AEROSPACE & FLIGHT TEST RADIO COORDINATING COUNCIL

February 4, 2008

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

Re: Ex Parte Filing
ET Docket No. 06-135
RM-11271
ET Docket No. 05-213
ET Docket No. 03-92

Dear Ms. Dortch:

Aerospace and Flight Test Radio Coordinating Council ("AFTRCC") hereby submits these ex parte comments in connection with the proposal for a secondary allocation in the band 2360-2395 MHz for body sensor networks ("BSNs"). As noted below, the proposal raises significant concerns regarding the compatibility of the proposed life-critical BSNs with aeronautical telemetry operations. In support, AFTRCC submits the following:

Introduction

As the Commission's records reflect, AFTRCC is 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 interference-free flight test operations are protected, and flight safety maximized.

AFTRCC is also an association for the nation's principal aerospace manufacturers. In this capacity AFTRCC serves as an advocate for the aerospace industry on matters affecting spectrum policy. This fundamental mission was at the heart of AFTRCC's formation 54 years ago. Among its many accomplishments in this regard is AFTRCC's role in helping lead efforts which resulted in the allocation of spectrum for flight test telemetry such as the band at issue (2360-2395 MHz). AFTRCC's membership includes the Companies shown on the attachment, among others.

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Background

As set forth in the Comments in the above-captioned proceedings,[1] the BSN proposal envisions an allocation for a new type of biomedical telemetry device. These devices would provide wireless links from individual sensors on a patient's body to a monitoring unit, in place of wire-based sensors. The monitoring unit would be either worn by the patient or located nearby for further transmittal upstream to medical personnel.

The Comments state that "BSNs must be capable of reliably conveying unprocessed life-critical monitoring data to devices that are responsible for processing and primary alarming. In these scenarios, if the link were lost, a serious event such as arrhythmia or hypoxia could go unalarmed."[2] Because of the critical nature of the communications links, GEH stresses the importance of "extremely reliable" communications links with a predictable quality of service.[3] It envisions the channels using approximately one megahertz.

The BSN technology would not be limited to hospitals. GEH contemplates that BSNs would be used on a mobile basis by patients outside the hospital setting (e.g. in their homes) and "would become ubiquitous."[4] GEH further states that "due to the need to share with other spectrum users, the Commission should allocate a sufficiently large quantity of spectrum such that the frequency agile and low power BSN devices will be able to avoid frequencies in use by other licensees ....."[5]

Initially, GEH estimated that five to ten megahertz of clear spectrum within the allocated band(s) would be required "*after* taking into account spectrum that may be in use by incumbent users at any point in time ...."[6] However, in its recent Ex Parte Comments GEH has upped the spectrum requirement to "at least 20 megahertz ... at any given time and location."[7]

GEH references several candidate bands, but most recently proposes 2360-2400 MHz.[8] It goes on to analyze the potential for interference between incumbent services, on the one hand, and BSN devices, on the other hand. GEH states that "normally there would be large separation distances between aeronautical mobile transmitters and victim receivers," but that at least a 10

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[1] See Comments filed October 31, 2006 and Reply Comments filed December 4, 2006 by GE Healthcare ("GEH").
[2] Comments at 8.
[3] Id. at 8 and 12; see also Ex Parte Comments of GE Healthcare filed December 27, 2007 at page 7 ("wireless quality of service ("QOS") will be a critical consideration for BSN design ...").
[4] Id. at 10-11.
[5] Reply Comments at 6.
[6] Id.
[7] Ex Parte Comments at 8-9.
[8] Id. at 9 et seq.

km separation would be required assuming a 25 watt incumbent transmitter.[9] It goes on to suggest that "BSN devices should be able to share with aeronautical operations…."[10]

Discussion

There are two basic concerns with the GEH proposal, either one of which is sufficient to dismiss at this juncture the notion of a secondary allocation for BSNs in the band 2360-2395 MHz. The first is the likelihood of interference to BSN devices from aeronautical telemetry. The second is the likelihood of interference from ubiquitous BSN devices to sensitive aeronautical telemetry receivers.

With respect to interference from aeronautical telemetry to BSNs, the ubiquity contemplated for these devices greatly complicates the sharing scenario. There can be no assurance that aeronautical telemetry operations would be able to maintain a separation of 10 km as computed by GEH, much less up to 32 km as computed in the attached Engineering Statement of Daniel G. Jablonski. On the contrary, at several flight test centers aircraft manufacturing facilities are located in or near major metropolitan areas. Examples of these include St. Louis, Wichita, Seattle, and Ft. Worth. BSN users could also be located in their homes and other non-hospital settings in close proximity to aircraft passing overhead on take-off and landing approach. In these and other areas, there is a material risk that patients with life-critical BSN devices would be located well within interference range of test aircraft. As GEH itself indicates, the consequences of an interruption in transmission of such data could be very serious for a patient.

This brings us to the next point. GEH stresses the importance of there being enough vacant spectrum in any given band such that its devices could hop to a vacant channel in the event of interference. However, in certain areas of the country there can be no such assurance. In the Southwestern United States, for example, flight test operations are conducted in multiple States by a complex of test ranges on a coordinated basis. In this area concurrent operations are conducted "wall-to-wall" using the entirety of the 2360-2395 MHz band. This calls into question the viability of the frequency agility which appears essential to the BSN.

With respect to the possibility of interference from BSNs to telemetry receivers, there is likewise the likelihood of interference. Telemetry receivers are designed to detect and process extremely weak and fluctuating signals from aircraft at distances of 200 miles. In areas like those mentioned above, where flight test receivers are located in or near metropolitan areas, there can be no assurance that portable BSN devices would maintain a required separation distance of at least 20 km in order to protect AMT operations in the in-building case of 1.0 mW power for the BSN. See Engineering Statement. Adding to the uncertainty are the potential aggregate

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[9] Id. and Appendix A.

[10] Id. at 9.

effects since it is impossible to know how many BSN devices might be operational in any given area at any given point in time.

The consequences of interference to flight test telemetry are serious. The attendant loss of data can require re-flights of test aircraft at a cost of hundreds of thousands of dollars to the manufacturer. If such interference occurs during critical maneuvers it can put the life of the pilot in jeopardy by depriving ground controllers of the real-time data they need to warn the pilot of dangerous conditions developing abroad the aircraft, such as over-stresses on control surfaces. Such a risk is intolerable -- which is why the U.S. many years ago dedicated the 2360-2390 MHz band exclusively for flight testing.

Conclusion

The two applications (AMT and BSNs) are not compatible. Given the difficult history the Commission has had with interference to biomedical telemetry,[11] AFTRCC urges the Commission to put aside the aeronautical band 2360-2395 MHz as a potential candidate for BSNs.

A copy of this ex parte letter is being submitted for the above-referenced proceedings.

Respectfully submitted,

Darryl J. Holtmeyer

Darryl J. Holtmeyer
Chairman

DJH/

cc: Julius Knapp
Bruce Romano
Geraldine Matise
Jamison Prime
Gary Thayer
Angela Giancarlo
Renee Crittendon
William Freedman
Ari Fitzgerald

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[11] Cf., e.g., Public Notice: "The Wireless Telecommunications Bureau Extends the Freeze on High Power Use of the 460-470 MHz Band Offset Channels until December 31, 2005," released July 9, 2004. The Commission will also recall the interference caused by DTV operations to biomedical telemetry in Dallas several years ago.

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SPECTRUM CERTIFICATION SOLUTIONS INC

ENGINEERING STATEMENT

Re: Compatibility Issues between Proposed Body Sensor Network Devices and Aeronautical Mobile Telemetry Systems in the Band 2360-2395 MHz

Introduction

In its filings in ET Docket No. 06-135, et al., GE Healthcare ("GEH") suggests that proposed Body Sensor Network (BSN) devices can share spectrum on a secondary basis with Aeronautical Mobile Telemetry (AMT) systems in the band 2360 – 2395 MHz. The GEH conclusion is based on erroneous assumptions and flawed analyses. Using corrected analyses and accurate technical details of AMT operations, the GEH conclusion that AMT spectrum can be shared with BSN devices is shown to be invalid.

A detailed discussion of these and other issues is presented below and in the Annex.

Interference to AMT Ground Stations from BSNs

The parameters for computing interference into AMT ground stations are given in International Telecommunications Union Recommendation ITU-R M.1459. The Recommendation specifies the interference threshold to AMT in terms of a power flux density (pfd) measured at the aperture of the AMT ground station receive antenna. When the GEH analysis is corrected using the M.1459 parameters and realistic AMT Ground station antenna pointing angles, it becomes apparent that emissions from a single BSN, even when located indoors, will interfere with AMT ground station receivers at distances of 20 km. For outdoor operation, this number doubles to 40 km.[1]

The computations presented by GEH incorrectly assume that BSNs will lie below the elevation angle of the main beam of an AMT ground station antenna.[2] However, these antennas are typically located 20 – 100 feet above the ground, enabling the common practice of operating down from 0 - 2 degrees of elevation in order to track aircraft at long range.

Interference to BSNs from AMT Aircraft

Using the parameters and assumptions from GEH's Ex Parte Comments, the air-to-ground separation distances to avoid interference from AMT equipped aircraft to BSNs are calculated herein to range from 8 km to 32 km, depending on assumptions about building/wall attenuation. Note that this conclusion has been determined using

[1] This number can be as high as 62 km, even for a propagation exponent of 2.4. 40 km represents the maximum line of sight distance between a BSN installation on the 10th story of a medical facility facing an AMT ground receive antenna located on a 100 foot tower.

[2] Ex Parte Comments, filed 27 December 2007, and Reply Comments, filed 4 December 2007.

GEH's new assumptions that BSNs can operate successfully at -85 dBm, whereas their previous comments required a signal to noise ratio of 10 dB with respect to this level.

Spectrum Agility

GEH assumes that BSNs will detect interference before AMT systems are affected, and that BSNs will then switch to a vacant channel within the AMT band.[3]

However, it should be stressed that the interference to BSNs depends on the distance between the AMT aircraft and the BSNs -- not on the distance between the BSN and the AMT ground station. The interference to AMT ground stations, however, depends on the distance from the BSN to the AMT ground station -- not on the distance between the aircraft and the BSNs.

The distance from an AMT aircraft to a BSN is unrelated to the distance from a BSN to an AMT ground station. Thus, there will be situations in which either the AMT ground station, or the BSN network, but not both, will experience interference. Hence, BSNs will cause interference to AMT ground stations without BSNs experiencing the prior interference that will cause the BSN to change frequencies.

Indeed, an AMT aircraft operating at one frequency could fly within the interference radius of a BSN, thus causing the BSN to hop to a channel in which it jams a ground station antenna tracking a different aircraft transmitting on a different frequency. In areas such as Wichita, Kansas, where several aircraft manufacturers have AMT ground stations located at what are essentially urban facilities, the likelihood of such an event is high. Note that even when aircraft fly at remote locations (which is not the case for instrumented takeoffs and landings, close-in operations, and during transit to and from test areas), the corresponding AMT ground stations are often located in urban areas near aircraft manufacturing facilities.[4]

Furthermore, in some areas of the country, such as the Southwestern U.S., where there is a concentration of government flight test ranges, flight test operations utilize the entire available spectrum in the upper S-band (2360 – 2395 MHz). Hence, the proposed use of frequency hopping techniques by BSN devices (i.e. spectrum agility) will not result in identification of open channels within which to operate in the event that an individual BSN device experiences interference from AMT equipped aircraft. This

[3] Reply Comments at Appendix A.

[4] GE references a 2004 Report and Order for the proposition that flight testing occurs mostly at "remote facilities" and at high elevation angles. Reply Comments at Page 9. While manufacturers seek to avoid conducting flight tests over populated areas, the telemetry receiving station vulnerable to interference is often located in or near urban areas. For example, AMT ground receiving stations at locations such as Wichita, St. Louis, Seattle, and Ft. Worth are in close proximity to developed, urban settings. Similarly, it cannot be assumed that AMT receive antennas are operated at high elevation angles: As noted above, these antennas are typically mounted 20 – 100 feet above the ground, enabling the common practice of operating down to zero degrees of elevation in order to track aircraft as much as 200 miles away.

represents an extremely problematic scenario for the operation of a life-critical BSN device.[5]

Aggregation of BSN devices

The GEH analysis does not address the aggregate effect on AMT operations of large numbers of BSNs. When large numbers of co-frequency and adjacent frequency BSNs are co-located within the beam of an AMT ground station antenna, the effect of interference on AMT operations will be greatly exacerbated. For example, 5 BSNs operating in the same medical facility in adjacent 1 MHz channels will double the minimum separation distance from the medical facility to the affected AMT ground station. This is because the AMT receive bandwidth is typically five times as large as the proposed BSN channel bandwidth. Thus, for large numbers of BSNs located within multiple medical facilities, physicians' offices, residential settings, and even outdoors, the operation of unregulated BSN networks within line of sight of an AMT ground station receive antenna is not feasible.

When multiple BSNs are dispersed within an AMT operational area, the range of azimuth angles at which AMT ground station tracking antennas will experience interference will increase significantly. Thus, any aggregation of BSNs, whether localized or dispersed, will compromise AMT operations.

Furthermore, one cannot assume that main beam conjunction of an AMT ground station tracking antenna with a BSN is a low probability event. AMT antennas do not rotate with a predictable period, as do some radar antennas. They follow the aircraft, and antenna azimuth angles can vary rapidly, or slowly, during different time segments of the same test flight.

Finally, the effect of even a short-term dropout in telemetry from a moving aircraft due to a short-lived co-alignment of an AMT antenna with both the flight test aircraft and a BSN is significant. Specifically, if a flight test ground station experiences even a momentary dropout of the AMT aircraft's telemetry stream, successful short term reacquisition of the signal is difficult to achieve. This is because the parabolic dish at the AMT ground station, which is tracking the motion of the aircraft, must "re-find" the aircraft. Because of the narrow beam of the parabolic dish antenna, this is a difficult and time-consuming process. During this search, bit synchronization is lost, and what would in many systems be a rapid and automatic signal reacquisition is, for flight test, a cold-start acquisition of the AMT signal. During this time, the flight test aircraft and crew are at risk, and the financial cost of re-flying "test points" can be very large. Of course, this does not even begin to address the problems associated with attempting to locate and shut down interfering transmissions from a ubiquitous, un-coordinatable consumer device.

Conclusion

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[5] GEH has stressed this as an important aspect of the proposed sharing. See Reply Comments at page 2 of Appendix A.

GEH states, "the conclusion is that … before the BSN can interfere with the [AMT] system, the [AMT] system will interfere with the BSN and cause it to vacate the channel."[6] This conclusion depends on the erroneous assumption that the AMT aircraft and AMT ground station are co-located. As stated above, there is no correlation between when a BSN causes interference to an AMT ground station and when an AMT aircraft causes interference to a BSN: Interference from AMT aircraft to BSNs, and from BSNs to AMT ground stations, will occur. The distances at which this interference will occur are large. Furthermore, AMT operations in a particular geographic region will often utilize the entire 2360 – 2395 MHz band during flight test of multiple aircraft.

In conclusion, sharing between AMT and BSN systems is not feasible. To the contrary, the analysis indicates that there are serious issues concerning a "life-critical" technology sharing spectrum on a secondary basis where interference to and from the primary service is not only possible, but likely.[7]

Daniel G. Jablonski
February 4, 2008

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[6] Reply Comments at Appendix A.
[7] My qualifications to present this paper are set forth in the attachment.

Analysis

Interference to BSNs from AMT

The interference from an AMT aircraft that is measured at the receive antenna terminals of a BSN is given by

$$P_r = \frac{\alpha\beta P_t G_t \lambda^2 G_r}{(4\pi)^2 \cdot r^x} \qquad (1)$$

where

$$\lambda = {}^{c}\!/_{f} \qquad (2)$$

The parameter α is a scale factor that can be used to account for building wall attenuation, etc., and β accounts for bandwidth differences between the AMT and BSN systems. For free space propagation, the exponent of r is $x = 2$. Note that P_r has the dimensions of Watts.

Interference from AMT to a BSN network will occur when the signal from the flight test aircraft approaches in magnitude the -85 dBm sensitivity of the victim BSN receiver, which is assumed to have a receive antenna gain of 0 dBi.

For the specifications presented in GEH's most recent filing,[8] a 3 dB rise in the BSN noise floor will raise the bit error rate of a BSN from its putatively acceptable value of 10^{-4} by a factor of ten, to 10^{-3}, which is considered unacceptable by BSN operators. Thus, the interference received by a BSN from an AMT-equipped aircraft must be significantly less than the -85 dBm noise floor of the proposed BSN devices.

An additional consideration is that BSNs, despite their 1 MHz channel bandwidth, must be able to operate over 10 – 40 MHz of bandwidth. Thus, they are susceptible to noise floor rise due to out-of-channel (but not out-of-band) interference from AMT aircraft.

Combining these effects, an acceptable interference to noise ratio of -10 dB from AMT-equipped aircraft to a BSN is assumed.

A typical AMT-equipped aircraft transmits $P_t = 10$ *Watts* through an antenna with a transmit gain G_t of 2 dBi over a line-of-sight distance r to a BSN receiver. A transmit

[8] Ex Parte Comments, filed 27 December 2007. Note the significant changes from the corresponding specifications in the the Reply Comments: EIPR levels for BSNs have increased from -10 dBm to 0 dBm, and the acceptable signal to noise ratio for the BSN has decreased from 10 dB to 0 dB with respect to the BSN noise floor of -85 dBm.

frequency f of 2377.5 MHz (i.e., at the center of the AMT band, and as assumed by GEH) and a BSN receiver antenna gain G_r of *0 dBi* for the BSN are assumed, as is a bandwidth of 5 MHz for the modulated AMT signal. For this air-to-ground transmission, the free space exponent is 2.

Assuming 12 dB of building attenuation, this yields an interference distance of 17.8 km between an AMT aircraft and a BSN located within a building. However, such attenuation cannot be assumed. An advertised feature of one major national chain of assisted living facilities is the presence of outdoor balconies on high floors. Likewise, patients may be located next to windows.

Thus, appropriate values for building/wall attenuation of 0 – 3 dB will often be appropriate, thus raising the interference distance to as high as 71 km. This is actually consistent with the GEH assumed value of 12 dB, which represents a mean value, when the rather large standard deviation of 6 dB is also taken into account.

<u>Interference to AMT Receive (Ground) Stations from BSNs</u>

ITU-R Recommendation M.1459 derives a threshold interference power flux density level of -180 dB Watts/m^2 in a bandwidth of 4 kHz that is appropriate to the present situation (i.e., AMT receive antenna elevation angles of 0 – 2 degrees). This pfd level reflects the high sensitivity of AMT receive systems, which use high gain parabolic dish tracking antennas and have a system noise temperature of 250K.

To compute the received power flux density (pfd) at the AMT receive antenna, the effective area $\lambda^2 G_r / 4\pi$ of the AMT receive antenna is deleted from equation (1) to yield a pfd (as opposed to an absolute power level) having dimensions of *Watts/m²*. This reduced equation can then be used, as shown below, where $P_t G_t$ represents the power and gain of the BSN transmitter.

The value of β is also changed in order to scale the 1 MHz wide signal of the BSN transmitter to the 4 kHz reference bandwidth specified in Rec. M.1459. This gives:

$$pfd_r = \frac{\alpha\beta P_t G_t}{4\pi \cdot r^x} \qquad (3)$$

where for a single BSN, conversion from a 1 MHz bandwidth to a 4 kHz bandwidth, per Rec. M.1459, changes the value of β to .004 = -24 dB.

Under these conditions, it is appropriate to include ground propagation affects between a BSN transmitter and an AMT receiver by using the value of $x = 2.4$ for the exponent of r in equation 3.[9] Equation 3 becomes

[9] This is identical to the value proposed in the GEH Ex Parte filing of 27 December 2008.

$$pfd_r = \frac{\alpha\beta P_{BSN} G_{BSN}}{4\pi \cdot r^{2.4}} \quad (4)$$

For $G_{BSN} = 0\ dBi$ and $\beta = .004$, the following threshold distances for interference between a single BSN transmitter and an AMT ground station receive antenna are computed.

	α = 0 dB	α = 12 dB
$P_{BSN} = 1.0\ mW$	*62.1 km*	*19.6 km*

Note that if 5 BSNs are co-located in the same medical facility on adjacent 1 MHz channels within the 5 MHz receive bandwidth of an AMT ground station receiver, all of the distances in the table will increase by a factor of $5^{(1/2.4)} = 1.96$. Thus, the maximum expected distance for interference will increase to 124 km.

However, for an AMT receive antenna located 100 feet above the ground, in view of BSNs located on the top floor of a 10 story medical facility, the line-of-sight radar horizon is given by

$$d = \sqrt{2h_1 r_e} + \sqrt{2h_2 r_e} \quad (4)$$

where r_e is the radius of the earth, and h_1 and h_2 are the heights of the AMT antenna and BSN network.

Note that for an AMT ground station antenna located on a 100 foot tower and a BSN at ground level, the radar horizon is approximately 20 km. If the BSN is located on the top floor of a 10 story high medical facility, the line of site limit will be approximately 40 km, although variations in local terrain can affect both values.[10]

In any case, interference from BSNs to AMT ground stations should be expected to be a common occurrence whenever a BSN, even when located indoors, is within the visibility horizon of an AMT ground station receive antenna.

[10] For example, line of site microwave communications between Skyline Drive and Washington, D.C., a distance of 120 km, are possible. Similar geometric scenarios can be found at flight test ranges in the Southwestern United States.

February 2008

Daniel G. Jablonski, Ph.D.

PROFESSIONAL EXPERIENCE

1991 - Present: Physicist and Electrical Engineer, the Johns Hopkins University Applied Physics Laboratory (JHU/APL), Laurel, MD

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

1981 – 1986: Research Physicist, Naval Surface Warfare Center, White Oak, MD

FACULTY APPOINTMENTS

1999 - Present: Instructor, Engineering Programs for Professionals, Whiting School, Johns Hopkins University

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

EDUCATION

Ph.D., Physics, Cambridge University, 1982

M.S. Electrical engineering and Computer Science, Massachusetts Institute of Technology, 1977

B.S. Electrical Engineering, Massachusetts Institute of Technology, 1976

TECHNICAL INTERESTS

Communications, microwave engineering, spectrum management, and spacecraft mission design, navigation, and analyses.

RECENT PROFESSIONAL ACTIVITIES

Over ten years analytical, laboratory, and range experience with aeronautical mobile telemetry operations, including flight line and flight test experience with F/A-18 E/F, F/A-18 C/D, T-2, T-38, V-22, and other aircraft.

Member of the U.S. Delegation, 2003 and 2007 World Radio Conferences, Geneva, Switzerland

Principal Investigator, "Steerable Beam Antennas for Flight Test Telemetry," for the Department of Defense, 2006 – 2008

Project Manager, "X-Ray Navigation and Autonomous Position Verification (Xnav)", for the Defense Advanced Research Projects Agency, 2006

Principal Investigator, "X-ray Communications", for the Johns Hopkins University Applied Physics Laboratory, 2008

Project Manager, Deep Space Network Antenna Arraying Analysis, NASA, 2008.

RECENT PUBLICATIONS AND PATENTS

Author, numerous FCC filings, engineering statements, and Coordination Agreements.

Author, numerous ITU submssions.

Author, several reports and analyses on compatibility and adjacent band interference between GPS and other systems, including L-band AMT.

Co-author, ITU-R Technical Report M.2118, "Compatibility between proposed systems in the aeronautical mobile service and the existing fixed-satellite service in the 5 091 – 5 250 MHz band", November 2007.

"The Three-Axis Antenna," provisional patent application filed 2007.

Contributor, Encyclopedia of Material Science and Engineering.

Contributor, **Reference Data for Engineers**, 9th Ed.

Contributor, **The World Book**, 2009 Edition.

Inventor of numerous other patents, applications, and disclosures

Author, over 60 additional publications.

PROFESSIONAL ACTIVITIES
Senior Member, IEEE
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Licensed professional engineer, State of Maryland