime/anywhere, use, consistent with the MBANs proponents' notion that the devices provide greater patient mobility. Moreover, it would allow the autonomous broadcast model of a patient equipped with multiple BSNs.

MBANS devices should be deemed "portable" for purposes of compliance with the Commission's RF exposure rules. *Id.* at ¶ 71. They would be used on the patient's body and thus should be subject to tighter scrutiny.

Finally, MBANs devices should be certificated for equipment authorization purposes. Notice at ¶¶ 72-74, and page 28. Certification provides a higher level of assurance that MBANs devices would comply with whatever technical rules the Commission adopts. The certification analysis should be conducted by the Commission based on submission of test data and representations by the applicant (together with a sample unit).

IV. CONCLUSION

Permitting de facto unlicensed use within a Restricted band is a fundamental policy change at odds with decades of Commission spectrum management policy, most especially given the availability of other spectrum choices which present none of the complications of mixing two safety services. Given the ready availability of suitable alternatives, an MBANs allocation in the band 2360-2390 MHz should not be pursued.

Respectfully submitted,

AEROSPACE AND FLIGHT TEST RADIO
COORDINATING COUNCIL

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Its Counsel

October 5, 2009

EXHIBIT A

AFTRCC Member Companies

Aerospace and Flight Test Radio Coordinating Council Members

AFTRCC
AEROSPACE & FLIGHT TEST RADIO COORDINATING COUNCIL

Bell Helicopter
A Textron Company

BOEING

BOMBARDIER

Cessna
A Textron Company

Honeywell

Gilfillan
ITT Industries

L3 communications
Integrated Systems

LOCKHEED MARTIN

LOCKHEED MARTIN Excellenc
Enterprise Information Systems

NORTHROP GRUMMAN

ISA
Integrated Systems and Aerostructures Sector

Raytheon
Electronic Sensors & Systems Sector

Rockwell Collins

Sikorsky
A United Technologies Company

Agilent Technologies

Bechtel Nevada

HERLEY
Lancaster

L3 communication
Telemetry-West

L3 Telemetry East

L3 communications
Communication Telemetry - East

SPECTRUM CERTIFICATION SOLUTIONS INC

EXHIBIT B

Engineering Statement

Engineering Statement

The Impact of Medical Body Area Networks on Aircraft Testing in the Band 2360 – 2390 MHz.

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5 October 2009

I. Introduction

In response to the Notice of Proposed Rulemaking (NPRM) regarding allocation of spectrum for Medical Body Area Network (MBAN) devices (also called Body Sensor Networks (BSNs)), this Engineering Statement supplies further analyses and measurements. It also provides additional information regarding the use of the noise-limited, restricted Aeronautical Mobile Telemetry (AMT) bands.

At issue in this proceeding is a possible change in what has long been a Restricted, safety of life band, currently allocated to AMT, from one that is noise-limited to one that is interference-limited. This is a fundamental paradigm shift in the use of safety of life spectrum.

II. The Shannon Limit and Link Margin

We begin by summarizing the underlying physics that defines the performance limits of any communications channel, be it wireless, fiber, or cable. As derived by Shannon, the well-known (by communications engineers) asymptotic limit of the maximum rate at which information can be transmitted error-free through a noisy channel is given, in bits per second, by

$$H = BW\log_2\left(1 + {}^{C}/_{N}\right) \qquad [1]$$

where the entropy *H* is the information rate in bits per second, *BW* is the bandwidth of the signal in *Hz*, *C* is signal power in *Watts*, and *N* is noise power, also in *Watts*. Noise, in this context, refers to naturally occurring electromagnetic noise, including microwave noise from the sun; black-body noise from the earth received in the side-lobes of, for AMT applications, a high-gain parabolic dish antenna; and internal noise generated in the AMT preamp and receiver electronics due to thermal effects.

Note that equation 1 provides a theoretical limit, not a methodology for designing systems that achieve this limit. In practice, C/N needs to be 12 dB or more for a wideband wireless communication system, such as AMT, operating at a typical bit error rate of 10^{-6}.

When the source of noise is from man-made sources, such as emissions from other users in the band, it is referred to as interference *I*, and equation 1 becomes

$$H = BW log_2 \left(1 + {}^{C}/_{(I + N)}\right) \qquad [2]$$

In order to allow the use of the band 2360 MHz to 2390 MHz for MBANs, the NPRM seeks comment on ways in which the parameters in equation 2 could be adjusted as functions of time and location, so that the interference at one location is either not seen by a spectrum user at a different location, or if seen, does not overly impact the throughput *H*.

Despite the fact that wireless systems do not typically operate at the Shannon limit, equation 2 shows how the parameters involved in closing a communications link budget depend on each other. For example, if *C/(I+N)* exceeds 12 dB, either *C* can be decreased, or *I* and/or *N* increased. This is typically plotted as curves of bit error probability versus signal to noise ratio.

However, it is also considered necessary for links to have a level of margin, typically 3 – 6 dB, above the 12 dB minimum value at which acceptable bit error rates are obtained.

In the case of AMT systems, this margin needs to be much larger, on the order of 30 dB, due to the extreme fading environment encountered during flight testing of rapidly maneuvering aircraft traveling at high speed (up to and above the speed of sound, but typically 400 knots for a fighter plane or commercial jet, and 100 – 400 knots for rotary wing vehicles and propeller driven aircraft, including unmanned aerial vehicles designed to fly slowly).[1] These maneuvers, which include steep banks, rolls, climbs, and dives, characterize flight testing, be it military or civil.

III. The Aircraft Fade Environment

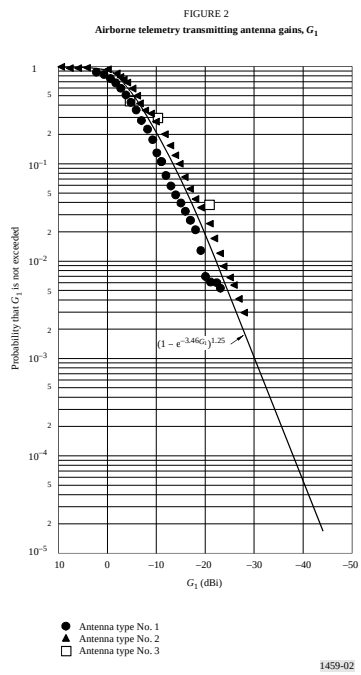
Figure 1, excerpted from Figure 2 of ITU-R Recommendation M.1459, shows a typical fade budget. Signal loss due to fades is expressed as a probability. The Figure provides a representative description of the fading environment seen in flight testing.

[1] See, for example, Figure 7 of the AFTRCC test report filed in this docket on 23 February 2009.

Note that experimental data for fades are measured for probabilities as low as 0.3%. This means that a corresponding 28 dB fade will occur, on average, for three seconds out of every 1000 seconds, or 17 minutes. This does not mean that fading as a function of time necessarily follows a Poisson distribution as a result of the rate of fading being a constant.[2] Fading is directly correlated to the maneuvers noted above. If the maneuver, such as a flutter dive or spin recovery test, is repeated, the fading associated with the maneuver will also be repeated. One cannot, and indeed, must not, assume that fades associated with dives occur only on some of the dives. The same holds true for the other extensive maneuvers that a test aircraft must conduct in order to become FAA certified.

Many of these maneuvers are inherently dangerous for the flight crew and, due the mechanical stresses involved, risk permanent damage to the air frame. Repetition of such tests due to data dropouts caused by interference is untenable. Flight test operators know their ranges well, and know where any multi-path effects may be severe enough to affect the test.

Figure 1. Fade Characteristics from Aircraft as shown in Figure 2 of ITU-R Recommendation M.1459.



Returning to Figure 1, above, the fades result from a variety of causes:

[2] The Poisson distribution describes the statistical properties of a process whose *average* rate of occurrence is fixed.

- long-path-delay multipath from ground reflections between an aircraft transmitter and a ground station receiver
- short-path-delay multipath from reflections off aircraft structures
- signal attenuation due to blockage by aircraft structures
- diffraction effects due to blockage by aircraft structures
- signal attenuation due to direct signal blockage by terrain features between the aircraft and the AMT ground station

The first and last effects are exacerbated by the low elevation angles between the aircraft and the AMT ground station. As the record reflects, AMT antennas typically operate from 2 degrees above the horizon to 2 degrees below the horizon. Aircraft are altitude-limited. Since an aircraft or missile travels at speeds of 200 – 600 knots, the vehicle's dwell time directly above an AMT ground station antenna is essentially nil. The test aircraft spend most of their time at long range (50 – 200 miles) from the ground station. When at the lower values of this range, they are typically at low altitude (~2000 4000 feet); at long range, the altitude is typically between 10,000 – 40,000 feet. In any case, the notion that interfering devices on the ground will consistently lie below the main lobe of the AMT receive antenna due to elevation angle is fallacious.

Long-path-delay multipath (LPDM) is a consequence of these low aircraft elevation angles. For wideband AMT signals, LPDM manifests as frequency selective fading, in which portions of the telemetry signal are enhanced due to multipath, while the remainder of the signal is corrupted by fades of 15 – 20 dB. Frequency selective multipath, for test aircraft moving at high speeds, typically becomes an issue for signal bandwidths greater than 2 MHz.

It should be stressed that there is an inherent problem with modeling propagation losses for wideband signals. Simple propagation models, including the modification of the space-loss exponent in a link budget computation from 2 to, for example, 2.4, presuppose that the propagation of a wideband signal can be described by a single value of propagation constant.

That this is not the case for wideband signals is evidenced by the use of OFDM signals under non-line-of-sight (NLOS) propagation conditions, as described in detail in the IEEE 802.16 standard. This standard takes advantage of frequency selective fading to accomplish non-line-of-sight (NLOS) operation, something that is not contemplated by most propagation models.

For example, field testing of BSN devices has shown repeatedly that if two BSNs are operated on adjacent frequencies, it is quite common, over a period of seconds, for the signal from one device to fade by 15 – 20 dB, while the same multipath effects cause enhancement for the signal from the other device of as much as +3 dB.[3] Thus, the use of

[3] See the Test Report, "Measurements of Co-channel Interference to Aeronautical Mobile Telemetry Systems from Devices Using Nordic Semiconductor Transceiver Chips, JHUAPL, Daniel G. Jablonski, Ph.D. Principal Investigator, filed with Aerospace and

a single channel propagation factor for an ensemble of 1 MHz BSNs operating simultaneously across a 5 MHz AMT channel will not provide accurate results.

IV. The Effect of Interference on Data Dropouts and Bit Synchronization

The downlink telemetry stream of a flight test aircraft is typically derived by transmitting a subset of the data messages that exist, in real-time, on 3 or more 20 MBPS data buses aboard the test aircraft. At best, only 1 in 12 of the desired messages is transmitted to the ground. If S-band spectrum were not in short supply, all 60 MBPS of data would be transmitted using modulation techniques with spectrum efficiency of, at best, 2 bits per Hz. (Higher efficiencies are possible, but are less robust in the fading environment described above.)

Newer technologies under development will permit two-way data links, thus enabling automatic resend requests, real-time reallocation of spectrum among test aircraft, and dynamic selection of message traffic from the aircraft data buses. When this happens, other users of the band must be prepared to tolerate interference from wide-band, high power uplink signals transmitted from tower-mounted omni-directional antennas.

Adequate S-band spectrum is not available to permit the use of spectrum-hungry techniques such as rate ½ forward error correction. Given this, the integrity of the AMT signal is monitored via the framing characteristics used to format the telemetry signal.

Telemetry is sent in frames and sub-frames. Although the data is essentially random, the frame headers are not. The header bits, which use Barker codes because of their special correlation properties, are used for bit synchronization, clock recovery, and data de-commutation of the down-linked telemetry signal.

It is commonplace, and important, for entire test flights to be conducted without a loss of bit sync. This is accomplished only by providing adequate link margin to accommodate the large fades described above. Thus, there is not, in fact, a large amount of link margin available to sustain interference from BSN devices.

V. Laboratory Measurement of the Effects of Interference from BSN devices to Bit-Sync and Data-Decommutation

In the NPRM, the Commission questioned previous laboratory measurements that demonstrated the equivalence, in terms of interference, of the signals from signal generators to those from prototypical BSN devices.

Additional laboratory measurements were recently made using a PCM-FM-NRZ flight test signal transmitted by an actual aircraft telemetry transmitter. The data stream included actual frame and sub-frame header bits. Attenuators were used to provide a 15 dB signal to noise ratio to a flight test telemetry receiver via an indoor antenna-to-antenna free-space telemetry link. Low-gain omni-directional antennas were used. A bit synchronizer and data de-commutator were connected to the output of the receiver.

Interference was introduced using a 1 mW Nordic transceiver transmitting through a low gain omni-directional antenna. As described in earlier filings, the device operated at a ~34% duty cycle over a bandwidth of 650 kHz.

The ~30% duty cycle is an appropriate model for a network of ten BSN devices operating at 3% duty cycle as a TDMA network on the body of a single patient, a typical use-case contemplated by GE Healthcare (GEH). The test showed that bit sync for the AMT receive system was consistently lost at distances of over 60 feet from the BSN transceiver to the AMT omni-directional (in this case) receive antenna.

The noise figure of the receiver is approximately 12 dB. An LNA was not used for this test. The C/N value for the experiment, prior to introduction of the interfering signal, was about 3 dB above the minimum acceptable signal level from a flight test aircraft for a long-duration flight test.

Interference from the BSN signal, corresponding to that from a single patient in a healthcare facility, occurred at a distance that, when scaled to the sensitivity improvements garnered from an LNA and high gain parabolic dish, is <u>well over ten miles</u>. An ensemble of interfering signals, even when defined using the probabilistic assumptions in the GEH Monte Carlo study, would overcome any effects seen from building and window attenuation.

Note also that the signals used for this test include:

- Accurate implementation of the frequencies, bandwidths, power levels, modulation, and duty cycles of the proposed MBANs networks
- Provision of an accurate PCM-FM-NRZ aircraft telemetry signal
- Use of an actual flight test telemetry transmitter and receiver
- Use of an actual flight test telemetry bit synchronizer
- Use of an actual flight test telemetry data de-commutator

Finally, the impact of BSN duty cycle on interference effects has been captured in the measurements.

The results from this series of tests are consistent with all of the tests to date performed in the laboratory, at Patuxent River, at Wichita, and at Seattle.

VI. The Challenge of Signal Reacquisition

Antenna tracking of flight test aircraft is accomplished using a conical scan sensor on the telemetry receive antenna. This provides an error signal that not only discerns that the flight test aircraft is leaving the main beam of the antenna, but also tells the antenna which direction to maneuver to maintain track. An antenna tracking unit takes signals derived from the antenna's conical scan elements to derive the steering voltages that are sent back to the antenna servo-motors.

An interference source, if strong compared to the weak signal from a distant aircraft, can capture the antenna tracking loop. If this happens, the pilot will be instructed by ground controllers to proceed to a predefined way point, and reacquisition of the aircraft by the telemetry antenna will be attempted. This is a time-consuming, fuel-consuming, and generally expensive process. It also presents additional risks for the pilot.

The process is sufficiently difficult that it serves as the *de facto* limit on the upper diameter, and hence gain, of a telemetry ground station antenna. Specifically, the beam width of an antenna that is larger than 15 feet in diameter is so small (< 1 degree) that reacquisition of an aircraft that is too far away to be visible using a bore-sighted video camera becomes essentially impossible.[4]

VII. AMT Noise-Floor Measurements

The band 2360 MHz to 2390 MHz is noise-limited, as the long experience of flight test engineers confirmed by noise floor measurements attests. GEH, however, has argued that:[5]

- If there is no interference, adding interference from its devices to the band will be inconsequential
- If there is interference, introducing additional interference will be inconsequential

Indeed, in one filing, GEH asserts that because there is no interference in the band, it is entitled to the full interference budget specified in Rec. M.1459 of I/N = - 3 dB.[6]

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[4] Even with excellent video equipment, haze and clouds often make video acquisition impossible even when the aircraft is within radio line of sight.

[5] IEEE 802.15 working group submission of September 2009, www.IEEE.org.

[6] In its submission to this docket on December 27, 2008 at page 38, GEH states, "As there are no BSS satellites present in the proposed 2360 – 2400 MHz band, we consider the composite interference of -2.68 dB I/N as a criteria for coexistence with aeronautical telemetry receivers."

To put this issue to rest, recent measurements were conducted at Wichita, Kansas and Seattle, Washington. These measurements, which are the subject of separate reports that will be submitted for the record, are consistent with measurements made previously at Pax River.

With respect to Wichita, for example, the downtown skyline represents an "urban wall" that is directly visible to the AMT ground stations at MidContinent Airport, where Cessna and Learjet have their test facilities. Test aircraft routinely fly over Wichita to flight test areas east of the city, with the Wichita skyline in constant view of the AMT ground station antenna during the entire test. The routine practice of flying successfully to distances of 200 miles under these conditions proves the point – ambient background noise due to spillover from adjacent bands does not raise the noise floor in the AMT band.

Put simply, the typical baseline noise floor observed on a daily basis on the front panels of telemetry receive equipment would not be possible if the noise alleged to exist in the band 2360 MHz to 2390 MHz did, indeed, exist.

VIII. The GEH Monte Carlo Analysis

The discussion in this section is complex. The discussion explains why probabilistic *C/(I+N)* criteria, proposed by GEH and modeled by it using Monte Carlo techniques, fail to demonstrate that sharing between AMT and MBANs networks is possible. We then show that the *I/N* criteria and the resulting *pfd* levels defined and justified in Recommendation ITU-R M.1459 must be used.

To begin, GEH has accepted the proposition that BSNs would cause interference to AMT ground stations depending on the separation distance. In an effort to avoid the implications of this for spectrum compatibility, it contends that sharing of the band is nonetheless possible if one utilizes the *C/(I+N)* criterion, rather than *I/N*. GEH then conducted a simulation using the SEAMCAT software to show that violations of *C/(I+N)* criteria occur with a much smaller probability than do violations of *I/N* criteria.[7,8]

Putting aside for the moment its use of the wrong criterion, GEH's *C/(I+N)* criteria under these exact circumstances are violated 1.7% of the time even for an exclusion zone with the GEH-suggested radius of 9.7 km.[9] Outages like this, for a safety service for which the target bit error rate is 10^{-6} are the very definition of "harmful."

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[7] The GEC ex parte of September 18, 2008 in this docket.

[8] Interestingly, the Monte Carlo feature of the analysis is of little importance. Using standard analytic techniques for merging probability distributions, the same results could have been achieved without the Monte Carlo approach's use of random trials.

[9] Case 10 of reference 7.

But the fact is that *C/(I+N)* is not the correct criterion. ITU-R Rec. M. 1459 specifies use of *I/N* for the simple reason that if one uses the *C(I+N)* criterion, and that value falls below the typical 12 dB threshold for proper receiver operation, the signal will be lost.[10] And once lost, the cost and risk in terms of re-acquisition are unacceptable.

As described previously, if the aircraft has flown out of the beam of the antenna during the dropout, difficult and time-consuming procedures must be followed to realign the antenna's very narrow beam with the rapidly moving aircraft. This is not a trivial undertaking. In other words, a short-duration *C/(I+N)* violation always causes a dropout for the duration of the violation, and often leads to a long-term dropout of the telemetry signal while attempts are made to re-aim the ground station antenna at the rapidly moving aircraft.

By contrast, when *I/N* limits are violated, the bit error rate of the link will increase. However, there is a better chance that the 12 dB signal to noise ratio needed for the receiver to maintain bit synchronization, a fundamental requirement for accurate data recovery, will be maintained.

GEH asserts that its interference is analogous to a fade in the AMT channel, and that the margin used to protect AMT against fades will also protect AMT from interference from MBANs networks, provided that the interference from an MBANs network does not occur at the same time as does a fade. However, its own simulations for scenario 10 show that 1.7% of the time, the fades and the interference will occur at the same instant in time, thus causing the AMT link to be lost, as described above.

This is despite GEH's use of the extended-HATA model (which assumes presence of ground clutter, e.g. buildings), and its assumption that MBANs devices are located uniformly only 1.5 meters above the ground. This combination of parameters effectively eliminates the direct line of sight condition which is of most concern.

In any event, we consider Case 10 of the GEH Monte Carlo study to be the only scenario for which the analysis holds any relevance.

All of the scenarios, including Case 10, suffer deficiencies.[11] These include, for example:

- The assumption that a single flight test aircraft is equally likely to be at all azimuth angles with respect to the AMT ground station. This assumption artificially minimizes the likelihood of interference (cases 1, 2, 3, 4, 5, 6, and 9) by assuming that the

[10] The pfd protection levels in Rec. M.1459 are a direct result of the I/N criteria computed in the Recommendation.

[11] Cases 0 and 8 are calibration runs, for which there are no interfering devices.

aircraft is essentially flying in a circle of radius 320 km around the ground station antenna.

- The use of frequency hopping across the entire 40 MHz band from 2360 MHz to 2400 MHz (cases 5, 6, 7, 9, and 10). This dilutes the number of BSNs seen in a single 5 MHz AMT channel while appearing to increase the number of interfering devices.
- The lack of multiple aircraft operating in different channels within the AMT band (cases 5, 6, 7, 9, and 10). This omission suggests that frequency hopping reduces interference, when in fact it will cause interference to aircraft operating in other portions of the flight test telemetry band.
- The spreading of BSN devices outside of the main-beam of the AMT antenna for a case in which the stated intent is to do just the opposite (Case 7, in which the AMT antenna has a gain of 41.2 dBi).

With further respect to Case 10, all of the BSN devices are located within the main beam of an AMT ground station antenna having a gain of ~30 dBi. In this scenario, there are 50 MBANs devices, of which on average only 8 are operating in a single 5 MHz telemetry channel. In addition to this shortcoming, the use of the extended-HATA model is inappropriate, as it reduces the effect of interference from the higher stories of a building. But Case 10 at least begins to model the situation in which the entire face of a healthcare facility is in view of an AMT ground station for more than an instant.

Consider, for the geometry of Case 10, the situation in which a jet aircraft is flying cross-range at 450 mph at a distance of 320 km from the ground station. It will take this aircraft 2 minutes to cross the field of view in which the signals from both the aircraft and interfering devices are simultaneously received in the main beam of the AMT ground station receive antenna. If the aircraft is flying down-range, the interference from the BSNs will remain in view indefinitely.

Returning to the question of whether C/(I+N) versus I/N criteria should be used, ITU-Recommendation M.1459 addresses the complexities of this situation in great detail. The Recommendation includes careful consideration of the geometries described above. After careful analysis, it concludes that *C/(I+N)* is not the correct criterion for protecting flight test telemetry Instead, Rec. M.1459 specifies use of the same *I/N* criterion that is widely used, and accepted, as appropriate for the protection of noise-limited services.

However, even with the use of the correct standard, GEH's own simulations in Case 10 of its study show that, under assumptions that greatly favor GEH,[12] the ***I/N***

[12] Specifically, the use of the extended-HATA model; the assumption that all BSN devices are located only 1.5 meters above the ground; and the spreading of the 50 devices across 40 MHz, which limits the average number of devices operating simultaneously in a single AMT channel to 8.

criterion of -3 dB from Recommendation M.1459 is violated fully 20 percent of the time even for a proposed exclusion zone radius of *9.7 km*!

Thus, the full 28 – 30 dB of AMT link margin must be dedicated to protection from fades, and not shared on a probabilistic basis with BSNs to mitigate their interference. Furthermore, this fade margin is in addition to the 12 dB signal to noise ratio required by the flight test telemetry receiver for accurate recovery of the AMT data.

In summary, the Monte Carlo analyses placed into the record by GEH are an attempt to change the long established use of *I/N* criteria for the protection of users of noise-limited bands. GEH proposes, instead, to use *C/(I+N)* criteria for protection of AMT on a probabilistic basis. The success of this approach depends on the incorrect assumption by GEH that the same margin can be used simultaneously as fade margin and interference margin. As discussed above, this is not the case.

IX. Cognitive Radio Techniques

In recognition of the challenges facing the use of a restricted, noise-limited safety-of-life band by low-quality consumer devices intended for disposal after short term use, it has been suggested that cognitive radio techniques will come to the rescue.

However, cognitive radio techniques depend on the ability of a receiver to engage in contention-based, listen before-talk protocols. In the case of an interference-limited device with a sensitivity of -96 dBm and a low-gain antenna (i.e., a BSN), the impossibility of detecting signals (i.e., AMT signals) operating under noise-limited conditions precludes the use of these so-called “cognitive techniques”.

Consider, for example, the argument put forth by proponents of cognitive radio that surveys can be conducted using spectrum analyzers having a noise floor of 30,000 Kelvin. Without integration times of many tens of seconds over bandwidths as low as 1 Hz, these devices are completely unable to detect satellite signals, telemetry signals, and certainly not the GPS signals upon which geolocation of devices will depend.

In any case, cognitive radio techniques do not work as a way to enable the co-frequency operation of noise-limited systems with interference-limited systems.

X. Interference from AMT to BSNs

Interference from flight test aircraft to BSNs will occur at distances from the aircraft to the healthcare facility of 10 - 20 miles, even for BSNs operating inside of buildings. Under circumstances in which multiple aircraft at a test facility are using the entire 30 MHz band, the possibility that an entire healthcare facility will be denied access to any of the flight test spectrum for extended periods is real.

Note that the distance in question is not the distance from the healthcare facility to the AMT ground station, but the distance from the aircraft to the healthcare facility. Given the large distances that aircraft fly from the ground station, the situations under which significant portions of the MBANs network within a healthcare facility will be denied service will be difficult both to predict and to mitigate against.

With respect to building attenuation, during measurements at AMT test sites, we routinely see building attenuations that are as low as 0 dB (e.g., for mobile devices transmitting through automobile windows or near windows in older buildings) to 30 dB for expensive, modern buildings with the latest in energy conserving window designs. More typical, however, are building attenuations of ~6 dB where the predominant transmission mechanism is through glass windows.

Aircraft, especially helicopters, can dwell in a location at low altitude for extended periods of time. For example, helicopter testing at Pax River often occurs over Breton Bay on the Potomac River. The geography is such that if multiple helicopters are being tested, as will likely be the case if the Presidential Support Helicopter program is restarted, not only will interference to St. Mary's Hospital and nearby healthcare facilities in Leonardtown, MD be affected, but there will be no free spectrum in the AMT band for BSNs to hop to.

The same will be true in Seattle, where simultaneous test flights of only two 787's will use the entire 30 MHz band. This will deny access to spectrum by MBANs over a very large portion of the Seattle-Tacoma metropolitan area.

XI. Exclusion zones

AFTRCC has demonstrated a willingness to coordinate with adjacent band users, and recognizes that operation over the radio horizon is of no consequence to fixed site AMT installations.

Co-frequency sharing with BSNs is an entirely different problem. GEH has stated repeatedly that patients equipped with BSNs are autonomous entities, that there will be no control station that communicates to the patient, and that there is nothing to prevent a patient from leaving a building with all ten of its transmitter operating at 3% duty cycle, with the net effect that the patient will be radiating 30 out of every 100 milliseconds.

Under these circumstances, and with GEH's stated intent to violate the I/N limits for flight test operation at least 20% of the time even when an exclusion zone is in place, further discussion of exclusion zones seems pointless.

XII. Alternative Bands

The Nordic devices proposed by GEH, and tested by AFTRCC, permit software controlled operation over any 1 MHz channel from 2300 MHz to 2425 MHz. Given this, there is no reason why 2300 MHz – 2305 MHz and 2390 MHz to 2400 MHz would not represent a suitable alternative, especially if on a primary basis.[13] Moreover, GEH has advised that "separate blocks within a particular frequency band" are adequate as long as it the blocks are not "separated by … more than 150 MHz." [14]

In short, there is absolutely no cost or performance issue with splitting the band in this manner.

Furthermore, just as it has proven practical to re-crystal the Nordic transceivers to operate at 2360 MHz, it is not out of the question to introduce an additional low cost upconverter/downconverter combination to permit their operation in C band at ~5.8 GHz.

XIII. Conclusions and Recommendations

As stated earlier, converting a Restricted, noise-limited, safety-of-life band into an interference-limited band represents a significant paradigm change for the use of spectrum. In the present case, a narrowband application would be enabled for which baseband data rates, according to GEH, are kilobits per second. This use of broadband resources for a narrowband application is an inefficient use of spectrum.

Readers of this Engineering Statement should be reminded that although air travel is safer per mile traveled than traveling by automobile, per minute spent en-route, air travel is, on average, more dangerous.[15]

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[13] Interestingly, the Nordic devices are sold with the stipulation that they are not to be used in life-support applications. Specifically, Nordic states in their data sheets (www.nordicsemi.com) that, "These products are not designed for use in life support appliances, devices, or systems where malfunction of these products can reasonably be expected to result in personal injury. Nordic Semiconductor ASA customers using or selling these products for use in such applications do so at their own risk and agree to fully indemnify Nordic Semiconductor ASA for any damages resulting from such improper use or sale." It is not clear whether Nordic contemplates the use of their devices in systems in which the units are physically attached to a person's body, and for which propagation of "creeping" waves on the surface of one's body will be an integral feature of their operation.

[14] Reply Comments of GEH filed December 4, 2006 in ET Docket No. 06-135, at page 6

[15] Fatalities for commercial US air travel have varied between zero and 531 per year over the past ten years, whereas automobile fatalities in the US range from 40,000 to 50,000 per year. Statistics that permit comparison of air travel with automobile travel can be found at www-nrd.nhtsa.dot.gov and at www.iii.org/media/facts/statsbyissue/aviation.

The AMT goal of no accidents and no fatalities, the latter within reach for periods of a year or more, is by no means guaranteed. Flight test telemetry that operates reliably despite high speed maneuvers and deep signal fades is essential to achieving and maintaining this enviable safety record.

I have read and am familiar with the attached Comments being filed by Aerospace and Flight Test Radio Coordinating Council. The statements made therein are true and correct to the best of my knowledge and belief.

EXHIBIT C

Holter Monitor Documentation

by

Philips Remote Cardiac Services

Patient Diary

This Holter monitor is a portable, continuous monitor of the electrical activity (ECG) of the heart. During the recording time, we hope to observe any cardiac arrhythmias that you may be experiencing. The Holter has an internal clock which will time stamp your ECG strip. When you record the time of your activities and symptoms in the diary, these can be compared to your ECG and help your physician to pinpoint any areas of concern. Your physician needs a complete picture of your activities. If you are in doubt, write it in your diary anyway. More information is a more complete test.

Patient Information (please print)

Name: _____

Age: _____ Gender: ❒ Male ❒ Female

Physician: _____

Holter Serial Number: _____

Start Date: _____ Start Time: _____ AM/PM

Hook-up Technician: _____

PHILIPS

Time	Activity	Symptoms

Time	Activity	Symptoms

Holter Recording Instructions

Your doctor has requested you to wear a portable monitor, generally referred to as a Holter recorder. The success of the recording depends on your cooperation. You will be expected to keep track of your activities and any symptoms in this diary.

Examples of activities

Please include in your diary record:

- Eating
- Sleeping
- Exercising
- Moving bowels
- Engaging in sexual activity
- Drinking
  (especially alcohol or beverages with caffeine)
- Taking medications

Examples of possible symptoms

Please include in your diary record:

- Pain
- Headache
- Dizziness
- Shortness of breath
- Any strong emotion
  (crying, anger, laughing, etc.)
- Any other physical symptoms

After the recording is completed and the electrodes removed, you may wish to use a skin care product to soothe any skin irritation.

Important Points to Remember:

1. Do not shower, bathe or swim, as any moisture will loosen the electrodes.
2. Do not use body powder or talcum.
3. Avoid using electric blankets, as they may interfere with the recording.
4. Do not remove any tape that has been placed over the lead wires.
5. If a lead wire comes unsnapped from an electrode, snap it back on and enter this in your diary.
6. If you experience severe chest pain or severe shortness of breath, contact your physician or go to the nearest hospital emergency room.

Do not remove the battery!

Removing the battery may result in recording failure.

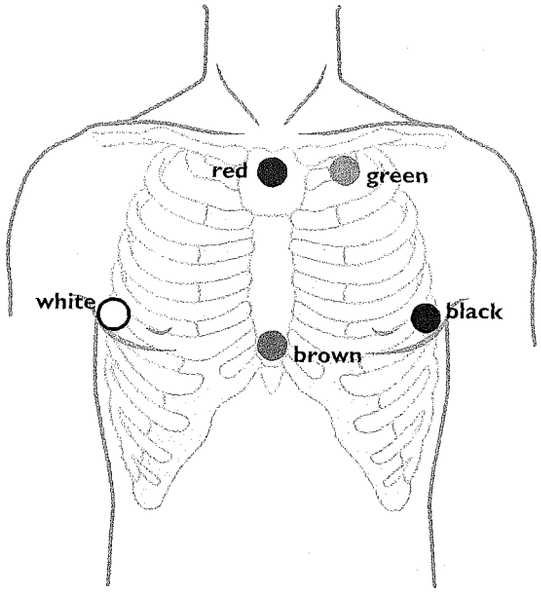
Questions:

If you have any questions or problems, please call your doctor's office. If they are unavailable, call Philips at:

800.242.7137
856.354.2222

Philips Remote Cardiac Services
7 Waterside Crossing
Windsor, CT 06095

www.philips.com/remotecardiacservices



5 Wire/12 Lead

Color	**Easi Lead Placement**
Red	Top of Sternum
Green	Upper Left Chest
Black	5th Intercostal, mid-auxillary left
White	5th Intercostal, mid-auxillary right
Brown	5th Intercostal, level of lower sternum