Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, D.C. 20554

In the Matter of	)	
	)	
Iridium Constellation LLC Petition for Rulemaking to Promote Expanded Mobile Satellite Service in the Big LEO MSS-band,	)	RM-11697
	)	
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	)	IB Docket No. 13-213 RM-11685

SUPPLEMENTAL COMMENTS OF IRIDIUM CONSTELLATION LLC

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SUPPLEMENTAL COMMENTS OF IRIDIUM CONSTELLATION LLC

Iridium Constellation LLC ("Iridium"), by its attorneys, hereby submits these Supplemental Comments demonstrating that the public interest would be served by granting Iridium's Petition for Rulemaking and allowing expanded sharing in the 1.6 GHz Lower Big LEO mobile satellite service ("MSS") band to meet Iridium's clear and important spectrum needs.[1] In its revised proposal, Iridium requested that the Federal Communications Commission ("FCC" or "Commission") designate the 1616-1617.5 MHz spectrum for shared use between Iridium and Globalstar, Inc. ("Globalstar"), and assign the 1617.5-1618.725 MHz spectrum (which includes 0.95 MHz of currently shared spectrum) exclusively to Iridium.[2] These Supplemental Comments are devoted solely to the issues associated with expanded spectrum sharing between Iridium and Globalstar. Iridium will address Globalstar's opposition to

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1 *See* Iridium Constellation LLC, Petition for Rulemaking, RM-11697 (filed Feb. 11, 2013); Supplemental Comments of Iridium Constellation LLC, RM-11697, IB Docket No. 13-213, RM-11685 (filed May 5, 2014) ("Iridium May 5, 2014 Supplemental Comments").

2 Iridium May 5, 2014 Supplemental Comments.

Iridium's proposed exclusive use of the 1617.5-1618.725 MHz spectrum following Globalstar's submission of information documenting its traffic on Channel 7.

These Supplemental Comments are precipitated by recent disclosures suggesting that the fundamental engineering and policy assumptions underlying the current Big LEO MSS band plan are not correct. In 2007, the Commission concluded that the "fully-loaded [Iridium] TDMA and [Globalstar] CDMA systems cannot share spectrum in a co-frequency, co-coverage manner without generally undesirable operational limitations."[3] As an outgrowth of meetings convened by the Commission's International Bureau, it is now clear that Iridium can share spectrum with Globalstar without its signal even being detected by Globalstar, let alone causing harmful interference to Globalstar. These facts, based on real-world experience and supported by engineering analysis submitted herewith, provide compelling proof that the Commission can and should grant Iridium's request for expanded sharing of Big LEO MSS spectrum.

I. INTRODUCTION AND SUMMARY

On October 2, 2014, the FCC's International Bureau convened a series of meetings with representatives from Iridium and Globalstar to discuss Iridium's revised spectrum proposal.[4] During its individual meeting with the International Bureau, Iridium presented a detailed showing that documented its need for additional spectrum.[5] Iridium also emphasized

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[3] *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, ¶ 16 (2007) ("*2007 Order*").

[4] *See* Letter from Jennifer D. Hindin to Marlene H. Dortch, Secretary, Federal Communications Commission, RM-11697, IB Docket No. 13-213, RM-11685 (Oct. 6, 2014).

[5] *See* Letter from Nancy J. Victory to Marlene H. Dortch, RM-11697, IB Docket No. 13-213, RM-11685 (Oct. 20, 2014); *see also Iridium Constellation LLC*, Joint Protective Order, RM-11697, IB Docket No. 13-213, RM-11685, DA 14-1500 (rel. Oct. 16, 2014).

that its expanded sharing proposal did not take spectrum from Globalstar but rather promoted efficient spectrum use without harm to Globalstar's MSS operations. Finally, Iridium noted that it had not detected any past or existing use by Globalstar of the 0.95 MHz spectrum already subject to sharing.

In a subsequent joint meeting with Iridium and Globalstar, the International Bureau disclosed to Iridium that Globalstar claimed to be using the 0.95 MHz shared spectrum and Globalstar had not detected evidence of Iridium using the shared spectrum. The International Bureau also informed Globalstar that Iridium claimed to be using the 0.95 MHz shared spectrum and Iridium had not detected evidence of Globalstar using the shared spectrum. The respective claims were a surprise to both companies, which were not aware of the other's use of the commonly-licensed spectrum.

During the joint meeting, Iridium questioned the extent to which Globalstar actually uses the 0.95 MHz shared spectrum. At the meeting and in subsequent *ex parte* responses, Globalstar stated that (1) Globalstar uses the shared spectrum "extensively in the United States and throughout the world";[6] (2) Globalstar "intensively utilizes . . . every MHz" of its spectrum;[7] (3) channel 7, which includes the shared spectrum, is its "second-most used set of frequencies";[8] and, (4) traffic information confirming its use of the 0.95 MHz of shared spectrum would be

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[6] Letter from L. Barbee Ponder IV, General Counsel & Vice President Regulatory Affairs, Globalstar, Inc. to Marlene H. Dortch, Secretary, Federal Communications Commission at 3, RM-11697 (filed Oct. 24, 2014) ("Globalstar Oct. 24 Letter").

[7] Letter from L. Barbee Ponder IV, General Counsel & Vice President Regulatory Affairs, Globalstar, Inc. to Marlene H. Dortch, Secretary, Federal Communications Commission at 4, Presentation at 15, IB Docket No. 13-213, RM-11685, RM-11697 (filed Oct. 6, 2014) ("Globalstar Oct. 6 Letter").

[8] *Id.*, Attachment pp. 15-16.

provided. To date, however, Globalstar has offered little more than generalized or prospective statements about its use of channel 7.

Iridium, as demonstrated in the presentation entitled *Iridium's Spectrum Petition, October 2, 2014* submitted under Protective Order, stated at the joint meeting that: (1) it is using the shared spectrum; (2) the shared spectrum carries subscriber voice and data traffic throughout Iridium's global footprint; and, (3) the traffic loads on its channels justify the request for additional spectrum.[9] Indeed, Iridium reaffirms herein that the maximum amount of the 0.95 MHz shared spectrum available with Iridium's channelization is integrated into Iridium's system and used to provide diverse services to Iridium's customers in the United States, on a daily basis, like all the other channels in spectrum licensed to Iridium.[10] In sum, Iridium is heavily using the currently shared spectrum that can be deployed consistent with its channelization.

The real-world facts brought to light by the International Bureau's individual and joint meetings provide concrete evidence that Iridium is utilizing the existing shared spectrum without any evidence of harmful interference to Globalstar's MSS and that this is occurring under conditions where Globalstar claims to be heavily using the spectrum in question. These disclosures provide: (1) a compelling basis for revisiting engineering assumptions relied upon in the Commission's 2007 *Second Order on Reconsideration* about the effects of sharing by the two 1.6 GHz Lower Big LEO MSS band operators[11] and (2) compelling support for Iridium's pending request for expanded sharing.

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9 *See supra* n.5.

10 *See* Exhibit 1, Affidavit of S. Scott Smith (describing Iridium's use of the 0.95 MHz shared spectrum). Iridium notes that due to its sub-band channelization, it operates in 0.725 MHz of the 0.95 MHz shared spectrum (1618.0 MHz and above). *Id.*

11 *2007 Order*, ¶¶ 15-20.

This is particularly true in light of the detailed documentation provided by Iridium under Protective Order demonstrating an urgent need for additional spectrum resources to meet escalating customer demand for MSS.[12] By contrast, Globalstar has made clear its intention to introduce a nationwide terrestrial low power service ("TLPS"), a service that precludes duplex MSS where it is deployed.[13]

As detailed below and corroborated by engineering analyses, expanded sharing does not create harmful interference to Globalstar itself. To the contrary, the risk of potential interference from the rare instances of peak usage by both systems in the same geographic location in the United States would be borne by Iridium. Accordingly, the record before the Commission clearly establishes that the public interest would be served by granting Iridium's petition and allowing expanded sharing of Globalstar spectrum by Iridium to meet its clear and important spectrum needs.[14]

II. REAL-WORLD EXPERIENCE AND ENGINEERING ANALYSIS CONFIRM THAT IRIDIUM'S TDMA OPERATIONS DO NOT CAUSE HARMFUL INTERFERENCE TO GLOBALSTAR'S CDMA OPERATIONS.

Iridium's request for shared use of the 1616-1617.5 MHz band can be granted without causing harmful interference to Globalstar. The engineering studies appended hereto demonstrate that Globalstar's Code Division Multiple Access ("CDMA") system is (a) highly

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12 *See supra* n.5.

13 *See* Letter from R. Michael Senkowski, Counsel for Iridium, to Marlene H. Dortch, Secretary, Federal Communications Commission, IB Docket No. 13-213, RM-11686, RM-11697 (filed Oct. 16, 2014) (hereinafter "Iridium Oct. 16 Written Ex Parte") (discussing Globalstar's explanation of its intent to deploy TLPS across a single nationwide license).

14 Again, because Globalstar has offered to provide traffic information showing its actual use of the 0.95 MHz of shared spectrum, Iridium defers its response on the part of Iridium's proposal seeking access to exclusive use of the 1617.5-1618.725 MHz spectrum until the information is made available on the record and Globalstar provides engineering support for its claim that its system requires three wideband channels for spectrum access purposes.

resistant to interference generally and (b) extremely resistant to interference from Iridium's narrow channel Time Division Multiple Access ("TDMA") operations.[15] Globalstar's CDMA-based satellite system, like any CDMA system, is designed to thrive in shared spectrum environments and is resistant to narrowband interference. The Big LEO MSS band was always intended to be home to as many as five satellite service providers, including four Frequency Division Duplexed ("FDD") CDMA systems and one Time Division Duplexed ("TDD") Frequency Division Multiple Access ("FDMA")/TDMA system. Iridium's request seeks to leverage the innate sharing capabilities of Globalstar's system architecture to provide Iridium access to much-needed spectrum resources.

As demonstrated in the Technical Appendix, aggregate Iridium uplink interference to Globalstar is less than 3 percent of Globalstar's intra-system interference plus noise density.[16] Moreover, the Technical Appendix shows that Globalstar's system allows it to accommodate maximum frequency reuse conditions for use of its own channels.[17] In sum, even when Iridium is heavily loaded, it does not produce harmful interference to Globalstar.[18]

Iridium's use of the currently shared spectrum at 1617.775-1618.725 confirms the absence of interference to Globalstar from Iridium. Iridium uses the currently shared spectrum on a daily basis, consistent with its channelization and integrated with the rest of its system, to provide voice and data services to customers around the globe. For instance, Iridium's services

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15 *See* Exhibit 2, at 3-5.

16 *Id.*, at 3.

17 *Id.*, at 5.

18 *Id.*

were heavily deployed following the Texas Wildfires in 2011 and Superstorm Sandy in 2012.[19] Neither of these usage spikes prompted interference complaints from Globalstar. Indeed, Globalstar confirms in its marketing materials and advocacy before the Commission of the effectiveness of its operations in the wake of Superstorm Sandy.[20]

Contrary to Globalstar's protestations that Iridium's revised proposal would cause "widespread harmful interference to Globalstar's CDMA operations"[21] and "materially degrade" its satellite system,[22] Globalstar's CDMA system is more than capable of sharing with Iridium in the 1616-1617.5 MHz band segment. In fact, as demonstrated in the attached Technical Appendix, even a heavily-loaded Iridium system produces interference into the Globalstar satellite receiver at levels:

- significantly lower than Globalstar's own intra-system interference plus noise density;
- much lower than anticipated from any of the other expected original CDMA systems; and
- significantly lower than the expected aggregate interference from all four hypothetical CDMA systems.[23]

As explained in the Technical Appendix, at just 37 kHz, a typical Iridium user transmission is *33 times narrower* than a Globalstar user transmission.[24] Globalstar's spread

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19 Reply of Iridium Constellation LLC, RM-11697, IB Docket No. 13-213, RM-11685, at 5 (Dec. 17, 2013); *see also supra* n.17 (illustrating increase in demand for Iridium's satellite services following Superstorm Sandy).

20 *See, e.g.*, Press Release, Globalstar, Inc., Globlastar Satellite Phones Prepare Residents for the 2014 Hurricane Season, http://www.globalstar.com/en/index.php?cid=7010&pressId=821 (May 22, 2014); Comments of Globalstar, Inc. at 5, IB Docket No. 13-213, RM-11685 (filed May 5, 2014).

21 Globalstar Oct. 24 Letter, at 7.

22 Letter from Regina M. Keeney to Marlene H. Dortch, Secretary, Federal Communications Commission, RM-11697, IB Docket No. 13-213, at 2 (Oct. 9, 2014).

23 *See* Exhibit 2, at 5.

spectrum system is designed to reject narrowband transmissions like those coming from Iridium terminals. In addition, an Iridium user transmits during only a single timeslot within an Iridium timeframe, meaning the user transmission duty cycle is 9.2%, which is effectively a reduction by 10 dB in power density.[25] Iridium's traffic spreading and frequency reuse mechanisms for most Iridium services efficiently ensure that large blocks of contiguous frequency channels are not assigned into a specific region.[26] Therefore, the Globalstar satellite receiver would not experience continuous interference from Iridium narrowband channels filling an entire Globalstar channel.[27]

Globalstar's recent October 24 *ex parte* Letter does nothing to change this analysis.[28] The fact that "Globalstar can only re-use channels twice in adjacent gateways" shows that adjacent gateways can reuse the same frequency channel, not that Globalstar's CDMA system is "interference limited."[29] Indeed, Globalstar presents no evidence that reusing channels twice is a problem with current traffic loading. Further, Globalstar's use of different "access" channels for its first- and second-generation systems evidences that it designed its second-generation system inappropriately without backward compatibility.[30] Even assuming *arguendo* this to be a problem, it would end with Globalstar's completed transition to its second-generation system.

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24 *See id.*, at 1.

25 *Id.*

26 *Id.*

27 *Id.*

28 *See* Globalstar Oct. 24 Letter.

29 *Id.*, at 4.

30 *Id.*, at 6.

In view of the foregoing, it is unsurprising that Globalstar has neither detected Iridium's ongoing operations in the currently shared spectrum nor "experienced any quality of service issues due to this sharing."[31] The lack of any interference is particularly notable given Globalstar's assertion that "Channel 7 represents the second-most used set of frequencies" for its MSS operations[32] and the documented fact that Iridium employs the shared spectrum extensively in its system. The record of successful sharing to date in the band combined with the engineering analysis above is conclusive evidence that granting shared access to the 1616-1617.5 MHz band segment can be accomplished without causing harmful interference to Globalstar.

III. IRIDIUM AND BIG LEO MSS CUSTOMERS CAN BENEFIT GREATLY FROM EXPANDED SHARING TO ACCOMMODATE DOCUMENTED SPECTRUM NEEDS.

Iridium has requested access to additional spectrum to address its significant existing and future spectrum needs.[33] Iridium has a thriving and growing MSS business focused on delivering innovative satellite solutions to its diverse body of public safety, government, enterprise, and consumer customers, including mission-critical emergency responder communications. Iridium has undergone tremendous growth in subscribers and traffic on its system since the Commission last examined spectrum assignments in the Big LEO MSS band, with more than triple the number of worldwide subscribers since 2007.[34]

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31 *Id.*, at 7 n.18.

32 *See supra* n.7, at Attachment Page 16.

33 *See supra* n.1.

34 *See supra* n.5, Iridium's Spectrum Petition, October 2, 2014, at 5 (redacted and submitted as set forth in the Joint Protective Order).

As Iridium explained in its Spectrum Petition Presentation, its need for spectrum is driven by growth in demand for its services.[35] Iridium provides its diverse line of innovative MSS offerings on only approximately 8 megahertz of unpaired Big LEO MSS band spectrum. Iridium constantly deploys advanced new products and services, such as its high-speed data service Iridium OpenPort® and its personal Wi-Fi hotspot product Iridium GO!™; and growth in demand is only expected to accelerate with the deployment of Iridium NEXT, which will begin launch in 2015.[36]

Iridium's access to additional spectrum through expanded sharing can help meet growing demand and benefit MSS customers. The additional spectrum requested by Iridium would enable Iridium to maximize the effectiveness of its current- and next-generation satellite systems and facilitate Iridium's continued development and introduction of new advanced services and expansion into new markets. Any increase in available spectrum, including shared spectrum, would allow Iridium to support more users and higher-bandwidth services and help to mitigate the spectrum needs experienced currently (as described in the documentation provided under the Protective Order).[37] Simply put, the spectrum would be used by Iridium to serve the Nation's critical satellite communications needs fully, effectively, and immediately.

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35 *See id.*

36 *See supra* n.5, Iridium's Spectrum Petition, October 2, 2014, at 11-12 (redacted and submitted as set forth in the Joint Protective Order).

37 *See supra* n.5.

IV. IRIDIUM AND BIG LEO MSS CUSTOMERS WILL BENEFIT FROM EXPANDED SHARING NOTWITHSTANDING THE POTENTIAL FOR GLOBALSTAR TO INTERFERE WITH IRIDIUM DURING PEAK PERIODS OF LIMITED DURATION IN RELATIVELY SMALL GEOGRAPHIC AREAS.

While Iridium's transmissions essentially are invisible to Globalstar's system, Iridium's FDMA/TDMA operations can experience harmful interference if Iridium's and Globalstar's systems experience peak usage in the same geographic area. According to the attached Technical Appendix, Globalstar user terminals produce transmissions 120 dB greater than the signals received by the very low noise receivers utilized by Iridium user terminals.[38] When a Globalstar terminal transmits within line-of-sight of an Iridium user terminal, it will de-sensitize the front end of the Iridium user terminal.[39] In addition, as shown in the Technical Appendix, peak usage of the Globalstar system operating in the same geographic area as Iridium produces interference at the Iridium satellite receiver that results in a reduction in the Iridium uplink margin.[40]

Additionally, because of its much wider channel bandwidth, interference from one Globalstar channel can affect multiple Iridium frequency channels and timeslots assigned to users.[41] The result, assuming peak operations by both Globalstar and Iridium in geographic proximity, can be to introduce interference levels greater than the Iridium receiver noise floor.[42] Raising the Iridium satellite receiver noise floor impacts the Iridium customer experience in

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38 *See* Exhibit 2, at 2.

39 *Id.*

40 *Id.*

41 *Id.*, at 1.

42 *Id.*

several ways: (1) an increase in blocked or dropped calls, (2) degraded call quality, and (3) a reduction in frequency reuse flexibility, which would inhibit handoffs.[43]

Nonetheless, such peak usage interference will be episodic and isolated in small pockets of Iridium's global network. As Globalstar acknowledges, peak usage generally occurs during and after disasters.[44] Such limited, short-term interference caused by peak usage in one remote geographic area will not affect Iridium's service in the vast remainder of Iridium's worldwide footprint. The distinctive architecture of Iridium's system, with sixty-six low-Earth orbiting, cross-linked satellites operating as a fully meshed network, allows it to serve domestic and international areas that Globalstar does not. Globalstar's "bent pipe" architecture relies both upon space stations and regional, terrestrial gateways,[45] limiting coverage to areas near where it has been able to license and locate ground infrastructure and thus leaving large swaths of the earth, particularly over the oceans and polar regions, without coverage.

Therefore, the following is clear. *First*, Iridium and Big LEO MSS customers absolutely benefit from having expanded sharing when there are no concurrent peak usage periods. Increasing access to spectrum will allow Iridium to support more users, provide higher-bandwidth services, and help mitigate currently experienced spectrum needs. *Second*, were it not for Iridium's need to meet existing and future customer demand for its innovative MSS, it would not have requested access to additional spectrum. Moreover, in light of the facts submitted under Protective Order concerning Iridium's current spectrum needs, Iridium is no worse off having

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43 *Id.*, at 2.

44 Globalstar Oct. 24 Letter, at 4.

45 *See* Letter from Regina M. Keeney to Marlene H. Dortch, FCC, IB Docket No. 13-213, RM-11685, RM-11697, Attached Presentation, at 7 (Dec. 13, 2013) (describing "Globalstar's unique bent-pipe architecture").

interference arise under the rare instances of concurrent peak conditions in the United States than it is in its situation today with its limited amount of spectrum.

Finally, Globalstar intends to deploy its TLPS service in "hundreds of thousands, if not millions" of access points across the country.[46] As discussed in prior filings, Globalstar's TLPS precludes its Big LEO duplex operations anywhere it is deployed.[47] If the Commission approves Globalstar's TLPS service, there can be little question that Globalstar's use of the L Band spectrum will be reduced and unlikely to ever be heavy in nature once TLPS is deployed across the country. Accordingly, Iridium is confident that it can put the new shared spectrum to immediate and productive use in its network with or without TLPS occurring.

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46 *See* Comments of Globalstar, Inc. at 11, IB Docket No. 13-213, RM-11685 (filed May 5, 2014) ("Globalstar Comments").

47 *See, e.g.*, Iridium Oct. 16 Written Ex Parte, at 2; *supra* n.5, Iridium's Spectrum Petition, October 2, 2014, at 14 (redacted and submitted as set forth in the Joint Protective Order).

V. CONCLUSION

Iridium's customers would benefit absolutely and immediately from expanded spectrum sharing. Iridium has provided detailed documentation under Protective Order demonstrating an urgent need for additional spectrum resources. Globalstar claims to be heavily using the existing shared spectrum, and Iridium has provided firm evidence that it utilizes the existing shared spectrum without any evidence of harmful interference to Globalstar's MSS. Engineering analysis corroborates that Iridium's TDMA operations will not cause harmful interference to Globalstar's CDMA operations. Further engineering analysis shows that the limited duration and geography of concurrent peak usage limit the impact of harmful interference from Globalstar to Iridium's truly global network. The bottom line is that even in the rare instances of concurrent peak usage in the United States, Iridium and its customers are no worse off having interference arise than in Iridium's current spectrum-limited situation. Because expanded sharing will produce instant benefits for Iridium customers without any harm to Globalstar's MSS operations, the Commission should grant Iridium's revised spectrum proposal.

Respectfully submitted,

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November 5, 2014

Exhibit 1
AFFIDAVIT OF S. SCOTT SMITH

I, S. Scott Smith, hereby declare as follows:

1. I am Chief Operating Officer of Iridium Communications Inc., the parent company of Iridium Constellation LLC ("Iridium").

2. Iridium shares 0.95 MHz of spectrum with Globalstar at 1617.775 – 1618.725 MHz.

3. Iridium currently operates by assigning 333.3 kHz sub-bands of eight contiguous channels to its beams. These sub-bands cannot be broken up. The lower boundary of the shared spectrum, 1617.775 MHz, falls in the middle of a sub-band. Therefore, the first, complete sub-band that can be used is 1618.0-1618.333 MHz. As a result, Iridium uses 0.725 MHz of the 0.95 MHz of shared spectrum.

4. Iridium uses this shared spectrum to provide diverse voice and data services to its government, military, public safety, and commercial customers on a daily basis across its entire global footprint.

I, S. Scott Smith, declare under penalty of perjury that the foregoing is true and correct to the best of my knowledge, information and belief.

Executed on November 4, 2014.

S. Scott Smith

Exhibit 2: Technical Appendix
Prepared by: Brandon Hinton, Consultant to Iridium and
Senior Principal Systems Architect Engineer, Exelis, Inc.

Iridium/Globalstar Band Sharing Analysis

Issue #1: Iridium Time Division Multiple Access (TDMA) vs Globalstar Code Division Multiple Access (CDMA)

In the 2007 *Second Order on Reconsideration* the FCC determined that the Big LEO MSS band should be segmented between the two remaining operators, Iridium and Globalstar.[1] The significant factor in segmenting the band was the disparate technologies used by the two systems.

Iridium supports users through individual frequency channels spaced 41.67 kHz apart, with each frequency channel divided into four user duplex timeslots via TDMA/TDD multiplexing. Globalstar supports users by assigning multiple users to a 1.25 MHz channel through spreading code sharing. The divergent technologies of the two systems mean that the interference experienced by each system from the other in band-sharing scenario is inherently very different. Iridium transmissions, as received by the Globalstar satellite system, appear as narrowband interference. Because spread spectrum signals, such as those used in Globalstar's L-band user links, were originally designed to withstand narrowband interference through processing gain, this type of interference has minimal impact on the Globalstar satellite receiver. The typical Iridium user transmission is 37 kHz occupied bandwidth, or about 33 times narrower than the Globalstar user transmission. The corresponding 15 dB of processing gain effectively provides 15 dB of resistance to interference. Furthermore, since an Iridium user is only transmitting during a single timeslot within an Iridium timeframe, the user transmission duty cycle is 9.2%, which is effectively a reduction by 10 dB in power density. Even in a heavily-loaded Iridium scenario, traffic spreading and frequency reuse mechanisms for most Iridium services prevent situations in which large blocks of contiguous frequency channels are assigned into a specific region. Therefore, the Globalstar satellite receiver would not experience continuous interference from Iridium channels filling an entire Globalstar channel.

Interference from Globalstar user uplink transmissions to the Iridium satellite are characterized much differently. Interference from a single Globalstar channel can impact up to 30 individual Iridium frequency channels and all four Iridium timeslots in a channel, resulting in a maximum of 120 Iridium channels being impacted by interference from a single Globalstar channel, though Iridium load spreading and frequency reuse would lessen the typical number of impacted users. Because each additional user in a Globalstar channel increases the interference received by the Iridium satellite by an equal amount, large numbers of users introduce a proportionally higher amount of interference. Given that each Globalstar channel can support over 100 users, the potential interference density received by the Iridium satellite could be increased by a factor of 20 dB.

Raising the satellite receiver noise floor impacts the Iridium user experience in several ways:

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[1] *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 (2007).

1. Reduced Iridium user link margin, which can prevent users from accessing the satellite, or, if already connected to the satellite, induce a call drop.
2. Degraded call quality, either in terms of voice quality or data bit error ratio (BER).
3. Reduction in frequency reuse flexibility; as the satellite senses increased receiver noise in particular spot beams, it must constrain how it dynamically assigns channel resources to users, effectively denying access to the satellite and preventing handoffs to occur between beams.

Emissions from Globalstar subscriber equipment (duplex or simplex service transmissions) also have potential to generate significant interference to Iridium subscriber equipment receivers. Iridium user uplink and downlink transmissions both occur in Iridium's 1617.775 – 1626.5 MHz authorized band through time division duplexing (TDD), in which Iridium's 90 ms timeframe is divided into transmit and receive timeslots. Iridium user terminals employ very low noise receivers having a sensitivity of -119 dBm. A nearby Globalstar user terminal, however, may produce transmissions at a level 120 dB greater than this sensitivity, possibly on the exact same channel that an Iridium terminal is receiving. Even with separation distances of hundreds of meters, a Globalstar terminal transmitting co-frequency to and within line-of-sight of an Iridium terminal will completely desensitize the front end of an Iridium user terminal.

Table 1 summarizes the impact of Globalstar user terminal interference to the Iridium satellite receiver as well as into Iridium user terminals. The analysis of Globalstar interference captured by an Iridium satellite spot beam uses a relatively high Globalstar channel loading of 40 users, which is the same number of users considered in the 2007 Electronic Communications Committee (ECC) Report 95 *Sharing Between MSS Systems Using TDMA and MSS Systems Using CDMA in the Band 1610-1626.5 MHz* ("ECC Report 95").[2] This number of users reduces the Iridium uplink margin by over 5 dB, which is a significant reduction considering that a wide array of Iridium user services require nominal link margins from 9 to 16 dB in a mobile and/or shadowed environment. Globalstar co-channel interference into Iridium terminals, as noted above, can significantly inhibit user communications if the Globalstar terminals are nearby. By extension, Globalstar interference into Iridium terminals and satellites is limited to geographic areas where the interference exists and does not produce system-wide impact.

In the case of uplink interference to Iridium satellites, the aggregate emissions from a concentrated number of Globalstar user terminals would be captured by an Iridium satellite antenna spot beam and therefore affect those Iridium users within that 200 – 400 km radius spot beam. For the case of Globalstar user terminal emissions interfering into Iridium user terminals, the impact is most severe when the two types of terminals are within line-of-sight to each other without obstructions between them.

[2] *See* ECC Report 95, *Sharing Between MSS Systems Using TDMA and MSS Systems Using CDMA in the Band 1610-1626.5 MHz*, at 33 (Feb. 2007).

Table 1: Globalstar Terminal Interference to Iridium Satellite and User Terminals

Globalstar Interference to Iridium Satellite		
Globalstar handset nominal e.i.r.p.	-10	dBW
Globalstar transmit bandwidth	60.9	dB-Hz
Globalstar e.i.r.p. density	-70.9	dBW/Hz
Iridium satellite altitude	780.0	km
Typical Iridium satellite slant range	1500.0	km
Frequency	1.618	GHz
Path loss	160.1	dB
Iridium sat. antenna gain (spot beam dependent)	23.0	dBi
Cross pol isolation	-6	dB
Iridium sat received power density from single Globalstar handset	-214.0	dBW/Hz
Iridium sat noise power density	-201.6	dBW/Hz
I/N	-12.4	dB
Iridium sat received power density from 40 Globalstar handsets	-198.0	dBW/Hz
I/N from 40 Globalstar handsets	3.6	dB
Increase in noise floor from 40 Globalstar handsets (i.e., reduction in Iridium user link margin)	**5.2**	**dB**

Globalstar Interference to Iridium Subscriber Terminals		
Globalstar handset nominal e.i.r.p.	-10	dBW
Globalstar transmit bandwidth	60.9	dB-Hz
Globalstar e.i.r.p. density	-70.9	dBW/Hz
Separation distance, d, between Iridium/Globalstar terminals	100.0	m
Ground wave propagation loss (d^4 loss)	91.3	dB
Iridium terminal antenna gain	0.0	dBi
Iridium terminal antenna cross-pol isolation	-6.0	dB
Iridium terminal receiver noise bandwidth	45.2	dB
Iridium terminal received interference from single Globalstar terminal	-93.0	dBm
Iridium terminal receiver sensitivity	-119.0	dBm
Iridium receiver co-channel C/I	**-26.0**	**dB**

Issue #2: Globalstar CDMA sharing design relative to other proposed Big LEO CDMA systems.

In the FCC's 1994 Big LEO Band NPRM, the expectation was that four separate CDMA-based MSS systems would share the 1610-1621.35 MHz band for uplink and the 2483.5-2500 MHz band for downlink, with Iridium uplink and downlink occupying the 1621.35-1626.5 MHz band.[3] The four CDMA systems, including Globalstar, were all expected to share their portion of the band on a co-frequency, co-geographical basis.

Table 2 below provides a detailed interference link budget showing the impact on a Globalstar satellite receiver in a loaded, multiple Iridium terminal interference scenario. Parameters for the Globalstar transmit power, satellite receiver and intra-system interference were taken from the 2004 *Petition for Reconsideration of Globalstar LLC* and the ECC Report 95.[4]

The left side of the table describes the parameters of the interfering Iridium terminals. In this scenario, the total number of interfering Iridium terminals is determined by taking into account the number of Iridium channels within a Globalstar channel, a loaded Iridium frequency reuse assumption, and the typical number of Iridium beams within a Globalstar beam. The resulting number of simultaneous Iridium users within a Globalstar beam, 18, was assumed in the ECC report and is assumed here as well.

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[3] *See Amendment of the Commission's Rules to Establish Rules and Policies Pertaining to a Mobile Satellite Service in the 1610-1626.5/2483.5-2500 MHz Frequency Bands*, Notice of Proposed Rulemaking, 9 FCC Rcd 1094 (1994).

[4] *See* ECC Report 95, *Sharing Between MSS Systems Using TDMA and MSS Systems Using CDMA in the Band 1610-1626.5 MHz* (Feb. 2007); Petition for Reconsideration of Globalstar LLC, IB Docket No. 364, ET Docket No. 00-258 (Sept. 8, 2004).

Table 2: Iridium Terminal to Globalstar Satellite Interference Link Budget

Iridium handset nominal e.i.r.p. (burst)	4.5	dBW	Globalstar handset nominal e.i.r.p.	-10	dBW
Duty cycle of Iridium transmission burst relative to total frame time	-10.4	dB	Globalstar transmit bandwidth	60.9	dB-Hz
Average Tx EIRP	-5.9	dBW	Globalstar e.i.r.p. density	-70.9	dBW/Hz
Globalstar satellite altitude	1414.0	km	Globalstar satellite altitude	1414.0	km
Typical Globalstar satellite slant range	1952.0	km	Typical Globalstar satellite slant range	1952.0	km
Frequency	1.618	GHz	Frequency	1.618	GHz
Path loss	162.4	dB	Path loss	162.4	dB
Globalstar sat. antenna gain	14.6	dBi	Globalstar sat. antenna gain	14.6	dBi
Cross-polarization isolation	6.0	dB			
Single received Iridium handset interference power	-159.7	dBW	Globalstar sat received power from single handset	-157.8	dBW
			Globalstar sat received power density (spread)	-218.7	dBW/Hz
Number of Iridium channels per Globalstar channel	29.5		Globalstar sat noise power density	-201.6	dBW/Hz
Iridium channel reuse	5.0		Globalstar;s self-proclaimed sat rx intra-system interference density	-193	dBW/Hz
Maximum realizable Iridium channels per Globalstar channel (rounded up)	6.0		Globalstar sat rx noise plus intra-system interference density	-192.4	dBW/Hz
Approximate number of Iridium spot beams per Globalstar spot beam	3.0				
Maximum realizable Iridium channels per Globalstar channel, per Globalstar spot beam	18.0				
Aggregate Iridium uplink interference power per Globalstar channel and spot beam	-147.1	dBW			
Globalstar sat. Tx bandwidth	60.9	dB-Hz			
Aggregate Iridium uplink interference power density	**-208.0**	**dBW/Hz**			
Aggregate Iridium uplink interference density to Globalstar receiver noise density, Io/No	-6.4	dB			
Ratio of aggregate Iridium uplink interference density to Globalstar receiver noise plus interference density	**-15.6**	**dB**			
=	**2.8**	**%**			
Hypothetical interference density from another co-frequency CDMA system	-201.6	dBW/Hz			
Hypothetical aggregate interference from 3 other co-frequency CDMA systems	-196.829	dBW/Hz			
Ratio of aggregate Iridium uplink interference density to aggregate interference from 4 other CDMA systems	**-11.2**	**dB**			

On the right side of the table, the typical Globalstar link budget is provided. Of particular note is that Globalstar's intra-system interference density of -193 dBW/Hz (as provided by Globalstar in the 2004 Petition for Reconsideration)[5] is 25.7 dB higher than the received signal power density from a single Globalstar duplex terminal calculated in the table. A factor of 25.7 dB translates to a decimal value of 370, which means it would take 370 co-channel Globalstar users to achieve this intra-system interference density of -193 dBW/Hz.

The bottom portion of the table summarizes the relative amount of Iridium interference to the Globalstar satellite receiver intra-system interference, as well as taking into account the amount of interference that would be seen by the Globalstar satellite receiver if sharing with three other CDMA MSS systems operating in a co-frequency, co-regional situation, as originally envisioned in the Big LEO band. The interference density provided by the other CDMA systems was assumed to be equal to the noise floor density (i.e., I/N=0 dB). The aggregate Iridium terminal uplink interference into the Globalstar receiver is only 2.8% of the Globalstar intra-system interference plus noise density. The aggregate Iridium terminal uplink interference is also 6.4 dB less than what would be expected from another hypothetical CDMA system and 11.2 dB less than the aggregate interference from three other CDMA systems.

ECC Report 95 used very stringent interference thresholds in providing a recommendation that sharing wouldn't be feasible between Globalstar and Iridium. The threshold for unacceptable interference to Globalstar was set as 3%, or I/N = -15 dB. This amount of interference would raise the Globalstar satellite receiver by 0.1 dB, which is also, as shown in Table 1, an interference level 23 dB *lower* than their own intra-system interference level. For the purposes of co-frequency sharing between two systems, 3% seems to be an inappropriately stringent requirement.

The analysis demonstrates that a heavily loaded Iridium system produces interference into the Globalstar satellite receiver at levels:

- significantly lower than Globalstar's own intra-system interference plus noise density
- much lower than anticipated from any of the other original CDMA systems
- significantly lower than the expected aggregate interference from the other three CDMA systems.

As a result, Iridium interference, even under heavily loaded conditions, does not produce harmful interference to the Globalstar satellite receiver and analysis shows that there is significant design margin in the Globalstar system to accommodate maximum frequency reuse conditions for use of its own channels. Globalstar satellites are able to operate without any significant interference impact from Iridium, even in loaded user traffic scenarios.

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[5] *See* Petition for Reconsideration of Globalstar LLC, Technical Appendix at Tbls. 1, 2, 3, ET Docket No. 00-258 (filed Sept. 8, 2004).