Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, DC 20554

In the Matter of	)	
	)	
Unlicensed Use of the 6 GHz Band	)	ET Docket No. 18-295
	)	
Expanding Flexible Use in Mid-Band Spectrum Between 3.7 GHz and 24 GHz	))	GN Docket No. 17-183

COMMENTS OF GLOBALSTAR, INC.

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COMMENTS OF GLOBALSTAR, INC.

I. Introduction and Summary

Globalstar, Inc. ("Globalstar") hereby comments on the Commission's above-captioned Notice of Proposed Rulemaking regarding potential unlicensed use of the 6 GHz band.[1] Globalstar appreciates the Commission's commitment to expanding the U.S. broadband spectrum inventory and agrees that the Commission should work to make broadband connectivity available to all Americans, especially those in rural and underserved areas. At the same time, Globalstar opposes the Commission's proposed rules permitting indoor unlicensed operations in the U-NII-8 band at 6875-7125 MHz, which is licensed in part to Globalstar's mobile satellite service ("MSS") feeder downlink communications. With considerable spectrum already designated to unlicensed use and more on the way, any benefits from adding the 6875-7125 MHz band to the Commission's inventory of unlicensed spectrum would be far outweighed by the significant harms resulting from this action. Unlicensed systems at U-NII-8 would cause

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[1] *Unlicensed Use of the 6 GHz Band; Expanding Flexible Use in Mid-Band Spectrum Between 3.7 and 24 GHz*, Notice of Proposed Rulemaking, FCC 18-147 (rel. Oct. 24, 2018) ("*6 GHz NPRM*").

substantial harmful interference to Globalstar's MSS feeder downlinks and other incumbent licensees in this band, in contravention of the Communications Act[2] and the Commission's rules.

Globalstar's four licensed domestic MSS gateway earth stations are not geographically isolated or otherwise protected from interference from unlicensed operations at U-NII-8, counter to the Commission's claim in the *NPRM*.[3] As described in the attached technical report from Roberson and Associates, LLC ("Roberson"),[4] indoor access points at U-NII-8 would likely cause unacceptable interference to Globalstar's feeder downlinks at each of these gateways, producing large areas of MSS degradation in the United States and also in Canada, Mexico, and other neighboring countries. In addition, unlicensed U-NII-8 operations would threaten harmful interference to any future gateways, which would likely freeze Globalstar's existing feeder link footprint in place and frustrate satellite innovation in this band. Finally, the proposed U-NII-8 rules would likely result in harmful interference to fixed and mobile broadcast auxiliary service systems throughout the United States, including licensed electronic newsgathering facilities used in live broadcast reporting. Given these unreasonable interference risks, the Commission should conclude that spectrum sharing between new unlicensed systems and incumbent licensees is not viable in the U-NII-8 band.

II. Globalstar and Its Global MSS Network

Globalstar's Satellite Business. Globalstar is a leading provider of global mobile satellite voice and data services. Globalstar is licensed domestically for uplink transmissions (mobile earth stations to satellites) in the Lower Big LEO band at 1610-1618.725 MHz and for downlink

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2 47 U.S.C. § 301.

3 *6 GHz NPRM* ¶ 67.

4 Technical Analysis of Impact of Unlicensed Operations in U-NII-8 on Globalstar Mobile Satellite Service, Roberson and Associates, LLC (Feb. 15, 2019) ("Roberson Analysis").

transmissions (satellites to mobile earth stations) in the Upper Big LEO band at 2483.5-2500 MHz.[5] In 2013, Globalstar completed the launch of a $1 billion, second-generation non-geostationary ("NGSO") satellite constellation, and it continues to invest hundreds of millions of dollars in ground infrastructure upgrades and an expanded line of enterprise, consumer, and government products.[6] Indeed, Globalstar recently executed a $17 million contract for the purchase of new ground station antennas, with the first such antennas being delivered later this year. With a fifteen-year design life, Globalstar's second-generation MSS system will support highly reliable, high-quality CDMA-quality voice and data satellite services to the millions of consumers, public safety personnel, and other potential customers covered by the new network. Overall, having invested more than $5 billion to date in its global MSS network, Globalstar uses its constellation of satellites and ground stations on six continents to provide affordable, high-quality MSS to over 700,000 customers in over 120 countries around the world.

Since initiating commercial MSS in 2000, Globalstar has been dedicated to providing state-of-the-art, mission-critical, and safety-of-life services to consumers, businesses, and

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[5] *Application of Loral/Qualcomm Partnership, L.P. for Authority to Construct, Launch, and Operate Globalstar, a Low Earth Orbit Satellite System, to Provide Mobile Satellite Services in the 1610-1626.5 MHz/2483.5-2500 MHz Bands*, Order and Authorization, 10 FCC Rcd 2333 (IB 1995); *see also Spectrum and Service Rules for Ancillary Terrestrial Components in the 1.6/2.4 GHz Big LEO Bands; Review of the Spectrum Sharing Plan Among Non-Geostationary Satellite Orbit Mobile Satellite Service Systems in the 1.6/2.4 GHz Bands*, Second Order on Reconsideration, Second Report and Order, and Notice of Proposed Rulemaking, 22 FCC Rcd 19733, ¶¶ 8, 18-20 (2007). Iridium is authorized to share spectrum with Globalstar at 1617.775-1618.725 MHz.

[6] Globalstar launched its second-generation Big LEO satellites in a series of launches from October 2010 to February 2013, and all 24 of these satellites are now in service. In March 2011, the Commission authorized Globalstar's domestic gateway earth station facilities and mobile earth terminals to communicate with its second-generation Big LEO satellites. *Globalstar Licensee LLC, Application for Modification of Non-geostationary Mobile Satellite Service Space Station License; GUSA Licensee LLC, Applications for Modification of Mobile Satellite Service Earth Station Licenses; GCL Licensee LLC, Applications for Modification of Mobile Satellite Service Earth Station Licenses*, Order, 26 FCC Rcd 3948 (IB 2011).

governmental and public safety users in remote, unserved, and underserved areas not reached by terrestrial deployments, both in the United States and globally.[7] Globalstar's MSS network provides critical back-up capabilities for public safety personnel during disasters, when terrestrial networks can be rendered inoperable. In situations where all terrestrial facilities are down in an affected area, Globalstar's global MSS network will continue to function normally. Public safety entities involved in relief efforts in the United States and around the world have relied on Globalstar's satellite services after earthquakes, hurricanes, and other disasters.

Over the past decade, Globalstar has focused on the development of affordable, consumer-oriented devices and services with significant public safety benefits. This "SPOT" family of MSS devices has played a critical role in providing emergency and safety-of-life services to individual consumers beyond terrestrial wireless reach. SPOT is responsible for initiating over 6200 emergency communications around the world – often life-saving, on land and at sea – since the 2007 introduction of this product.[8] During 2018 alone, SPOT products were used to initiate 759 emergency communications, an average of approximately two per day. Globalstar's subscribers transmitted more than 1.3 billion SPOT and other simplex messages last year, and that figure continues to grow at a significant rate year over year.

With the launch of its second-generation constellation, Globalstar's network now carries increasing duplex (two-way) voice and data traffic. To support its global two-way messaging services, Globalstar has developed an innovative "half-duplex" communications platform that it is currently deploying at its gateway earth stations around the world. As a result of this

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[7] In addition to individual consumers, Globalstar's customers include entities in government, the military, emergency preparedness, transportation, heavy construction, oil and gas, mining, forestry, and commercial fishing.

[8] From any location in Globalstar's global MSS footprint, SPOT devices can transmit a user's GPS coordinates and status updates to any e-mail, handheld device, or smartphone in the world.

deployment, most of Globalstar's future products, including the "Sat-Fi2" and "SPOT-X" products introduced during 2018, will include duplex functionality, relying heavily not only on Globalstar's licensed feeder downlink spectrum at 6 GHz, but also on its feeder uplink spectrum at 5 GHz and 2.4 GHz downlink frequencies.

Globalstar's Gateway Earth Station Infrastructure. Globalstar's gateway earth station facilities are an essential part of its global MSS network infrastructure. Globalstar's satellites currently communicate with 23 gateway earth stations around the world.[9] In the United States and its territories, Globalstar currently operates gateway earth stations in Clifton, Texas; Sebring, Florida; Wasilla, Alaska; and Barrio of Las Palmas, Cabo Rojo, Puerto Rico.

Globalstar is authorized for feeder uplink transmissions from its gateway earth stations to its space stations at 5096-5250 MHz and for feeder downlink transmissions between its satellites and its gateway facilities in the 6875-7055 MHz band. In Globalstar's MSS architecture, its satellites' feeder downlink transmissions at 6875-7055 MHz convey all traffic originating from Globalstar's MSS simplex (one-way) and duplex (two-way) user devices over a radius of approximately 2900 km on the earth's surface. Globalstar's domestic gateway earth stations consist of multiple antennas that receive this downlink traffic from multiple satellites at particular time intervals determined by the motion of Globalstar's orbiting satellites in its Big LEO MSS constellation. Globalstar's gateways receive, translate, amplify, and transmit this user-initiated

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[9] In order for Globalstar to provide services to an MSS subscriber, that customer must be within line-of-sight of a satellite and that satellite must be within line-of-sight of a gateway earth station. Globalstar has positioned its gateways to enable its provision of MSS over most of the world's land area and population. Globalstar currently owns thirteen gateway earth stations, with the rest owned by independent gateway operators. Specifically, Globalstar owns and operates gateways in the United States, Canada, Venezuela, Puerto Rico, France, Brazil, Singapore, and Botswana.

traffic into the public switched telephone network ("PSTN"), to cellular or other wireless networks, or to the Internet, depending on the nature of the MSS customer's call and connection.

III. The Commission Should Not Authorize Indoor Unlicensed Operations at U-NII-8

Globalstar supports the Commission's ongoing effort to make additional spectrum available for next-generation and mobile broadband applications in order to meet the extensive consumer demand for these services. Globalstar itself has sought in recent years to increase terrestrial use of its own licensed Big LEO satellite spectrum, petitioning the Commission for more flexible terrestrial rules in this band in 2012 and in 2017 obtaining authority to provide terrestrial broadband services at 2483.5-2495 MHz.[10]

The U-NII-8 band, however, does not appear to be a necessary or essential component of the Commission's terrestrial wireless broadband inventory. There are almost 650 megahertz designated for current or future unlicensed use in the United States in the 2.4 GHz and 5 GHz bands, and the Commission in the *NPRM* is now proposing to designate an additional 950 megahertz to unlicensed operations in the U-NII-5, U-NII-6, and U-NII-7 bands at 6 GHz.[11] Given this abundance of unlicensed spectrum, the marginal benefits of also opening up the 6875-7125 MHz band to unlicensed use would be far outweighed by the substantial harms to Globalstar and other incumbent licensees in this band, as described below.

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10 *See* Petition for Rulemaking of Globalstar, Inc., RM-11685 (Nov. 13, 2012); Application for Modification of Globalstar Licensee LLC, IBFS File No. SAT-MOD-20170411-00061, Call Sign S2115 (filed Apr. 11, 2017; granted Aug. 8, 2017); *Satellite Policy Branch Information Action Taken*, Public Notice, Report No. SAT-01260, DA No. 17-756, at 1 (rel. Aug. 11, 2017); and Application for Modification of GUSA Licensee LLC, IBFS File No. SES-MOD-20170412-00422, Call Sign E970381 (filed Apr. 11, 2017; granted Aug. 11, 2017); *see also Satellite Communications Services Information re: Actions Taken*, Public Notice, Report No. SES-01982, at 5-7 (rel. Aug. 16, 2017). *See also Terrestrial Use of the 2473-2495 MHz Band for Low-Power Mobile Broadband Networks; Amendments to Rules for the Ancillary Terrestrial Component of Mobile Satellite Service Systems*, Report and Order, 31 FCC Rcd 13801 (2016).

11 *See, e.g.*, *6 GHz NPRM.*

Certainly, as the Commission works to expand terrestrial wireless broadband, it must ensure that existing licensees can continue to operate their facilities to the full extent permitted under their authorizations and the Commission's rules. Under its rules and the Communications Act, the Commission has the fundamental duty to protect Globalstar and other licensees at 6 GHz from harmful interference from unlicensed operations.[12] Neither the Commission nor unlicensed proponents have shown that unlicensed facilities – even low-power, indoor systems – can share the U-NII-8 band without causing harmful interference to existing licensees.

A. Indoor Unlicensed Operations at U-NII-8 Would Cause Harmful Interference to Globalstar's MSS Feeder Downlink Operations

The Commission must ensure that Globalstar's existing, licensed feeder downlinks at 6875-7055 MHz are fully protected from harmful interference and not subject to any disruptions or restrictions due to unlicensed use. While Globalstar supports the Commission's proposed prohibition against outdoor unlicensed operations at U-NII-8, it opposes the Commission's proposal to allow indoor unlicensed use of this band.

As described in the attached Roberson Analysis, indoor unlicensed operations at U-NII-8 would pose a substantial threat of harmful interference to Globalstar's feeder downlinks, given the high-gain receive antennas employed at Globalstar's gateway earth stations and the close proximity of these unlicensed systems relative to Globalstar's satellites (its satellite-to-gateway downlinks range from 1400 to 3500 kilometers in length, depending on the elevation angle). Indoor U-NII-8 access points with line-of-sight could cause detrimental interference to

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[12] Section 301 of the Communications Act protects licensed wireless operators from harmful interference. 47 U.S.C. § 301.

Globalstar's gateways even from a substantial distance, given that building and walls result in only limited signal attenuation at 6875-7125 MHz.[13]

In its technical analysis, Roberson applies a harmful interference threshold of -12.2 dB (interference-to-noise ratio), the interference criterion developed by the International Telecommunications Union and codified in recommendations for the Fixed Satellite Service.[14] As Roberson describes, this interference threshold would be substantially exceeded at each of Globalstar's four existing gateway earth stations. Contrary to the Commission's claim in the *NPRM*, Globalstar's existing gateways are not geographically "isolated" and thereby protected from interference from U-NII-8 unlicensed operations.[15] As Roberson describes, there are a considerable number of residences, businesses, and enterprises located near all four of these Globalstar's current gateway sites.[16] For instance, Globalstar's Sebring, FL site is near the Sebring Airport, Sebring Raceway, and a large hotel, and is also within close proximity of the town of Sebring and multiple recreational vehicle parks.[17] Globalstar's Wasilla, AK site is near three small towns (Wasilla, Meadow Lakes, Knik-Fairview, and Palmer), while its Clifton, TX facility is near the town of Clifton, the largest municipality in Bosque County, TX.[18] Globalstar's Puerto Rican gateway in Las Palmas is less than 1 kilometer from a group of

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13 *See, e.g.*, Roberson Analysis at 1.

14 *See* Recommendation ITU-R S.1432, Apportionment of the allowable error performance degradations to fixed-satellite service (FSS) hypothetical reference digital paths arising from time invariant interference for systems operating below 30 GHz (2006). This interference criterion corresponds to a $\Delta T/T$ of 6%. Roberson Analysis at 7, n.3. As Roberson points out, Globalstar's outside frequency coordinator applies this accepted interference criterion in the coordination analyses contained in its monthly Frequency Protection Reports for Globalstar's four gateways. *Id*.

15 *6 GHz NPRM* ¶ 67.

16 Roberson Analysis at 8-17.

17 *Id*. at 8-11.

18 *Id*. at 12-15.

residences.[19] Given typical access point densities and the resulting level of unlicensed activity nearby Globalstar's gateways, Roberson projects that the relevant interference threshold would be exceeded by at least 25 dB (i.e., more than 300 times) at each of these facilities, an outcome that would have a substantial detrimental impact on Globalstar's public safety users and other customers around the United States (*see* Section II B. below).[20]

Significantly, unlicensed transmitters at U-NII-8 would threaten harmful interference not only to Globalstar's existing gateway earth stations, but also to any additional gateways that Globalstar considered deploying in the future. Under the current 6 GHz regulatory framework, Globalstar could construct additional gateways in order to achieve greater frequency reuse of its feeder link spectrum and increase system capacity and spectrum efficiency. Globalstar might also utilize portable gateways in the future as a means of providing greater MSS capacity to its customers in regions affected by natural disasters or other emergencies. If the Commission permits indoor unlicensed operations in this band, however, the resulting interference threat would discourage investment in ad2ditional gateway facilities in this band by Globalstar and potentially other future satellite systems, thereby locking Globalstar into its existing feeder link technology and stifling innovative satellite uses of this spectrum going forward. This decision would effectively repurpose Globalstar's licensed spectrum at 6875-7055 MHz to near-ubiquitous indoor unlicensed operations throughout the United States.

B. Harmful Interference to Globalstar's Feeder Downlinks Would Have a Substantial Detrimental Impact on Globalstar MSS Offerings to Public Safety Customers and Other End Users

As described in the Roberson Analysis, interference-related disruptions to Globalstar's feeder downlink communications in North America would have a significant, detrimental

19 *Id*. at 16.

20 *Id*. at 17.

impact on Globalstar's services to end users.[21] Globalstar's feeder downlinks represent a crucial component of its MSS network infrastructure, transmitting all user traffic emanating from Globalstar's MSS duplex and simplex devices in the United States to its four existing gateway earth stations and, in turn, into public wireline and wireless networks. Globalstar's duplex traffic (such as voice service and SPOT-X) includes life- and mission-critical communications during natural and manmade disasters, while Globalstar's one-way SPOT and simplex traffic includes life-critical emergency messaging and management-related transmissions. Globalstar's feeder downlinks also convey critical satellite system monitoring telemetry and command data necessary to maintain control and operation of its satellites.

Assuming that unlicensed U-NII-8 activity reaches the levels projected by Roberson, harmful interference to Globalstar's feeder downlink communications would disrupt current and future services to Globalstar's end users and impair Globalstar's ability to properly control its satellite constellation. Such interference would materially reduce the capacity and geographic reach of Globalstar's MSS network, diminish the quality of its services, and cause unacceptable harm to first responders, public safety personnel, consumers, and other customers who rely on Globalstar's MSS offerings.[22] As Roberson points out, because the proposed U-NII-8 band overlaps the entirety of Globalstar's licensed feeder downlink spectrum at 6875-7055 MHz, harmful interference to a particular gateway earth station will have these detrimental effects over the entire service area of a satellite communicating with that gateway, equivalent to an area more than three times the size of the contiguous United States.[23]

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[21] *Id*. at 1-2, 6, 18-19.

[22] *Id*. at 1-2. In addition, Globalstar would experience degraded sensitivity of its feeder downlink channel for telemetry and command information, data which is key to maintaining the control and operation of its satellites. *Id*. at 2, 19.

[23] *Id*. at 1, 6.

Furthermore, as indicated above, Globalstar's gateways consist of multiple antennas receiving downlink traffic from multiple satellites, given the dynamic nature of Globalstar's constellation. If a gateway earth station's antennas suffer interference from nearby unlicensed U-NII-8 operations, that interference could degrade Globalstar's satellite offerings within the aggregate service area covered by *all* the satellites with which that gateway is communicating. This would result in an even more expansive area of Globalstar service degradation that includes large portions of the United States and adjacent areas of Canada and Mexico, Caribbean nations, and Central and South American countries.[24]

As the Commission considers options at U-NII-8, it should bear in mind that Globalstar is already experiencing aggregate interference in its feeder uplink spectrum at 5096-5250 MHz, due to the Commission's 2014 order permitting high-power, outdoor unlicensed operations in the U-NII-1 band at 5150-5250 MHz.[25] The Commission should not exacerbate the growing interference threat to Globalstar's MSS business by allowing indoor unlicensed use of Globalstar's feeder downlink spectrum.

C. The Commission's Proposed U-NII-8 Rules Would Fail to Protect Licensed Broadcast Auxiliary Service Systems in This Band

The Commission's proposed rules would also fail to protect the services of other U-NII-8 incumbents, consisting primarily of fixed and mobile broadcast auxiliary service ("BAS") systems licensed under Part 74 of the Commission's rules. BAS operations in this band include electronic newsgathering ("ENG") use of portable transmitters on handheld cameras to relay audio and video to horn antennas, often in indoor environments such as sports venues, political

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[24] *Id.* at 18.

[25] *Revision of Part 15 of the Commission's Rules to Permit Unlicensed National Information Infrastructure (U-NII) Devices in the 5 GHz Band*, First Report and Order, 29 FCC Rcd 4127 (2014).

conventions, and other indoor events. BAS facilities at U-NII-8 also provide communications links between mobile and portable ENG transmitters and receive sites located miles away on towers or building rooftops, frequently in urban areas. In previous filings with the Commission, NAB and other commenters have explained that low-power, indoor unlicensed operations would pose a significant threat of harmful interference both to portable, indoor ENG transmissions and to longer outdoor portable/mobile ENG links.[26] In particular, ENG links to urban receive sites would likely be vulnerable to harmful interference from indoor access point operations in urban office buildings with glass exteriors.[27]

The Commission's regulatory proposal for unlicensed operations in the U-NII-5 and U-NII-7 bands – involving the use of automatic frequency coordination ("AFC") to protect incumbent operations – cannot be extended to the U-NII-8 band. As the Commission correctly found in the *NPRM*, the mobile nature of BAS/ENG systems makes AFC infeasible at U-NII-8.[28] AFC requires information regarding the incumbent receiver location and antenna orientation, and such information will not be available for mobile BAS operations. Accordingly, the Commission cannot apply an AFC approach to protect incumbent licensees at U-NII-8.

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[26] *See* Letter from Patrick McFadden, National Association of Broadcasters, to Marlene H. Dortch, Secretary, FCC, ET Docket No. 18-295, GN Docket No. 17-183, at 1 (Oct. 10, 2018); Letter from Patrick McFadden, National Association of Broadcasters, to Marlene H. Dortch, Secretary, FCC, ET Docket No. 18-295, GN Docket No. 17-183, at 1 (Oct. 17, 2018).

[27] *See, e.g.,* Letter from Cheng-yi Liu, Counsel for the Fixed Wireless Communications Coalition, to Marlene H. Dortch, FCC, ET Docket No. 18-295, at 6 (Oct. 2, 2018) (stating that "[t]all buildings [] have more glass, which offers little attenuation" and that "[f]rom an interference standpoint, an RLAN in a room on the building periphery might as well be outdoors.").

[28] *6 GHz NPRM* ¶ 61.

D. Under the Commission's Proposal, There Would Likely Be a Significant Volume of Unauthorized Outdoor Unlicensed Operations at U-NII-8, Further Raising the Risk of Harmful Interference to Incumbent Services

The threat of harmful interference to Globalstar's feeder downlink operations and BAS ENG operations incumbents would be even greater if the Commission permitted unlimited outdoor unlicensed operations in the U-NII-8 band. Accordingly, Globalstar strongly supports the Commission's proposed U-NII-8 prohibition against unlicensed operations at outdoor locations. The Commission should make clear that this outdoor prohibition also precludes indoor unlicensed deployments that provide coverage to outdoor users.[29]

Unfortunately, even under the Commission's proposed indoor restriction, a significant amount of outdoor unlicensed operations at U-NII-8 would be inevitable. Universal compliance with the proposed indoor restriction is highly unlikely, and a significant percentage of residential and enterprise unlicensed users would almost certainly deploy U-NII-8 access points outside. To prevent such unauthorized use, the Commission proposes a GPS-based mechanism for preventing outdoor U-NII-8 operations, with access points designed to terminate U-NII-8 operations if the available GPS signal is above a given signal strength threshold. This approach does not appear reliable, however, since terrain or buildings could block GPS signals' path to many outdoor access points and leave those devices free to operate. In addition, it is not possible to prevent user client devices from transmitting outdoors to access points located indoors. With enforcement of the Commission's proposed indoor restriction

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[29] The Commission's current rule prohibiting outdoor unlicensed operations at 92-95 GHz effectively applies to such indoor deployments, stating that "the emissions from [indoor] equipment operated under this section shall not be intentionally directed outside of the building in which the equipment is located, such as through a window or doorway." 47 C.F.R. § 15.257(a)(3).

virtually impossible, unauthorized outdoor U-NII-8 operations would intensify the threat of harmful interference to Globalstar's MSS offerings and other incumbent services.

IV. Conclusion

Globalstar urges the Commission to abandon its proposed U-NII-8 rules and continue to prohibit unlicensed operations in the U-NII-8 band at 6875-7125 MHz. As described in these Comments, indoor unlicensed transmissions at U-NII-8 would cause harmful interference to Globalstar's MSS offerings and other incumbent licensees in this band.

Respectfully submitted,

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Technical Analysis of Impact of Unlicensed Operations in U-NII-8 on Globalstar Mobile Satellite Service

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Executive Summary

The impact of indoor unlicensed wireless access points operating in the proposed U-NII-8 band at 6875-7125 MHz on Globalstar's licensed fixed feeder satellite downlinks is analyzed in this report. This analysis shows that the accepted interference-to-noise ratio (I/N) criterion is exceeded for indoor access points operating within line-of-sight of Globalstar's earth station receiving antennas, degrading mobile satellite traffic originating from terminals in the entire service area of the satellite. The interference limit corresponds to a ΔT/T of 6%, which is the established value for coordination purposes in the Fixed Satellite Service that includes 6875-7125 MHz.

Globalstar's earth stations include multiple antennas which receive downlink communication traffic from multiple satellites simultaneously at certain time intervals due to the motion of the satellites in the Globalstar constellation. When multiple earth station antennas at a single location are simultaneously receiving mobile satellite traffic on their respective feeder downlinks, all traffic originating from mobile terminals in the service areas of those satellites will potentially be impacted by interference created by terrestrial sources in the vicinity of the single earth station location.

Globalstar operates earth station sites in Sebring (Florida), Wasilla (Alaska), Clifton (Texas), and Las Palmas (Puerto Rico). Examination of the environment around Globalstar's earth stations indicates a substantial commercial, residential, and consumer presence within line-of-sight of Globalstar's antennas. Given this presence, there is a high likelihood of harmful interference to Globalstar's satellite-to-earth station downlinks and in turn to Globalstar's mobile satellite service, including simplex, emergency, and duplex voice and data services, if unlicensed indoor operations are allowed in U-NII-8, as proposed by the Commission.[1]

The Sebring gateway earth station is within 1 km of the Sebring airport, Sebring Raceway, and a large hotel serving both of those venues. The Sebring gateway is also within 10 km of several RV parks and the town of Sebring itself. The Wasilla earth station is within 2.5 km of the towns of Wasilla, and within 20 km of Meadow Lakes, Knik-Fairview, and Palmer. The Clifton earth station is near the town of Clifton in Bosque County, Texas. Las Palmas is within a kilometer of a small residential neighborhood. All of these population centers in the vicinities of Globalstar earth station sites have user densities high enough to result in sufficient indoor access point deployments in the U-NII-8 band to cause interference that exceeds the accepted limit. In all four current Globalstar earth station locations, the accepted interference limit is exceeded by greater than 25 dB (more than 300 times).

The detrimental impact on Globalstar's mobile satellite services and users would be substantial. Since the U-NII-8 band overlaps the entire Globalstar feeder downlink, interference from unlicensed U-NII-8 devices beyond the accepted I/N limit would impair or block communications for the entire coverage area of a satellite, an area that is more than 3 times larger than the 48 states of the Continental US (CONUS) and also larger than the area of the North American continent. The services impaired or blocked by the interference would include Globalstar's simplex "Spot" life-critical emergency S.O.S.

[1] FCC 18-147; Notice of Proposed Rulemaking, Unlicensed Use of the 6 GHz Band, October 24, 2018.

service calls to the International Emergency Response Center, as well as Globalstar's continuous location tracking messages and duplex Spot, voice, and data calls. The system's telemetry channel would also suffer degraded sensitivity from a rise of the noise floor caused by U-NII-8 interference.

Introduction

This document provides an analysis of the interference and impact on Globalstar that can be expected as a result of the Commission's Notice of Proposed Rulemaking that would authorize the deployment of unlicensed devices in 6875-7125 MHz (U-NII-8). The interference is experienced on Globalstar's satellite to earth-station feeder downlink at 6875-7055 MHz. The subsequent impact on Globalstar's mobile satellite service (MSS) is harm to the entirety of the user simplex and duplex traffic handled by Globalstar's satellites, as well as to the downlink satellite command and control channel.

Globalstar Mobile Satellite Network

Globalstar currently operates a global mobile satellite service using a constellation of non-geostationary low earth orbit (LEO) satellites.[2] The Globalstar system architecture includes earth station "gateways," four of which are located in the United States and its territories, which interconnect with terrestrial networks and communicate with the satellites using a 5096-5250 MHz uplink and a 6875-7055 MHz downlink. Signals from the mobile devices (the "reverse link") are transmitted to the satellites in CDMA channels in the frequency band 1610-1618.725 MHz. Transponders on the satellite translate the CDMA channels conveying user information from the mobile devices to the 6875-7055 MHz band for retransmission to the earth station gateway, where high-gain antennas track the satellites and receive both mobile user information and satellite command and control information.

Globalstar's mobile satellite services and devices include full-duplex voice handsets, Sat-Fi satellite data hotspots, Simplex and Duplex satellite data modems, continuous location-tracking devices, and life-critical Spot S.O.S. emergency messaging.

The four segments composing Globalstar's satellite network are shown in Figure 1.

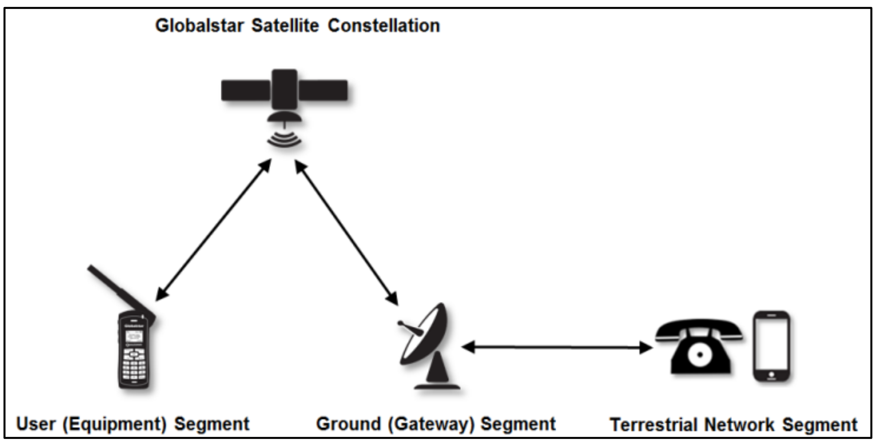

Figure 1. Globalstar Architecture

[2] Information provided by Globalstar, Inc., and *The Globalstar System, Applied Microwave and Wireless*, Summer 1995.

- User terminals – The Globalstar user segment consists of satellite phones, Sat-Fi devices, and other fixed and mobile equipment used to send and receive voice and data. Many of the terminals can send S.O.S. messages to an International Emergency Response Center.
- Satellite (space) – The Globalstar space segment is a constellation of 24 LEO satellites arranged in 8 orbital planes, providing global communications. The constellation provides a "bent-pipe" service between satellite phones and gateway earth stations.
- Earth station (gateway) – An operational gateway is required to send and receive voice and data to other sat phones and the terrestrial network.
- Terrestrial network – The terrestrial network refers to existing public telephone and data networks that Globalstar uses to route communications to the desired destination.

Interference Scenario at 6875-7125 MHz (U-NII-8)

The Globalstar satellite network provides service to mobile terminals globally. The network uses the frequency band 6875-7055 MHz for the “reverse” downlink from the satellites to the earth stations. This is shown in Figure 2 below.

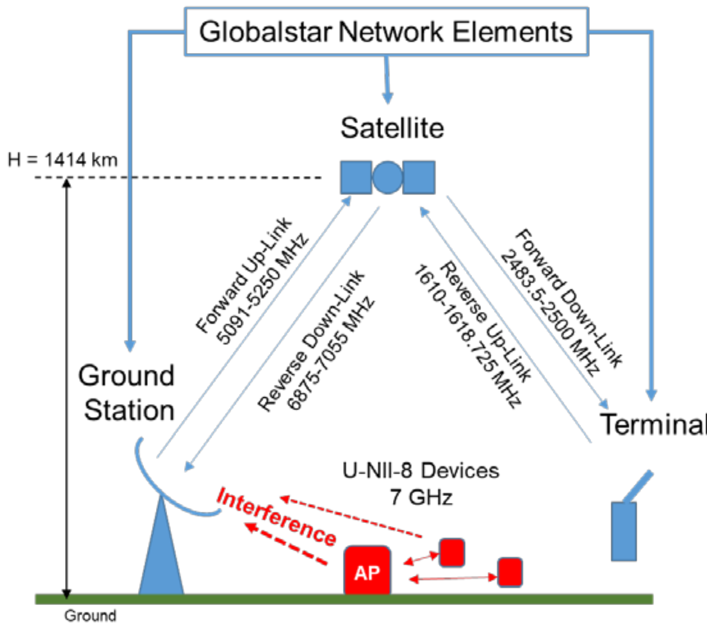

Figure 2. U-NII-8 Interference Scenario

The spectrum licensed to Globalstar is the lower 178 MHz out of the 250 MHz designated as the U-NII-8 band. This is shown in Figure 3.

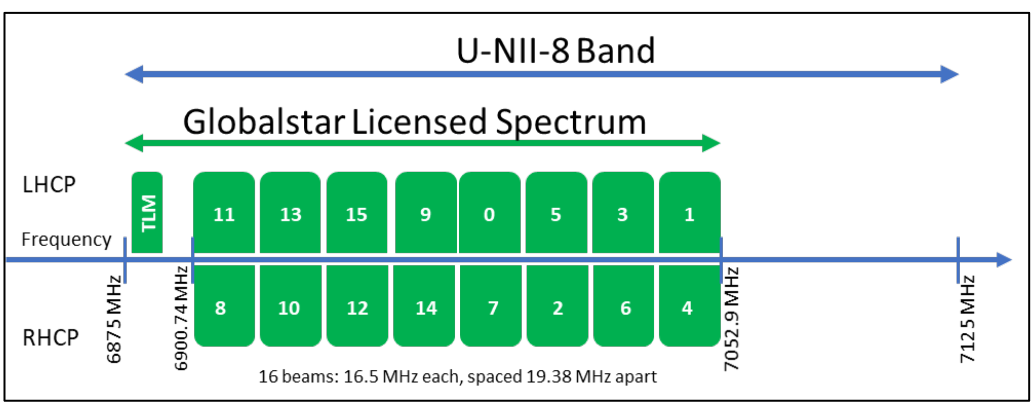

Figure 3. Interference Scenario- RF Spectrum View

The reverse link uses 16 groups of CDMA channels numbered 0…15 in the diagram. These channels correspond to 16 coverage beams on the reverse link. An additional channel labelled as “TLM” in the diagram is used for the system telemetry. Both Left Hand Circular Polarization (LHCP) and Right Hand Circular Polarization (RHCP) are used on the reverse link. This implies that the polarization of the

interference power at the gateway earth station is irrelevant since all of the interference power will be received as a linear combination of LHCP + RHCP, regardless of any polarization. The beams for the reverse link are arranged radially around a central beam numbered 0. This is shown in Figure 4, for a satellite over Lincoln Center, Kansas, close to the center of the North American continent.

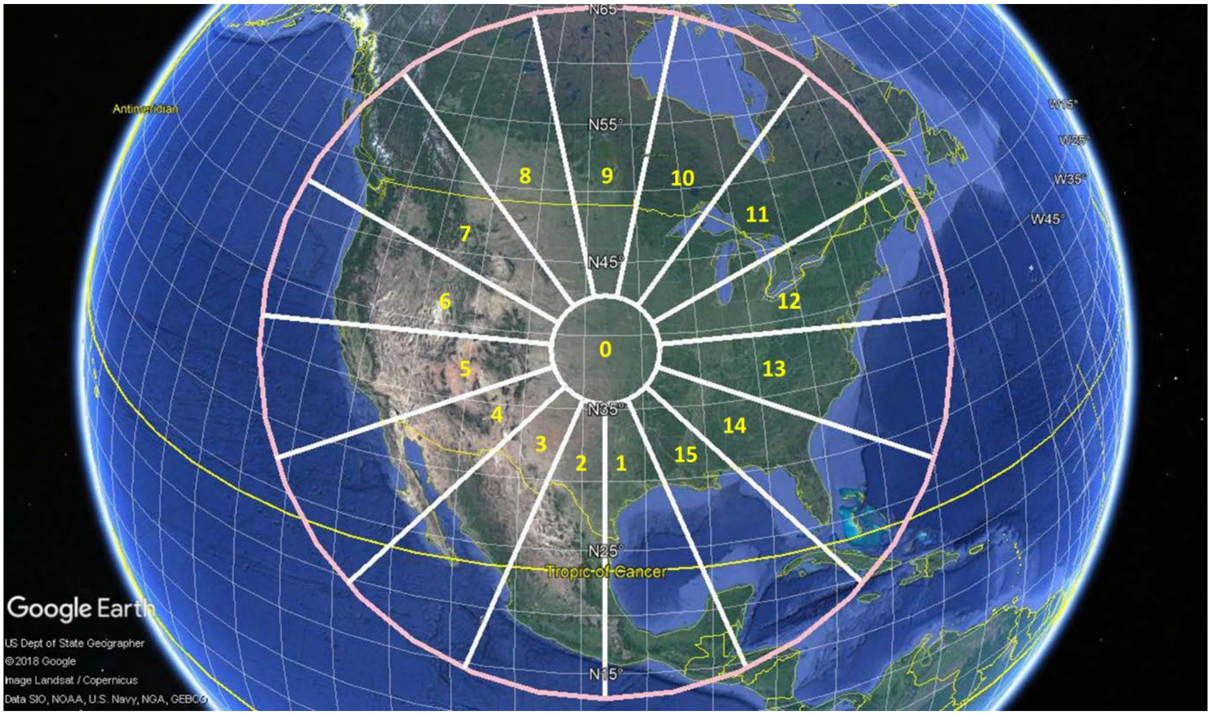

Figure 4. Service Area of a Globalstar Satellite; Area Impacted by Interference

The total area of coverage by a single satellite is a circular area with a diameter of 5850 km. At the edge of the coverage circle, the satellite is at an elevation of 10° above the horizon, and therefore the bore-site of the earth station antenna is also at an elevation angle of 10°. The total service area covered by a single satellite is 26.4 million square km. The area of beam 0 is 0.9 million square km and each of the 15 radial beams covers 1.7 million square km. This compares with 8.1 million square km for the total area of the Continental US (CONUS) consisting of the 48 states and the District of Columbia. Each of the 15 individual radial beams covers an area of about 1/5 of the CONUS area. The total satellite coverage area is 3.26 times the area of CONUS. The coverage area is also larger than the entire area of the North American continent at 24.7 million square km. During a satellite orbit that passes through the center of North America, a satellite will pass over the 52^{nd} parallel north of the Canadian border with CONUS, and its coverage area will include Alaska and the rest of the northwestern corner of the North American continent. As it descends through the center of the continent it will pass over the Caribbean and cover all of the southern portions of North America. Interference with ground stations in the US and its territories will therefore affect service over the entire North American continent. This coverage area is the area of service disruption from harmful interference in the U-NII-8 band to a Globalstar gateway earth station.

Interference Analysis for Indoor U-NII-8 Operations

This section describes the method to analyze the interference from indoor access points (APs) deployed according to the FCC's proposed rules for the U-NII-8 band. The detailed calculation is described in Annex A. This analysis includes details of transmitter power levels, antenna gains, and other factors, as well as details of Globalstar's victim earth station receivers including noise floor levels, antenna gains, and other factors. The results are compared with the interference criterion of -12.2 dB I/N recommended by the ITU for operations in the Fixed Satellite Service.[3] Interference below this accepted threshold would avoid harm to the Globalstar feeder downlink carrying user traffic and satellite telemetry information.

The interference calculation method is captured in the example interference Link Budget tabulated below. The calculation shows that interference from APs in the town of Sebring incident upon the SBR site exceeds the accepted limit by 22.3 dB (line R).

Table 1: Example Interference Link Budget

Line	Transmitters		Units	Note
A	P_0	0.25	W	
B	B	250	MHz	
C	A	0.1		Activity factor
D	N_{AP}	1526		Likely number in town of Sebring
E	G_{AP}	6	dB	
F	E[BEL]	11.0	dB	Traditional Building Entry Loss
G	PSD_{TX}	-13.2	dBW/MHz	$10 \log_{10}(P_0 \, A \, N_{AP}/B) + G_{AP} - E[BEL]$
	Path Loss			
H	λ	4.28	cm	
I	D	10	km	Distance from town to SBR site
J	L_p	135.4	dB	$20 \log_{10}(4 \pi D/\lambda)$
	Globalstar Gateway Earth Station Victim Receiver			
K	G_1	7	dB	
L	k	1.38E-23	J/K	
M	T	200	°K	Noise temperature
N	B	1.00E+06	Hz	
O	N_0	-145.6	dBW/MHz	$10 \log_{10}(kTB)$
P	I/N	10.1	dB	G-J+K-O
Q	Limit	-12.2	dB	ITU-R S.1432
R	Exceed	22.3	dB	P-Q

[3] Deliberation in the ITU-R and standard publication in ITU-R Recommendation S.1432 has established that an I/N criterion of -12.2 dB is applicable to operations in the Fixed Satellite Service, of which Globalstar's 6875-7055 MHz feeder downlink operations are a part. Globalstar employs the services of an outside frequency coordinator to apply this criterion to potential interferers to Globalstar's gateway earth stations. The coordinator provides monthly Frequency Protection Reports. In January 2019, the coordinator analyzed and reported more than 100 earth station interference analysis cases. A -12.2 dB I/N corresponds to a $\Delta T/T = 6\%$.

Analysis of Interference at Current Globalstar Gateway Earth Stations

This section analyzes the interference from areas around the four current Globalstar earth stations in the United States and its territories. These are located in Sebring, Florida; Wasilla, Alaska; Clifton, Texas; and Las Palmas, Puerto Rico. The Sebring site is near the Sebring Airport and the Sebring Raceway as well as a large hotel that serves the visitors there. The Wasilla site is near four small towns in the area: Wasilla, Meadow Lakes, Knik-Fairview, and Palmer. Clifton is near the town of Clifton which is the largest town in Bosque County, Texas. Las Palmas is less than 1 km from a small group of residences that are probable locations for indoor U-NII devices.

Sebring Interference Scenario

The immediate vicinity of the Sebring site ("SBR") is shown in the Google Earth images shown in Figures 5 through 8.

Figure 5. Sebring, FL Vicinity

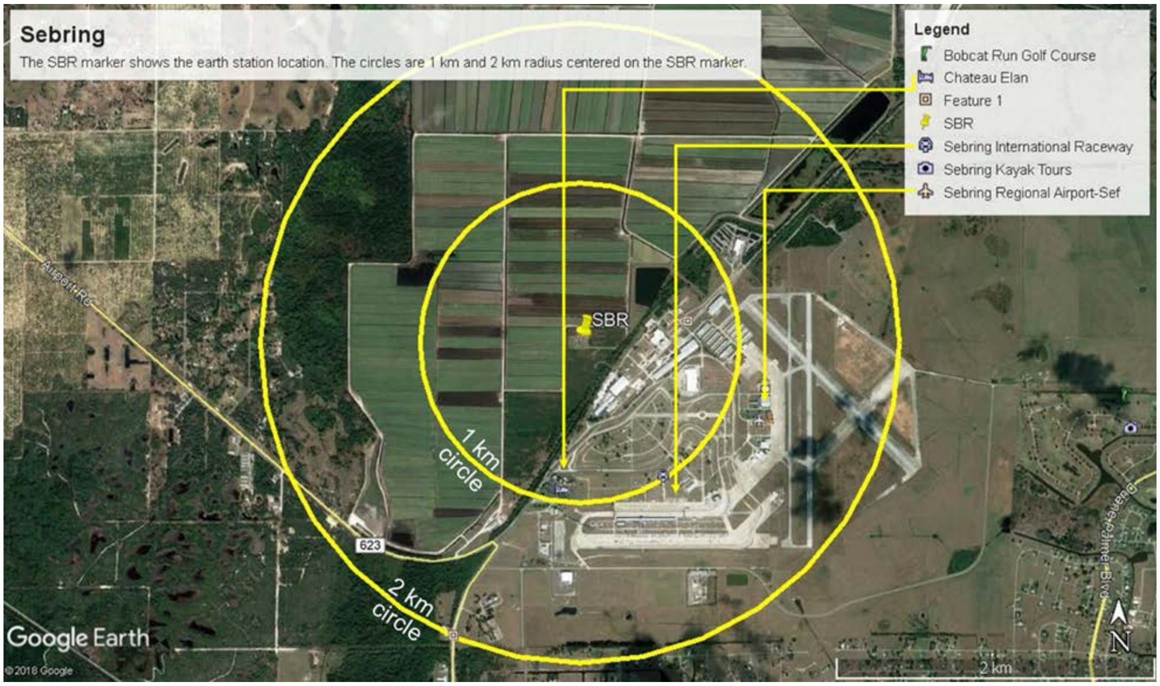

Figure 6. Sebring, FL Interference within 2 km

The circles in Figure 6 have radii of 1 km and 2 km. The SBR thumb-tack shows the gateway earth station location. The Sebring Airport is easily visible southeast of the SBR site. The grandstands for the Sebring Raceway are south of SBR just beyond the 1 km circle. The Sebring Raceway attracts 100 to 200 thousand visitors annually. The Chateau Elan Hotel is south of SBR and just inside the 1 km circle. The hotel is a 4-story structure that is shown again in Figure 8.

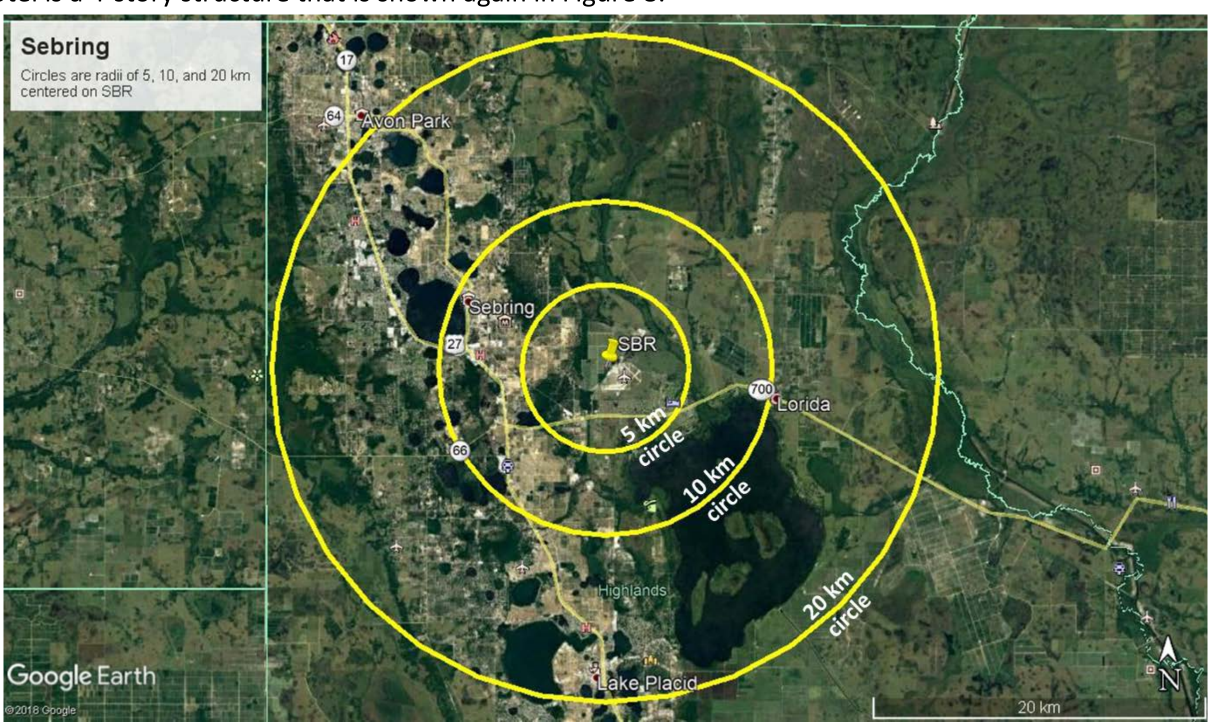

Figure 7. Sebring, FL Interference within 20 km.

The image in Figure 7 shows the town of Sebring about 10 km northwest of SBR. Highway 27 runs north-and-south through Sebring and it has numerous RV parks for tourists and spectators of the Sebring Raceway. Both the town of Sebring and the RV parks along Highway 27 are within the circle of 10 km radius. The town of Sebring has a population of 10.7 thousand residents. Several buildings in central Sebring have second or third floors above the first (ground) floor. The towns of Highlands and Lake Placid are within 20 km of SBR. All of these features are within the LOS of SBR, and they are possible sources of interference.

Figure 8. Hotel within 1 km of Sebring Earth Station

Figure 8 shows the Chateau Elan Hotel viewed from the south. The SBR site is just visible in the picture in the top right corner of the frame. The hotel is a structure that is four stories high. The front of the building with the main entrance is visible in the picture. The rear of the building overlooks a pool and it faces part of the track of the Sebring Raceway and also the SBR site.

Analysis of Interference at Sebring Gateway Earth Station

The interference at the Sebring gateway earth station can be estimated by separately calculating the number of APs and the path loss to each source of interference. This is tabulated below for selected major sources of interference.

Table 2. Sebring Interference Analysis

Interference Source	N_{AP}	D	L_p	I/N	Amount Exceeding Interference Limit
Chateau Elan Hotel	8	0.9 km	108.4 dB	8.2 dB	20.4 dB
Sebring Airport	2	1.2 km	110.9 dB	-0.3 dB	11.9 dB
Sebring Raceway	4	1.2 km	110.9 dB	2.7 dB	14.9 dB
RV Parks	40	8 km	127.4 dB	-3.8 dB	8.4 dB
Sebring town	1526	10 km	129.3 dB	10.1 dB	22.3 dB
Total of All Sources	1580			13.0 dB	25.2 dB

The number of APs in the U-NII-8 band (N_{AP}) for the towns within line of sight to the Sebring site is derived from the population of the town by applying a factor of 14.27%. This factor derives from ITU-R wireless LAN sharing studies in WP5A.[4] In these ITU-R studies, the total number of APs in a given population is a ratio using 400 million APs in the continent of Europe with a population of 701 million (ratio=57.06%). These APs are presumed to be capable of operation in any of 4 bands, one of which is U-NII-8, so 25% of the APs can interfere in U-NII-8. The product of the ratios is 14.27%.

The I/N is calculated by using a PSD_{TX} with N_{AP}=1, so PSD_{TX} = -45.0 dBW/MHz.[5] An expected E[BEL] of 11.0 dB is used. The N_0 threshold is $10 \log_{10}(kTB) - G_1$ = -152.6 dBW/MHz. The difference is 107.6 dB. This is then decreased by the path loss (L_p) and increased by $10 \log_{10}(N_{AP})$ to obtain the I/N.

$$I/N = 107.6 - L_p + 10 \log_{10}(N_{AP})$$

All the interference levels from each source identified above exceed the accepted interference limit of -12.2 dB, with the excess varying from 8.4 dB to 22.3 dB. Some factors can vary to make this interference problem even more severe. The number of APs (N_{AP}) could be significantly higher than shown in the calculation. Since the transient population of Sebring will significantly exceed the resident population during events at Sebring Raceway,[6] it is very likely that data traffic could increase and spectators could bring their own hotspots to increase N_{AP} during racing events. Any increase in data traffic would directly increase interference, even if N_{AP} remained unchanged. Additional sources of interference could include APs deployed in Highlands and Lake Placid that are not counted in this calculation. Other contributors of interference are the user terminal devices. While a terminal device would normally emit less power than an AP, it could operate outdoors without any building attenuation on the LOS path to the SBR site.

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[4] See for example: ITU-R; document number R15-WP5A-C-0976; Annex 16; Working document towards a preliminary draft new report ITU-R M.[RLAN REQ-PAR]; November 2018; section 3.6, p.16.

[5] See Annex A for a description of the terms used in the I/N calculation.

[6] See https://www.sebringraceway.com/24-hospitality-sponsorships for information about Sebring Raceway events. The site advertises: "…nearly 200,000 in attendance, and over 130 vendors and exhibitors each year…"

Wasilla Interference Scenario

The immediate vicinity of the Wasilla gateway earth-station site is shown in the images from Google Earth in Figures 9 through 11.

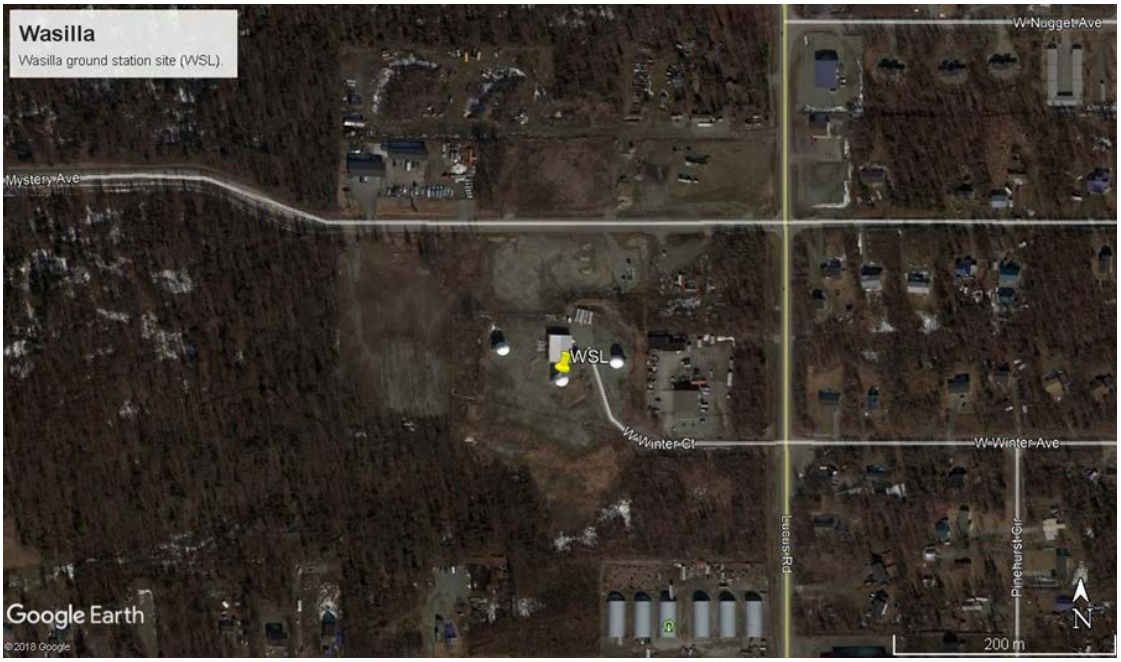


Figure 9. Wasilla Interference Scenario

Figure 10. Wasilla Interference within 2 km.

The Wasilla gateway earth station site (WSL) is in a residential district near Wasilla. The town of Wasilla

itself is just outside the 2 km circle to the south east of WSL.

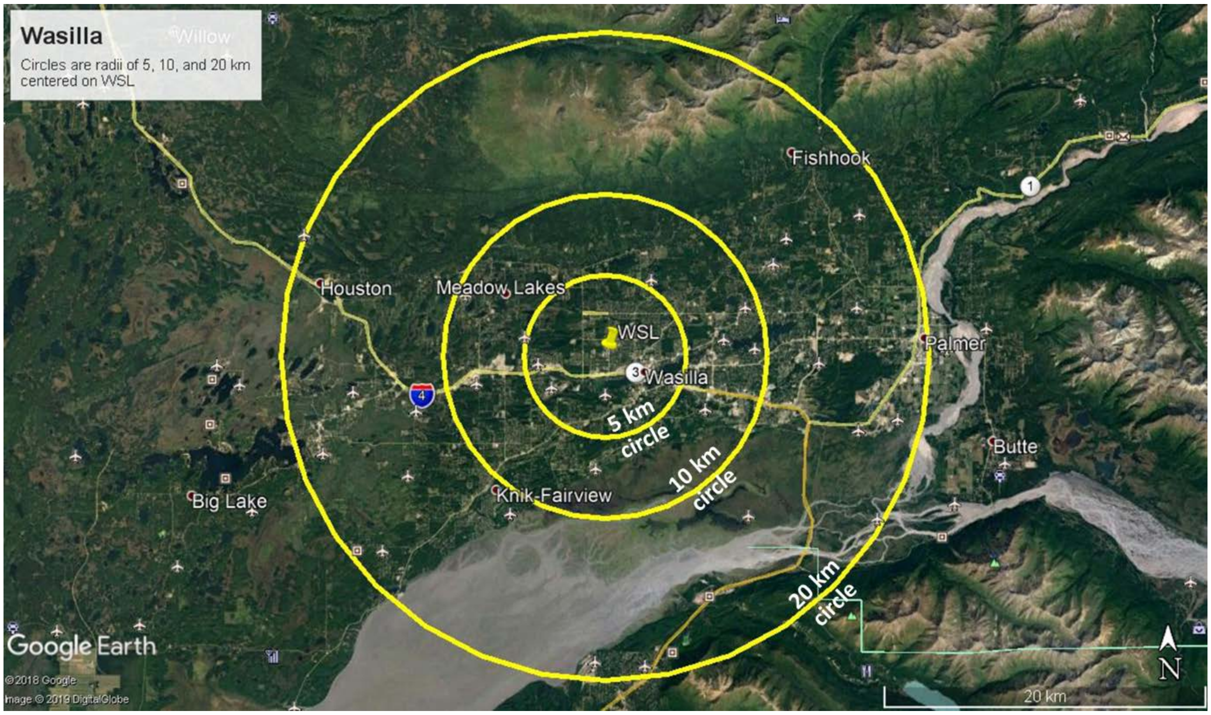


Figure 11. Wasilla Interference within 20 km.

The vicinity of the Wasilla site (WSL) has the following features: Town of Wasilla with a resident population of 10.2 thousand, Meadow Lakes with a population of 7.5 thousand, Knik-Fairview with a population of 14.9 thousand, and Palmer with a population of 7 thousand. Meadow Lakes is at a distance of 7.5 km and Wasilla is about 2.5 km.

Analysis of Interference at Wasilla Gateway Earth Station

The interference at the Wasilla gateway earth station can be estimated by separately calculating the number of APs and the path loss to each source of interference. This is tabulated below.

The northern climate in Alaska suggests a building entry loss (BEL) function for Thermally Efficient buildings. See Annex C for a description of a Monte Carlo analysis with the BEL function. The expected E[BEL] is 20.2 dB.

Table 3. Wasilla Interference Analysis

Interference Source	N_{AP}	D	L_p	I/N	Amount Exceeding Interference Limit
Wasilla	1455	2.5 km	117.3 dB	12.7 dB	24.9 dB
Meadow Lakes	1070	7.5 km	126.9 dB	1.8 dB	14.0 dB
Knik-Fairview	2126	11 km	130.2 dB	1.5 dB	13.7 dB

Palmer	999	19.8 km	135.3 dB	-6.9 dB	5.3 dB
Total of All Sources	5650			13.4 dB	25.6 dB

The number of APs in the U-NII-8 band (N_{AP}) for towns is derived from the population of the town by applying a factor of 14.27%. See the discussion for Sebring I/N ratios for an explanation of this factor.

The I/N is calculated by using a PSD_{TX} with N_{AP}=1, so PSD_{TX} = -54.2 dBW/MHz. An expected average E[BEL] of 20.2 dB is used. The N_0 threshold is $10 \log_{10}(kTB) - G_1$ = -152.6 dBW/MHz. The difference is 98.4 dB. This is then decreased by the path loss (L_p) and increased by $10 \log_{10}(N_{AP})$ to obtain the I/N.

$$I/N = 98.4 - L_p + 10 \log_{10}(N_{AP})$$

The Wasilla I/N ratio exceeds the accepted interference limit of -12.2 dB by 24.9 dB. The total interference for all the sources exceeds the limit by 25.6 dB. Some factors can vary to make the interference problem more severe. The number of APs (N_{AP}) could be significantly higher than is shown in the calculation. Anchorage, Alaska, is within range of the Wasilla site since both Anchorage and Wasilla are elevated 30 meters above the Knik inlet, and this elevation can extend the LOS path between them out to 50 km. This means that all buildings in Anchorage over 50 meters in height have a direct line-of-sight path to the Wasilla site, and this includes the 10 highest buildings in Anchorage. The highest building in Anchorage is 90 meters high. Other contributors of interference are the terminal devices. While a terminal device would normally emit less power than an AP, it could do so outdoors without any building attenuation on the LOS path to the Wasilla site.

Clifton Interference Scenario and Interference Analysis

The immediate vicinity of the Clifton site (CLF) is shown in Google Earth images in Figure 12. The town of Clifton is within a circle of 5 km radius centered on CLF.

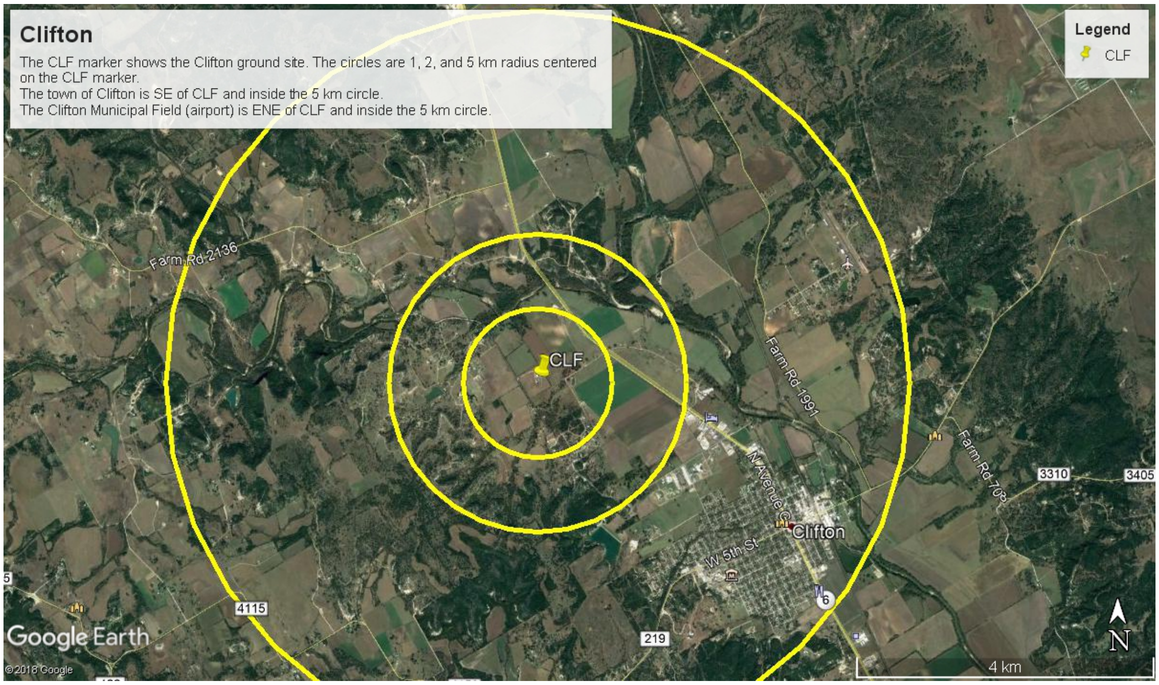


Figure 12. Clifton Interference Scenario

The interference at the Clifton (CLF) gateway earth station can be estimated by the calculation shown in Table 4 below.

Table 4. Clifton Interference Analysis

Interference Source	N_{AP}	D	L_p	I/N	Amount Exceeding Interference Limit
Clifton	491	3.9 km	121.2 dB	13.3 dB	25.5 dB

The I/N is calculated by using a PSD_{TX} with N_{AP}=1, so PSD_{TX} = -45.0 dBW/MHz. An expected E[BEL] of 11.0 dB is used. The N_0 threshold is 10 $\log_{10}$(kTB) – G_1 = -152.6 dBW/MHz. The difference is 107.6 dB. This is then decreased by the path loss (L_p) and increased by 10 $\log_{10}(N_{AP})$ to obtain the I/N.

$$I/N = 107.6 - L_p + 10 \log_{10}(N_{AP})$$

The calculation shows the interference exceeding the accepted limit by 25.5 dB.

Las Palmas Interference Scenario and Interference Analysis

The immediate vicinity of the Las Palmas site (LPA) is shown in the Google Earth image in Figure 13. A small residential neighborhood along highway 303 is less than 1 km north of LPA.

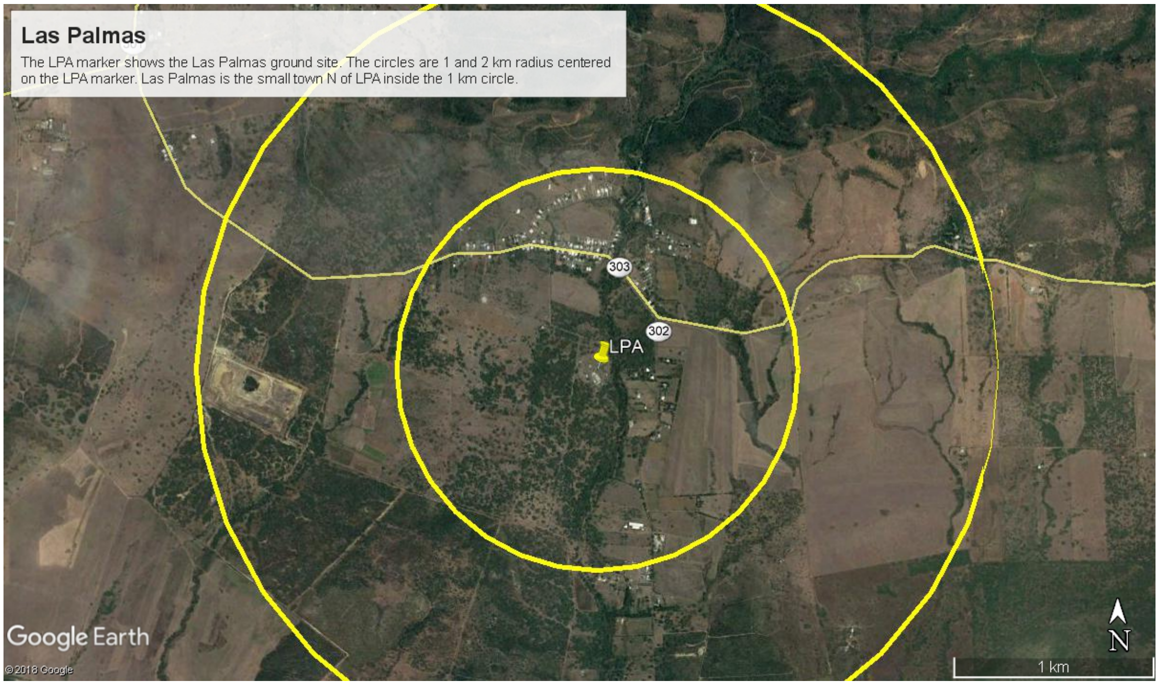


Figure 13. Las Palmas Interference Scenario

The interference at the Las Palmas gateway earth station can be estimated from the calculation shown in Table 5.

Table 5. Las Palmas Interference Analysis

Interference Source	N_{AP}	D	L_p	I/N	Amount Exceeding Interference Limit
Las Palmas	20	0.73 km	106.6 dB	14.0 dB	26.2 dB

The I/N is calculated by using a PSD_{TX} with N_{AP}=1, so PSD_{TX} = -45.0 dBW/MHz. An expected E[BEL] of 11.0 dB is used. The N_0 threshold is 10 $\log_{10}$(kTB) – G_1 = -152.6 dBW/MHz. The difference is 107.6 dB. This is then decreased by the path loss (L_p) and increased by 10 $\log_{10}(N_{AP})$ to obtain the I/N.

$$I/N = 107.6 - L_p + 10 \log_{10}(N_{AP})$$

The calculation shows the interference exceeding the accepted limit by 26.2 dB.

Interference Summary

The total I/N values for each of Globalstar's gateway earth station locations are summarized in Table 6 below.

Table 6. Interference Summary

Site	Total I/N	Amount Exceeding Interference Limit
Sebring	13.0 dB	25.2 dB
Wasilla	13.4 dB	25.6 dB
Clifton	13.3 dB	25.5 dB
Las Palmas	14.0 dB	26.2 dB

The interference to Globalstar's gateway earth stations is more than 25 dB above the accepted I/N limit of -12.2 dB in every case. This is a 316x factor for power. This interference is significant enough to render all the downlink traffic channels unusable. The consequence for Globalstar's mobile satellite service would be a disruption of all user traffic on the satellite system.

Impact of Interference on the Mobile Satellite Traffic of Multiple Satellites

Globalstar's earth stations in the United States and its territories consist of multiple antennas which receive downlink communications traffic from multiple satellites at certain time intervals due to the motion of the satellites in the Globalstar constellation. When multiple earth station antennas are receiving mobile satellite traffic on their respective feeder downlinks, there is the potential that all traffic originating from mobile terminals in the service area of those satellites will be impacted by interference created by terrestrial sources.

Figure 14. Multiple Satellite Coverage

Figure 14 shows an example of the scenario when an earth station is receiving feeder downlink traffic composed of voice and data originating from mobile satellite terminals in the service area of multiple satellites. In this figure, the Sebring gateway earth station is receiving mobile user traffic from three satellites, whose intersecting service areas are shaded. In this scenario, all traffic originating from mobile terminals in the service area of those satellites can be degraded by the interference created by terrestrial sources in the vicinity of the single earth station location. The figure further shows that service area degraded by the interference includes not only large portions of the United States, but also adjacent areas of Canada and Mexico, Caribbean nations, and Central and South American countries.

Conclusion

Under the FCC's proposed rules for the U-NII-8 band, there is a significant risk of harmful interference to current Globalstar gateway earth stations and to Globalstar users from likely deployments and use of indoor unlicensed low-power access points. Calculations of the expected interference to noise (I/N) ratios show that indoor access point transmitters within line-of-sight of the Globalstar gateway earth station antennas will cause the accepted limit for interference of -12.2 dB I/N (or ΔT/T = 6%) to be exceeded. The interference power at all four Globalstar earth station sites will exceed the accepted limit by at least 25 dB, or a factor of 316x the power level.

The detrimental impact on Globalstar mobile satellite users and Globalstar services would be substantial. Since the U-NII-8 band overlaps the entire Globalstar feeder downlink, interference from unlicensed U-NII-8 devices beyond the I/N limit would impair or block communications for the entire coverage area of a satellite, an area that is more than 3 times larger than CONUS and larger than the area of the North American continent. The services impaired or blocked by the interference would include Globalstar's simplex "Spot" life-critical emergency S.O.S. service calls to the International Emergency Response Center, as well as Globalstar's continuous location tracking messages, and duplex Spot, voice, and data calls. The system's telemetry channel would also suffer degraded sensitivity from a rise of the noise floor caused by U-NII-8 interference.

Globalstar's earth stations in the United States and its territories consist of multiple antennas which receive downlink communication traffic from multiple satellites at certain time intervals due to the motion of the satellites in the Globalstar constellation. When multiple earth station antennas at a single location are receiving mobile satellite traffic on their respective feeder downlinks, all the traffic originating from mobile terminals in the service areas of those satellites will potentially be impacted by interference created by terrestrial sources within the vicinity of the single earth station location.

Annex A. Interference Analysis

This annex analyzes the interference from indoor U-NII access points (APs) deployed according to the Commission's proposed rules in U-NII-8. This analysis includes details of transmitter power levels, antenna gains, and other factors, as well as the details of the victim gateway earth station receivers including noise floor levels, antenna gains, and other factors. The results are compared with accepted recommended limits for I/N ratios to avoid interference.

Globalstar Gateway Earth Station

Each gateway earth station site has 3, 4 or 5 dish antennas. Each dish is a 5.5 meter diameter antenna on a mount that can track satellites from 10 degrees elevation above the horizon, to the zenith, and back down to 10 degrees elevation. In the illustration a typical height above the ground for part of the antenna is slightly more than the dish diameter of 5.5 m. For the following analysis a height of 5.5 m is used.

The distance to the horizon is easily computed using the following formula. [7]

D_1 = distance to horizon

= $\sqrt{2\,h_1 R_e}$

Substituting the dish diameter for the height obtains the following distance to the horizon.

h_1 = antenna height = 5.5 m, and

R_e = effective earth radius = 8495 km

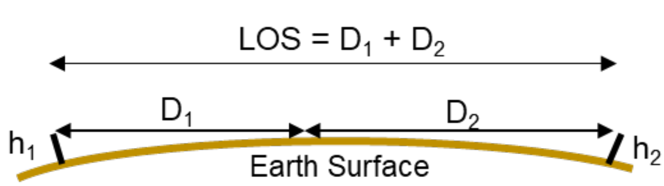
D_1 = 9.67 km

Terrestrial Propagation

The Line of Sight (LOS) between two antennas of height h_1 and h_2 is:

LOS = $D_1 + D_2 = \sqrt{2\,h_1\,R_e} + \sqrt{2\,h_2\,R_e}$

for R_e as the effective earth radius.



The effective earth radius is affected by atmospheric refraction of radio waves and light. This is caused by a gradual change in

[7] See: Jakes, William; *Microwave Mobile Communications*; 2.1.5 Transmission over a Smooth Spherical Earth; equation 2.1-17; p.86. Also see Annex B for a derivation of the distance to the horizon.

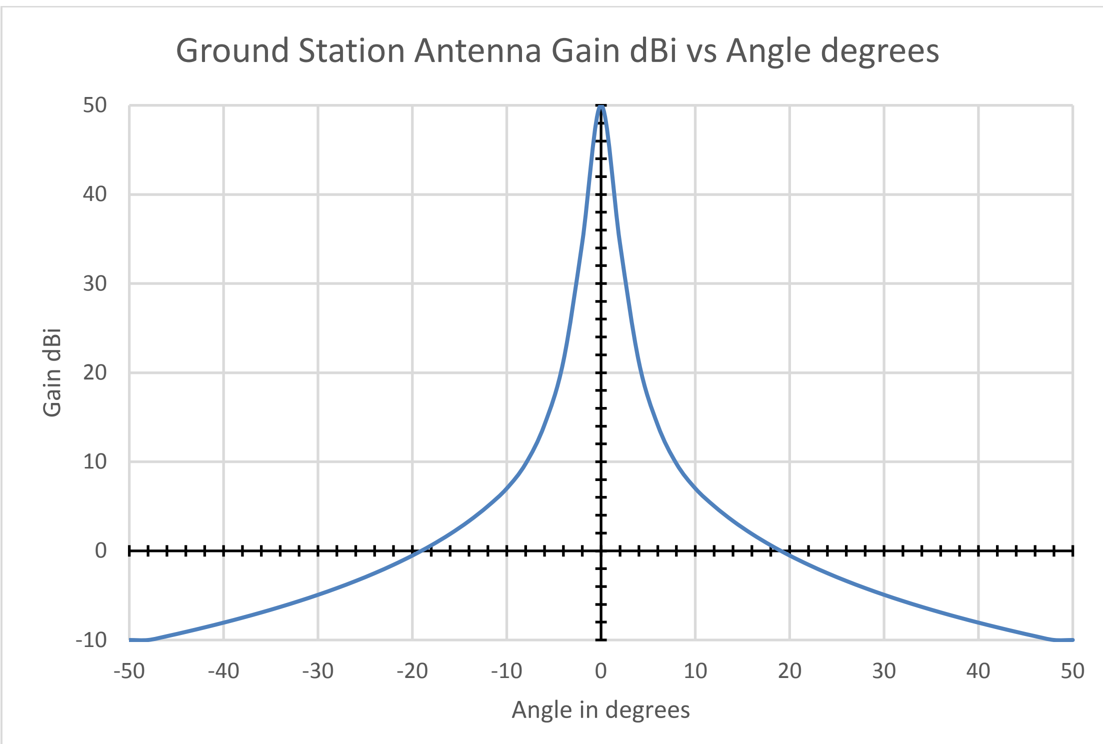
atmospheric density and the index of refraction, with increasing altitude. The customary compensation for this effect is to set the effective earth radius $R_e = \frac{4}{3} R_0$ with R_0=radius of the earth.[8] For R_0=6371 km → R_e=8495 km

For typical antenna heights considered here, h_1 is the height of the earth station antenna and h_2 is the height of interfering transmitter (h_2=6m for approximate ceiling height above the ground of a two-story building):

h_1 = 5.5 m, h_2 = 6 m
LOS = 19.8 km

Gateway Earth Station Antenna Pattern

The antenna gain pattern for the gateway earth station is similar to that given in ITU-R Rec. S.465-6. The antenna gain is plotted in the following figure. The angle is relative to the boresight of the antenna. At 0° the antenna obtains 50 dBi of gain for desired signals from the satellite. At 10° from the boresight the gain drops to 7 dBi, so the antenna provides 43 dB of gain selectivity between a desired signal in the direction that the antenna points and any interference that is 10° away from that direction. The minimum elevation for the satellite to be tracked by the antenna is 10° so the antenna gain at that angle for terrestrial interference sources is 7 dBi.



[8] See: Jakes, William; *Microwave Mobile Communications*; 2.1.4 Refraction and Equivalent Earth's Radius; pp. 84-85; 1974.

Gateway Earth Station Receiver (Interference Victim) Parameters

The basic receiver sensitivity (S_0) is determined by the thermal noise temperature of the receiver. The basic receiver sensitivity Power Spectral Density (PSD) = N_0 = kTB = -145.6 dBW/MHz for Boltzmann constant k, noise T=200°K, and bandwidth (B) of 1 MHz.

The maximum accepted Interference-to-Noise ratio, I/N, must be less than -12.2 dB per ITU-R Rec. S.1432. The I_0 threshold is therefore: S_0 – 12.2 dB. -12.2 dB I/N corresponds to a ΔT/T of 6%, and is the established limit for coordination purposes in the Fixed Satellite Service that includes 6875-7125 MHz.

The victim antenna tracks satellites as they pass overhead above 10° elevation from the horizon. The maximum sensitivity to interference occurs at 10° elevation with $G_1(10°)$=7 dBi. The interference power should be below a threshold set for this gain.

Interference Risk Assessment from Access Points

For APs deployed in buildings, the recommended distribution for the Building Entry Loss (BEL) is given in ITU-R Rec. P.2109. A Monte Carlo analysis with multiple buildings selects BEL values from the curve to represent the distribution of losses. See Annex C for a description of the Monte Carlo analysis process.

Access Point (AP) parameters for this analysis are summarized as follows. Together these parameters permit an estimate of the PSD that is emitted by some number of APs.

P_0 = 0.25 W (low power)
Bandwidth = B = 250 MHz
G_{AP} = 6 dBi, antenna gain
Activity factor = A = 10%
Number of APs = N_{AP} = 1526

The number of APs is variable depending on the situation, a value of N_{AP}=1526 is used here in this calculation to represent the likely number of APs in the town of Sebring capable of operation in the U-NII-8 band. The E[BEL] for this number is 11.0 dB for Traditional buildings. The total Transmit PSD (PSD_{TX}) that includes the building loss is computed as follows:

$PSD_{TX} = 10 \log_{10}(N_{AP}\ A\ P_0/B) + G_{AP} - E[BEL]$
$= -13.2$ dBW/MHz

The path loss is derived from the usual path loss for free space propagation:[9]

Path Loss = L_p
$= 20 \log_{10} (4 \pi D/\lambda)$ in dB; for $\lambda = c/f_c$ = 4.28 cm for f_c = 7 GHz

D = 10.0 km represents the distance from the town of Sebring to the SBR site as shown in Figure 7.

L_p = 129.3 dB

This entire calculation is captured in the Link Budget tabulated below. The I/N in the victim receiver is given on line P.

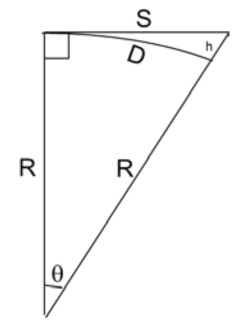
[9] For example see ITU-R Rec. P.525-3 equation 3 for free space path loss.

Link Budget

Line	Transmitters		Units	Note
A	P_0	0.25	W	
B	B	250	MHz	
C	A	0.1		Activity factor
D	N_{AP}	1526		Likely number of APs in Sebring
E	G_{AP}	6	dB	
F	E[BEL]	11.0	dB	Traditional Building Entry Loss
G	PSD_{TX}	-13.2	dBW/MHz	$10 \log_{10}(P_0 \, A \, N_{AP}/B) + G_{AP} - E[BEL]$
	Path Loss			
H	λ	4.28	cm	
I	D	10	km	Distance from town of Sebring to SBR
J	L_p	129.3	dB	$20 \log_{10}(4 \pi D/\lambda)$
	Globalstar Gateway Earth Station Victim Receiver			
K	G_1	7	dB	
L	k	1.38E-23	J/K	
M	T	200	°K	Noise temperature
N	B	1.00E+06	Hz	
O	N_0	-145.6	dBW/MHz	$10 \log_{10}(kTB)$
P	I/N	10.1	dB	G-J+K-O
Q	Limit	-12.2	dB	ITU-R S.1432
R	Exceed	22.3	dB	P-Q

The calculation shows that interference from 1526 APs deployed indoors in the town of Sebring, will generate interference power to increase the I/N ratio to +10.1 dB, or 22.3 dB above the accepted limit of -12.2 dB.

Annex B. Approximation for Horizon Distance



The approximation of the distance $D = \sqrt{2hR}$ to the horizon in terms of a height, h, above ground and the radius of a sphere, R, is derived as follows. The exact formula for the arc length D is used.

$$D = R\,\theta = R\cos^{-1}\left(\frac{R}{R+h}\right)$$

$$\cos\theta = \frac{R}{R+h}$$

Series expansions for the first 2 terms for the cosine function and the binomial result in the following approximations for small θ and $h<<R$.

$$\cos\theta \approx 1 - \tfrac{1}{2}\theta^2 \qquad \text{and} \qquad \frac{R}{R+h} \approx 1 - \frac{h}{R}$$

Equating these yields a simple equation: $\frac{1}{2}\theta^2 = \frac{h}{R}$. This equation is then solved for θ and then D:

$$\theta = \sqrt{2\,\frac{h}{R}} \;\rightarrow\; D = \sqrt{2\,h\,R}$$

This is also the same approximation for the slant distance S, which is derived as follows. When h is small relative to the distances S and D, then the slant distance and the ground distance are nearly the same and so the same approximation holds for both.

S = slant distance

$(R+h)^2 = R^2 + S^2$ from the Pythagorean theorem for right triangles

$2\,h\,R + h^2 = S^2$

$S = \sqrt{2\,h\,R + h^2}$

$S \approx \sqrt{2\,h\,R}$ for $h<<R$

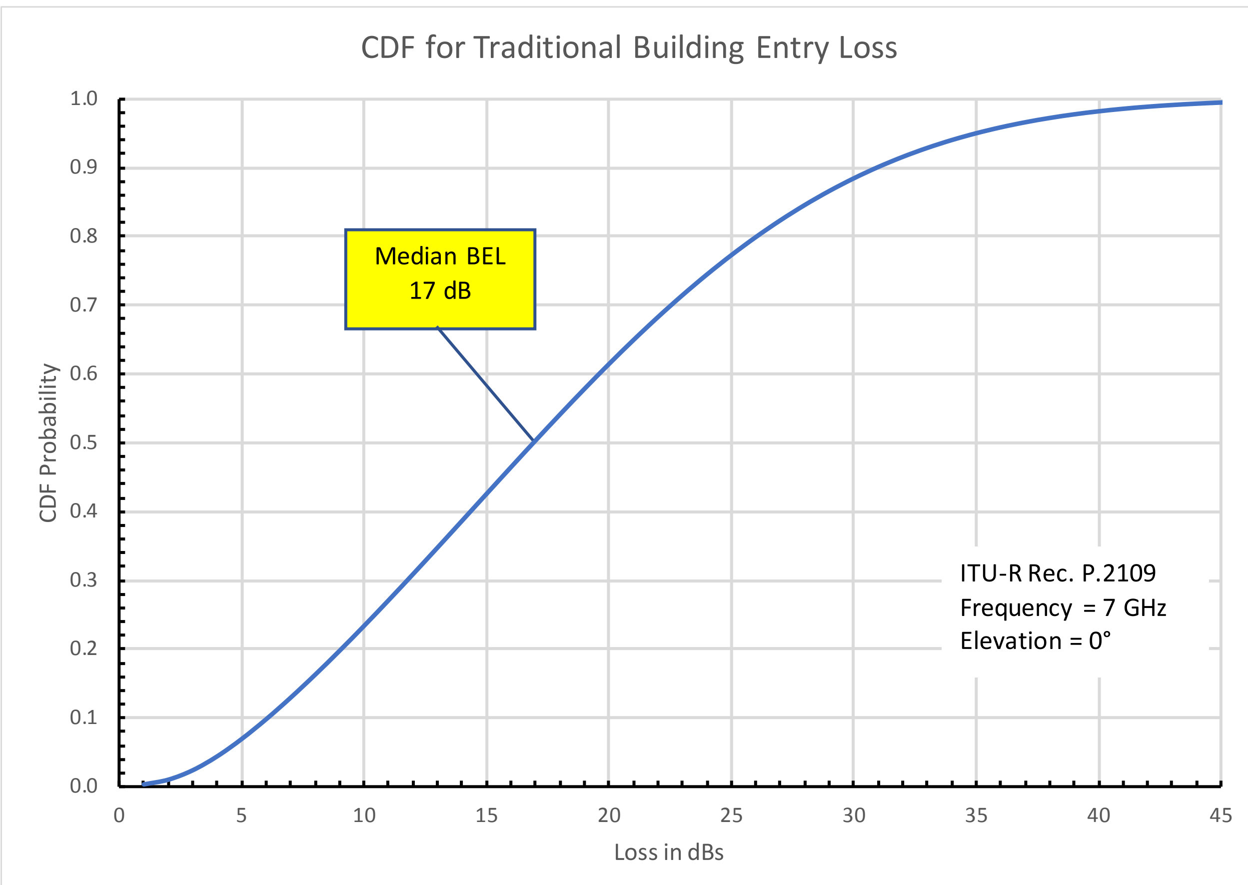
An example calculation can compare the exact distances D and S with the approximations to show the magnitude of the error.

R = 8000 km, h = 5 m = 0.005 km
D = 8.944269585 km exactly.
D or $S \approx$ 8.94427191 km approximately. The difference with D is 2.3 mm.
S = 8.944273308 km exactly. The difference with the approximation is 1.4 mm.

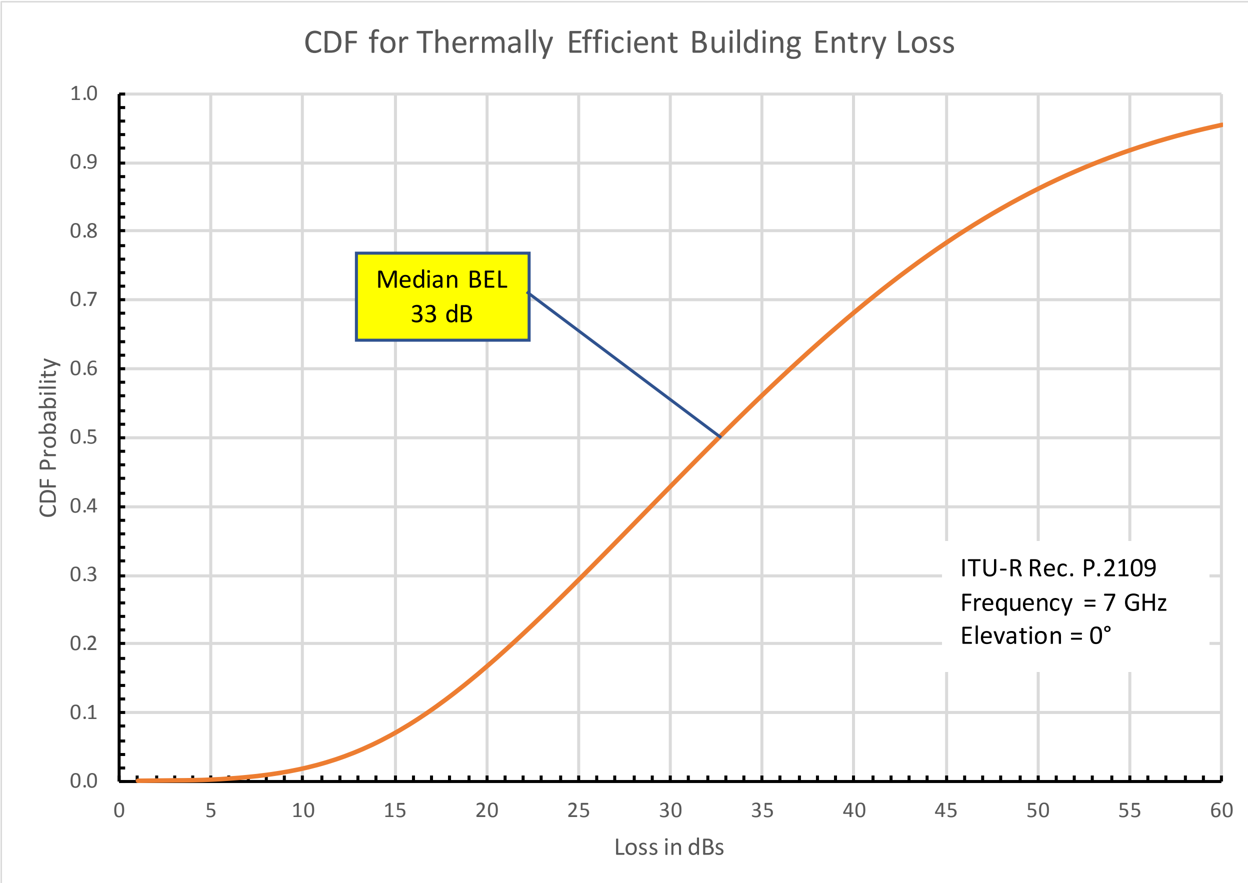
For horizon distances of several kilometers, the approximation is within a few mm of the correct value.

Annex C. Monte Carlo Simulation of Transmit Power Spectral Density

The indoor deployment of U-NII-8 devices introduces a Building Entry Loss (BEL) in the path from the transmitter to the victim receiver. The Building Entry Loss is described in ITU-R Rec. P.2109 as a probability distribution. The distribution is described with a Cumulative Distribution Function (CDF) curve showing the probability that the BEL value is less than some number of dB on a horizontal axis. There are two CDF curves given in P.2109: one for Traditional buildings and another for Thermally Efficient buildings. The CDF curves have parameters for elevation angle and frequency, and these are set to 0° and 7 GHz, respectively, in the Monte Carlo analysis. The CDF curves are separately graphed here, and the median BEL is shown as 17 dB for the Traditional BEL and 33 dB for the Thermally Efficient BEL.



The Monte Carlo analysis for some number of indoor APs (N_{AP}) consists of selecting that number of random points from the BEL distribution to compute the aggregate interference power incident upon the victim receiver. This process is repeated multiple times to converge upon an average aggregate interference power. The average interference power is then used in the calculation of the I/N ratio.



The average interference power can then be used to obtain an Expectation of the BEL function for the distribution of power values. The Expected BEL is denoted as E[BEL] using the mathematical expectation operator.

Annex D. Profile: Roberson and Associates, LLC

Roberson and Associates, LLC, is a technology and management consulting company serving government, commercial, and academic customers and provides services in the areas of radio frequency (RF) spectrum management, RF measurement and analysis, strategy development, and technology management. The organization was founded in 2008 and is composed of a select group of individuals with corporate and academic backgrounds from Motorola, ARRIS, Bell Labs (AT&T, Bellcore, Telcordia, Lucent, and Alcatel-Lucent), BroadView Communications, Cisco, Department of Defense (DARPA), DePaul University, Google, IBM, Illinois Institute of Technology (IIT), Illinois Institute of Technology Research Institute (IITRI), Illinois Tool Works (ITW), Massachusetts Institute of Technology (MIT), NCR, Nokia, S&C Electric, Vanu, Inc., and independent consulting firms. Together, the organization has over 1,000 years of high technology management and technical leadership experience with a strong telecommunications focus.

Profiles: Roberson and Associates, LLC, Staff

Dennis A. Roberson, President and CEO, Roberson and Associates

Mr. Roberson is the Founder, President, Chief Executive Officer, and Member of Roberson and Associates, LLC and has 46 years of industry experience. In parallel with this role, he serves a Research Professor in Computer Science and Law at Illinois Institute of Technology where he is an active researcher in the wireless networking arena, is a co-founder of IIT's Wireless Network and Communications Research Center (WiNCom), and a co-founder of the Intellectual Property Management and Markets Program. His wireless research focuses on dynamic spectrum access networks, spectrum measurement systems and spectrum management, and wireless interference and its mitigation, all of which are important to the Roberson and Associates mission.

Previously, he served as Vice Provost for Research at Illinois Institute of Technology. Prior to IIT, Mr. Roberson was Executive Vice President and Chief Technology Officer at Motorola. He had an extensive corporate career, which included major business and technology responsibilities at IBM, Digital Equipment Corporation (DEC, now part of Hewlett Packard), AT&T, and NCR. He has one issued patent. He has been involved with a wide variety of technology, cultural, educational, and youth organizations, which currently includes Chair of the Federal Communications Commission Technical Advisory Council, membership on the Commerce Spectrum Management Advisory Committee, and Chair of the Board of SonSet Solutions. Mr. Roberson currently serves on the governing and/or advisory boards of several exciting technology-based companies. He is a frequent speaker at universities, companies, technical workshops, and conferences around the globe.

Mr. Roberson has Bachelor of Science degrees in Electrical Engineering and in Physics from Washington State University and a Master of Science in Electrical Engineering from Stanford University.

Kenneth J. Zdunek, Ph.D. –V.P. and Chief Technology Officer

Dr. Zdunek joined Roberson and Associates in 2009 and is Vice President and the Chief Technology Officer. He has 41 years of experience in wireless communications and public safety systems.

Concurrently, he is an Adjunct Professor in Electrical Engineering at Illinois Institute of Technology in Chicago, Illinois, where he conducts research in the area of dynamic spectrum access and efficient spectrum utilization. He also taught a graduate course in wireless communication system design. He is a Fellow of the Institute of Electronics and Electrical Engineers (IEEE) and recognized for his leadership in integrating voice and data in wireless networks.

Prior to joining Roberson and Associates, Dr. Zdunek was Vice President of Networks Research at Motorola and was awarded Motorola's Patent of the Year in 2002 for a voice-data integration approach that is licensed and extensively used in cellular communications. He holds 17 other patents, including patents used in public safety trunked systems and cellular and trunked systems roaming. He directed the invention and validation of Nextel's Integrated Digital Enhanced Network (iDENR) voice-data air interface and IP based roaming approach and was the principal architect of Motorola's SmartNetR public safety trunking protocol suite. In the 1990s, he directed a Spectrum Utilization and Public Safety Spectrum Needs Projection submitted to the Federal Communications Commission in support of the 700 MHz spectrum allocation for public safety.

Dr. Zdunek was awarded a Bachelor of Science in Electrical Engineering degree and a Master of Science in Electrical Engineering degree from Northwestern University, and a Ph.D. in Electrical Engineering from Illinois Institute of Technology. He is a registered Professional Engineer in the State of Illinois. He is past president and serves on the board of directors of the Chicago Public Schools Student Science Fair, Inc.

Alan Wilson, Principal Engineer III

Mr. Wilson joined Roberson and Associates in 2016 and has 40 years' experience in the Telecommunications industry. Mr. Wilson worked at Motorola to develop the Astro product line that supports the Project 25 radio standards suite. This became a $6 billion business for Motorola that has continued to diversify beyond the original market for public safety and mission-critical radios. Mr. Wilson authored dozens of standards for the P25 standards suite that were published by the Telecommunications Industry Association (TIA). He moved to Tyco Electronics and later Harris Corporation to continue to work on P25 standards for Phase 2 to double the spectrum efficiency with Time Division Multiplexing Access (TDMA). After the launch of Phase 2, Mr. Wilson chaired the wide band data committee to begin working on the Mission Critical Push to Talk (PTT) standards for 3G PTT and Long Term Evolution (LTE) through a joint project with Alliance of Telecommunications Industry Solutions (ATIS). The joint project is known as Joint Land Mobile Radio Long Term Evolution (JLMRLTE), and it intends to interconnect private Land Mobile Radio (LMR) radio systems with LTE telephone systems to provide encrypted digital voice and data services across networks. Mr. Wilson has been an inventor on 27 patents and an author of several publications by the Telecommunications Industry Association (TIA) and Project 25 Technology Interest Group.