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VIA ELECTRONIC FILING

James L. Ball
Chief, Policy Division
International Bureau
Federal Communications Commission
445 12th Street, S.W.
Washington, DC 20554

Re: Review of the Spectrum Sharing Plan Among Non-Geostationary Satellite Orbit Mobile Satellite Service Systems in the 1.6/2.4 GHz Bands, IB Docket No. 02-364—Response to Request for Additional Information

Dear Mr. Ball:

Pursuant to your request of November 21, 2003, Iridium Satellite, LLC ("Iridium"), by its attorneys, hereby respectfully submits its response to your request for additional information in consideration of the pending proceeding to rebalance the 1.6/2.4 GHz band.[1]

Iridium's mobile satellite system is unique in its ability to provide continuous coverage to virtually everywhere in the world. The design of Iridium's satellite system enables it to efficiently achieve global coverage capability.

Although Iridium has been able to make this impressive MSS offering with only 5.15 MHz of spectrum, Iridium has been experiencing a severe spectrum shortage, which constrains its ability to expand or improve its services. At this point, the 5.15 MHz of spectrum assigned to Iridium under the current band plan is not enough to meet the continually increasing demand for MSS services; nor is it sufficient to accommodate the introduction of new services that will enable Iridium to remain competitive in the MSS marketplace. Iridium is in immediate need of additional spectrum to meet documented capacity needs to handle call volumes, improve data rates, and improve voice quality.

Finally, the Iridium satellite system was designed to utilize 10.5 MHz of spectrum, so service improvements can occur promptly after spectrum allocation and

[1] Iridium is submitting its response on this date pursuant to the extension granted by the International Bureau.

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regulatory approvals are obtained. For these reasons Iridium urges the Commission to act on its request expeditiously.

Respectfully submitted,

/s/ Peter D. Shields

Peter D. Shields

Attachment

cc: Thomas S. Tycz, Chief, Satellite Division

Following are the specific responses of Iridium Satellite LLC (Iridium) to the questions submitted by the International Bureau to Iridium on November 21, 2003, in IB Docket No. 02-364:

Question 1: An explanation of how, from a technical, system-engineering perspective, access to additional spectrum in the United States supports an increase in Iridium system capacity for services provided in other geographic areas.

The Iridium system operates using a single, defined range of spectrum over the entire earth due to the design and implementation of the satellite software. The system and spectrum-related telephony software were designed to operate with 10.5 MHz of spectrum over the band 1616-1626.5 MHz, which resulted in, among other things, the current telephony algorithms that attempt to provide complete coverage beneath a given satellite and prevent self-interference between elements of the Iridium system. However, the Iridium system was licensed in the U.S. to operate with service links at 1621.35-1626.5 MHz.

The Iridium system could, from a technical perspective, commence operations in the U.S. and other geographic areas with additional L-band frequencies as soon as it receives FCC approval. Practically, however, Iridium would wait until it receives similar authorizations and approvals from other countries before commencing operations with the additional frequencies.

The FCC is the Administration that licensed and coordinated Iridium's space segment, so other countries are not likely to change the frequency assignments unless and until the FCC acts. Indeed, when licensing the Big LEOs, countries were asked initially to follow the FCC's Big LEO band plan; and most of them did, so it is to be expected that they would consider the FCC ruling on this issue prior to taking any action. This was furthered by the 1997 Big LEO Agreement, pursuant to which the three Big LEO operators (Iridium, Globalstar, and Odyssey) agreed to seek in other countries what the FCC had done in its Big LEO Band Plan.

Iridium is poised to begin the process of seeking the increased spectrum assignment in other countries as soon as the Commission acts.

Can the Iridium system use different frequency assignments over different geographic areas?

The Iridium system has not been designed to support the use of different frequency assignments over different geographic areas. Iridium understands that, during the system design phase, a geographic-based spectrum assignment capability was envisioned and pursued. However, numerous system architecture considerations as well as technical trade-offs ultimately effectively precluded this capability from being implemented in the Iridium system. The system architectural considerations that effectively precluded this capability from being implemented are discussed below within the context of what modifications to the operational Iridium system would be necessary to permit this functionality.

Notwithstanding the decision not to implement a comprehensive geography-based spectrum allocation capability, a limited capability narrowly focused on the radio astronomy sites was developed to comply with requirements to protect the Radio Astronomy Service (RAS). The Iridium system is designed to protect RAS by being capable of determining the location of each satellite beam and, when an active beam impinges on a protected radio astronomy zone, to avoid using frequencies within that beam that might cause harmful interference. The system also protects the RAS by being capable of determining the location of its mobile terminals and, when the terminals are within a protected radio astronomy zone, to avoid transmitting signals that would cause harmful interference. This radio astronomy protection capability has been carefully designed to maintain the Iridium out-of-band (within the RAS band) emissions levels within these specified limits independent of the spectral allocation in use by the Iridium constellation. This radio astronomy protection functionality is described in more detail in Iridium's response to question 2.

The capabilities of the Radio Astronomy protection software are limited to specific RAS site locations and do not provide a practical means to control frequency usage on a country-by-country basis. Satellite on-board memory limitations, coarse geographic selectivity, and practical processor computation limits prevent this limited capability from being expanded to provide frequency selectivity on a country-by-country basis. For example, the RAS mechanism for manipulating frequency usage is on a coarse geographic basis defined by the 6,032,000 km^2 footprint (120 degree pie-shaped wedge with a radius of 2400+ km) of the 16 beams that are generated by a single Main Mission Antenna panel. These country-by-country frequency selectivity complexities are discussed below.

The Iridium system also currently has the capability to deny access to users who are in a geographic area where service is not authorized. This is performed using the gateway restricted location area code (LAC) functionality.

If not, what modifications to the Iridium system would be necessary to permit use of different frequency assignments over different geographic areas?

As discussed above, Iridium understands that, during the system design phase, a geographic-based spectrum assignment capability was envisioned and pursued. It was to have been implemented as an integral part of the Dynamic Channel Management system referred to as Space Vehicle Real Time (SVRT) and discussed in the response to item 4.

However, upon the first licensee's initial grant of only 5.15 MHz for the Iridium system, and due to fundamental design constraints associated with the system's operation in such a confined bandwidth, a decision was reached to not implement the Spectral Management portion of the SVRT design.

As the Spectral Management functionality was originally envisioned, beam-by-beam spectral control would have been implemented based on the individual beam locations, which would have been defined by the beam locations of their geographic beam center points. A database containing allowed spectral usage was to be defined, with each entry (16,200 in total) containing the allowed spectrum in a two degree by two degree (2x2) latitude-longitude box. Throughout its 100 minute orbit, each satellite would continuously cross-reference the latitude and longitude positions of all currently active beams against the spectral licensing database to determine if there were any upcoming violations of the spectral restrictions. This would have been done at beam turn-on and when adding additional capacity (i.e., traffic channels) to the beam. This also would have been done at regular four second intervals to accommodate the satellite's orbital motion.

For spectral maintenance all active channels in a beam would have been checked against the database, and all channels outside of the allowed spectrum would have been reassigned. The reassignment process entailed the movement of all control channels and, furthermore, required that all active traffic channels (soon to be) outside of the currently allowed/licensed band be moved via the intra-beam handoff process (as discussed in the response to Question 4).

The complexity of these combined operations and de-conflictions, coupled with potentially rapidly varying frequency allocations between small geographic country boundaries and dense regional traffic loads, would have resulted in a significant increase in the dropped and blocked call rates and was deemed detrimental to system operations, given Iridium's original allocation of only 5.15 MHz of L-band spectrum.

Question 2. Given that Iridium has a bidirectional-system, how does Iridium plan to provide protection to the Radio Astronomy Service if Iridium were to receive 10.5 MHz of MSS spectrum in the 1.6 GHz band?

To provide protection for the RAS in the 1.6 GHz band, the Iridium system supports both uplink and downlink protection mechanisms.

Downlink Protection: As summarized in the response to question 1, each Iridium satellite has Radio Astronomy protection software designed to minimize downlink out-of-band (OOB) emissions in the 1610.6-1613.8 MHz band. Prior to commercial operations, Motorola performed extensive on-orbit tests, spending vast amounts of engineering time gathering and analyzing emission data. These efforts involved hundreds of hours of analysis, modeling, and on-orbit testing and measurement evaluation. Satellite transceiver elements, panel effects, inter-modulation products, and spurious emissions were all carefully evaluated to ensure that the Iridium system would protect the RAS and be compliant with the Commission's rules and with the terms and conditions of agreements reached with the RAS observatories.

The Radio Astronomy protection software was designed to ensure compliance with the RAS protection requirements if Iridium were to operate over a full 10.5 MHz of spectrum. The RAS protection software performs channel crowding, which will limit the frequency of operation of a satellite to the upper end of the 10.5 MHz frequency allocation while in proximity to an RAS site. Since the Iridium satellite directs the subscriber unit to the appropriate satellite channel, both the uplink and downlink will reside in this limited spectrum. The Radio Astronomy software on-board each of the satellites is activated when a satellite space-to-ground beam comes within a pre-defined distance of a defined Radio Astronomy Site. The RAS mechanism for minimizing out-of-band emissions is implemented on a Main Mission Antenna (MMA) panel-by-panel basis. All MMA panels that have beams impinging on an RAS site will be operated in the Radio Astronomy mode. An MMA panel generates a group of 16 beams with a projected ground coverage of 6,032,000 km^2 (120 degree pie-shaped wedge with a radius of 2400+ km). When RAS mode is active for a given MMA panel, all active beams on that panel will have spectral allocations limited to the upper end of the 10.5 MHz frequency allocation. All control channels and active traffic channels will be moved to the upper sub-bands (a sub-band is a 333.33KHz block of spectrum containing eight 46.7 KHz frequency access channels). This mode ensures that the Iridium emissions within the RAS band are not affected by an increase in spectrum, since this additional spectrum is not utilized within proximity to the RAS site. The Radio Astronomy protection mechanisms in both the uplinks and downlinks were designed to ensure that Iridium emissions are maintained within the RAS-specified levels independent of Iridium's spectral operating range.

Uplink Protection: The Iridium system supports gateway-restricted, location area code (LAC) functionality, which provides a protected zone around each specified RAS site by ensuring Iridium users cannot use their subscriber terminals within the assigned LAC. These LAC protection zones are specifically designed to protect each RAS site, which results in all users within that LAC being denied access to the Iridium system. This Gateway-restricted LAC feature is independent of assigned system bandwidth and ensures that Iridium uplink emissions are fully compliant with RAS protection requirements.

Question 3. In the Technical Annex of its May 8, 2003 letter,[1] Iridium provided information on a number of bench-mark user terminals. These terminals were referred to as "Autodialers" in Table Attachment 5. Specifically, the annex listed the number of monthly transmissions and the percentage of successful monthly transmissions for the following Autodialers "Virginia to DoD" and "Australia to Tempe". Please provide the daily values of the same two numbers (the number of daily transmissions and either the number of successful daily transmissions or the percentage of successful daily transmissions) for these Autodialers from March 15, 2003 to May 30, 2003.

The table below summarizes the daily autodialer results for the two specified parameters. Note that on the few days for which no autodialer results were reported, an autodialer failure occurred, corrupting or preventing data recording for that day. As evident from the data below, the autodialer performance has remained very stable over the period of interest.

[1] Letter from Peter Shields to Thomas Tycz dated May 8, 2003, responding to Globalstar's opposition of continuing STA for Iridium (May 8 *Ex Parte* Letter).

Virginia_DOD Autodialer			
Date	Call Attempts	Successfully Established	Establishment Rate
3/15/2003	1121	1103	98.40%
3/16/2003	1130	1104	97.70%
3/17/2003	1134	1111	98.00%
3/18/2003	458	449	98.00%
3/19/2003	1133	1117	98.60%
3/20/2003	1109	1082	97.60%
3/21/2003	1140	1110	97.40%
3/22/2003	1120	1096	97.90%
3/23/2003	873	856	98.10%
3/24/2003	1134	1118	98.60%
3/25/2003	1125	1096	97.40%
3/26/2003	1135	1121	98.80%
3/27/2003	1134	1111	98.00%
3/28/2003	1136	1112	97.90%
3/29/2003	1126	1110	98.60%
3/30/2003	1137	1117	98.20%
3/31/2003	1128	1109	98.30%
4/1/2003	1130	1090	96.46%
4/2/2003	1129	1099	97.30%
4/3/2003	1043	1016	97.40%
4/4/2003	1132	1100	97.20%
4/5/2003	1136	1113	98.00%
4/6/2003	1113	1081	97.10%
4/7/2003	1130	1109	98.10%
4/8/2003	530	524	98.90%
4/9/2003	1129	1099	97.30%
4/10/2003	1131	1103	97.50%
4/11/2003	1120	1072	95.70%
4/12/2003	1133	1053	92.90%
4/13/2003	1133	1090	96.20%
4/14/2003	1133	1081	95.40%
4/15/2003	1137	1104	97.10%
4/16/2003	1136	1103	97.10%
4/17/2003	1135	1096	96.60%
4/18/2003	No Data	No Data	No Data
4/19/2003	159	158	99.40%
4/20/2003	1127	1080	95.80%
4/21/2003	1160	1138	98.10%
4/22/2003	1131	1102	97.40%
4/23/2003	147	138	93.90%
4/24/2003	1134	1098	96.80%
4/25/2003	1087	1036	95.30%
4/26/2003	1130	1109	98.10%
4/27/2003	1115	1068	95.80%
4/28/2003	1131	1100	97.30%
4/29/2003	1104	1083	98.10%
4/30/2003	1135	1118	98.50%
5/1/2003	1136	1114	98.10%
5/2/2003	1133	1115	98.40%
5/3/2003	1117	1094	97.90%
5/4/2003	1136	1110	97.70%
5/5/2003	1123	1093	97.30%
5/6/2003	1138	1123	98.70%
5/7/2003	1135	1118	98.50%
5/8/2003	1105	1072	97.00%
5/9/2003	1132	1116	98.60%
5/10/2003	1126	1100	97.70%
5/11/2003	1135	1102	97.10%
5/12/2003	1137	1110	97.60%
5/13/2003	1126	1100	97.70%
5/14/2003	No Data	No Data	No Data
5/15/2003	No Data	No Data	No Data
5/16/2003	1125	1082	96.20%
5/17/2003	1108	1100	99.28%
5/18/2003	1136	1089	95.90%
5/19/2003	1129	1111	98.40%
5/20/2003	1131	1117	98.80%
5/21/2003	1130	1109	98.14%
5/22/2003	1128	1107	98.14%
5/23/2003	1129	1102	97.60%
5/24/2003	1132	1106	97.70%
5/25/2003	1134	1094	96.50%
5/26/2003	1142	1109	97.10%
5/27/2003	1124	1090	97.00%
5/28/2003	1136	1109	97.60%
5/29/2003	1127	1104	98.00%
5/30/2003	1128	1107	98.10%
5/31/2003	1120	1079	96.30%

Australia Autodialer to Tempe			
Date	**Call Attempts**	**Successfully Established**	**Established Rate**
3/15/2003	561	557	99.29%
3/16/2003	No Data	No Data	No Data
3/17/2003	167	160	95.81%
3/18/2003	572	565	98.78%
3/19/2003	1131	1119	98.94%
3/20/2003	1127	1111	98.58%
3/21/2003	566	559	98.76%
3/22/2003	1131	1115	98.59%
3/23/2003	561	541	96.43%
3/24/2003	1129	1109	98.23%
3/25/2003	1134	1116	98.41%
3/26/2003	1134	1113	98.15%
3/27/2003	1136	1121	98.68%
3/28/2003	1131	1107	97.88%
3/29/2003	1133	1113	98.23%
3/30/2003	1148	1123	97.82%
3/31/2003	1138	1120	98.42%
4/1/2003	No Data	No Data	No Data
4/2/2003	1130	1112	98.41%
4/3/2003	1129	1111	98.41%
4/4/2003	1134	1123	99.03%
4/5/2003	1137	1123	98.77%
4/6/2003	1135	1118	98.50%
4/7/2003	1132	1117	98.67%
4/8/2003	1131	1114	98.50%
4/9/2003	1130	1117	98.85%
4/10/2003	567	558	98.41%
4/11/2003	1129	1077	95.39%
4/12/2003	1135	1081	95.24%
4/13/2003	1136	1082	95.25%
4/14/2003	1136	1091	96.04%
4/15/2003	1134	1111	97.97%
4/16/2003	564	548	97.16%
4/17/2003	1135	1109	97.71%
4/18/2003	1138	1113	97.80%
4/19/2003	1126	1106	98.22%
4/20/2003	1138	1099	96.57%
4/21/2003	1132	1085	95.85%
4/22/2003	1132	1103	97.44%
4/23/2003	1139	1116	97.98%
4/24/2003	1129	1116	98.85%
4/25/2003	1131	1111	98.23%
4/26/2003	1129	1113	98.58%
4/27/2003	562	548	97.51%
4/28/2003	1130	1115	98.67%
4/29/2003	1127	1112	98.67%
4/30/2003	1131	1114	98.50%
5/1/2003	1136	1119	98.50%
5/2/2003	1134	1116	98.41%
5/3/2003	565	557	98.58%
5/4/2003	1133	1110	97.97%
5/5/2003	1132	1110	98.06%
5/6/2003	566	553	97.70%
5/7/2003	1134	1114	98.24%
5/8/2003	1125	1107	98.40%
5/9/2003	1132	1123	99.20%
5/10/2003	1123	1104	98.31%
5/11/2003	1138	1117	98.15%
5/12/2003	1126	1101	97.78%
5/13/2003	1132	1115	98.50%
5/14/2003	1138	1117	98.15%
5/15/2003	567	556	98.06%
5/16/2003	1133	1110	97.97%
5/17/2003	1129	1114	98.67%
5/18/2003	1132	1121	99.03%
5/19/2003	562	558	99.29%
5/20/2003	1134	1127	99.38%
5/21/2003	1131	1097	96.99%
5/22/2003	1120	1106	98.75%
5/23/2003	922	908	98.48%
5/24/2003	1122	1105	98.48%
5/25/2003	1130	1110	98.23%
5/26/2003	1132	1112	98.23%
5/27/2003	1118	1080	96.60%
5/28/2003	1123	1103	98.22%
5/29/2003	559	548	98.03%
5/30/2003	1139	1119	98.24%
5/31/2003	1132	1117	98.67%

Question 4. Please provide the same information as provided in Attachment 3 of the May 8 Ex Parte Letter for satellites with more than 150 connections.

The channel assignment data reflected in Attachment 3 of Iridium's May 8 *Ex Parte* Letter is obtained from "connection image records" (CIRs) generated by each Iridium satellite. These CIRs are relayed to the Satellite Network Operations Center (SNOC) via the space-to-ground telemetry links. When CIR reporting is enabled[2] each call "statechange" will generate a CIR, which contains a wealth of data unique to the call. A call "state change" can be triggered by a variety of mechanisms, e.g., a new channel/frequency assignment, a beam-to-beam handoff, or an inter-satellite handoff. These CIRs contain not only data on the specific satellite hardware assigned to the connection but also detailed information necessary to "debug" a call (e.g., current call state, frequency assignment, timeslot assignment, gateway assignment).

It should be noted that this CIR reporting mechanism was initially developed solely to support early on-orbit testing and checkout, and it was not originally intended to be employed during "normal commercial operations." Furthermore, by current system design, the underlying CIR reporting mechanism is autonomously disabled by the satellite whenever the connection count exceeds 150 calls.[3] The CIR cutoff is "hard-coded" into the satellite software and was intended to preserve satellite onboard computer processing resources for other more time critical processes (e.g., ongoing call management). Iridium has, when necessary, continued to utilize this CIR-based "satellite commissioning and checkout" functionality to perform detailed operational system

[2] CIR reporting can be turned on or off by ground command from the SNOC, subject to connection count limitations.

[3] The disabling of CIR reporting is performed autonomously by the satellites whenever the instantaneous connection count exceeds 150 calls and can not be overridden by ground command.

performance monitoring. Given the current (software-imposed) reporting limits, the channel assignment data that are reflected in Attachment 3 of the May 8 *Ex Parte* Letter are not available when the instantaneous satellite call loading exceeds 150 connections.

It should be noted that the 150-connection trigger that is used to disable CIR reporting does not, in any way, modify the channel assignment/selection processing that is performed by the satellite. In fact, the satellite software "domain" that is responsible for assigning physical channels (i.e., the "L-Band Physical Domain") is not even notified that CIR reporting has been terminated by the "Connection Domain" software (i.e., the section of software that is responsible for CIR generation and load based disabling).

The channel assignment process is unchanged by the termination of CIR reporting and, consequently, the statistical nature of the channel assignments (i.e., the uniform distribution of channels vs. frequency as reflected in the referenced Attachment 3) is completely independent of the state of CIR reporting (i.e., "enabled" or "disabled"). Thus, the data presented in Attachment 3 of the May 8 *Ex Parte* Letter fairly and accurately represent the uniform nature of the channel assignment process, regardless of whether the instantaneous call volume is greater than or less than 150 calls.

In the same attachment, Iridium mentioned that "each satellite randomly assigns channels to spot beams." Does this mean that the Iridium system can distribute channels throughout the entire system? If not, please explain the meaning of this statement. How does Iridium reuse its frequency channels in this situation? How is the gateway used to assign frequencies for subscriber use in this scenario?

The Iridium system employs a satellite-based, fully dynamic channel assignment process. The wording "randomly assigned," as used in the heading of Attachment 3, was intended to reflect the fact that Iridium traffic channels[4] can be assigned from the entire pool of frequencies and timeslots, and are not artificially constrained by the type of service offered (e.g., voice, data, short-burst data, or aviation services), or geographical location of the mobile earth terminal (MET) device.

Iridium's dynamic channel process stands in stark contrast with the inefficient, static frequency plan currently employed by other systems wherein entire 1.25 MHz CDMA channel blocks are uniquely assigned to service types[5] (i.e., MSS terrestrial voice/data services, aviation services, "simplex telemetry" services, and future ATC services) regardless of the instantaneous loading on each of the service offerings, and are further constrained based on the gateway servicing the call. All of these (artificially imposed) band segmentations are at the ultimate expense of spectral efficiency.

By contrast, the only design constraint in the Iridium system is that the channels utilized be sufficiently de-conflicted[6] so as to not create undue intra-system reuse interference, regardless of service type. In fact, the design of the Iridium system is solely intended to maximize spectral efficiency by enabling the system to respond, in real time, to high levels of offered load anywhere in the world by dynamically assigning any/all available channels to any region(s) experiencing high levels of offered load.

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[4] In the Iridium system. a user channel (voice or data channel) is currently comprised of a single frequency and a single timeslot. Full rate voice service is enabled by assigning a single frequency and a pair of timeslots, in effect doubling the per-channel capacity, and significantly improving voice quality.

[5] *See* Joint Reply Comments of L/Q Licensee, Inc., Globalstar, L.P., and Globalstar USA, L.L.C., IB Docket No. 02-364, at 7-8 (filed July 25, 2003).

[6] In this context "de-conflicted" means that the channel reuse distance is closely managed to maintain an adequate C/Ireuse ratio for all calls in the system. C/Ireuse is the ratio of the received powers for the desired call and all of the frequency-reuse interference power received from other nearby beams sharing the same channel (i.e., frequency and timeslot).

The Iridium channel assignment process is not in fact truly random.[7] Rather, at the time of call initiation, the serving satellite searches the entire assigned operating band (i.e., the full licensed L-band assignment) for the channels with highest carrier-to-interference ratio. Once an acceptable channel is identified, the access request is accommodated by assigning the requesting subscriber unit to this channel. This C/Ireuse calculation takes into account all active channels on all nearby beams – whether these call/beams are on the serving satellite or adjacent satellites.

The serving gateway has no role in the physical channel assignment process and is never informed of the physical channel assigned (the gateway has no need for this information). Rather, the channel assignment function is performed entirely by the serving satellite (and, as will be discussed below, by its nearby neighboring satellites). The overall dynamic channel management functionality, as implemented by the Iridium system, is referred to as Space-Vehicle Real-Time (SVRT), and was implemented (at significant financial cost) for the sole purpose of maximizing the system's spectral efficiency.

The basic philosophy underpinning the SVRT design is that all L-band channels (i.e., frequency/timeslot pairs) represent a pool of resources that should be universally shared and continuously managed in order to maximize capacity of each satellite and the entire system. Since channels can be dynamically assigned throughout the entire system, the goal of the SVRT functionality is continuously to monitor the system for co-channel interference and orchestrate the necessary channel assignment/re-assignment changes

[7] A truly random channel assignment process would create numerous frequency conflicted channels, and would not serve to maximize the system's spectral efficiency.

necessary to eliminate reuse-channel conflicts – without terminating ongoing calls. Some of the very unique features of this SVRT functionality are listed below:

1) All aspects of the physical channel management process (frequency and timeslot) are managed by the satellites – not by the ground assets (gateways or SNOC).

2) Heavily loaded satellites are able to "command" subscriber equipment supporting an in-progress call on a lightly loaded beam to change frequency assignment (or timeslot assignment) in order to free up a needed channel on a more heavily loaded beam. This is referred to as a "directed handoff order." This allows dynamic channel management to be performed for both new calls, and in-progress calls, thereby greatly improving overall efficiency.

3) Furthermore, heavily loaded satellites can actually direct nearby satellites (via the satellite-to-satellite crosslinks) with lesser loads to move/change existing channel assignments (again implemented through the "directed-handoff order" process). This allows a more heavily loaded satellite to better optimize (*i.e.,* maximize) its connection-by-connection C/Ireuse ratio. These nearby satellites are referred to as "near-neighbor SVs," the list of which is continually updated as the satellites approach higher latitude regions (resulting in more near neighbor SVs).

4) Each one of the 3168 beams in the Iridium system continuously maintains/updates its own data base of nearby beams and the current channels in use on these nearby beams.[8] When a new channel is required (for a new call or a beam-to-beam handoff), the beam in question immediately knows which channel(s) represent the highest quality (i.e., highest C/Ireuse).

5) These beam/channel assignments are continuously passed (shared) between satellites every 4.32 seconds, with the underlying data-exchange process being referred to as a "near-neighbor update."

6) Whenever a C/Ireuse conflict is detected (*i.e.,* a beam is utilizing a frequency/timeslot combination in close proximity to a nearby beam utilizing the same frequency/timeslot), the satellite with the lower overall load is required to move the conflicted channel assignment (again via the "direct handoff order" process).

7) The SVRT functionality not only detects and manages co-channel/co-timeslot conflicts, but also detects and manages co-channel/adjacent timeslot conflicts (associated with nearby satellites/beams utilizing adjacent timeslots with the same frequency), and adjacent channel/co-timeslot (Doppler imposed) channel

[8] Nearby beams can be on the same satellite or nearby, adjacent satellites.

conflicts (caused by varying relative velocities of the serving satellite and the interfering satellite, or satellites). Either of these mechanisms can result in a channel conflict as a result of the varying propagation delays, or Doppler shifts, between the MET terminal in question and the satellite(s) in question.

It should be emphasized that the current SVRT process has been fully tested and has been operational since Iridium first went into commercial service in November 1998. It should also be noted that several evolving wireless standards (e.g., 802.11b and Bluetooth) are currently studying (and in some cases employing) "dynamic channel selection" approaches which are, in their underlying philosophy, quite similar to Iridium's SVRT dynamic channel management process. For example, various proposed 802.11b proposals would enable local access points to employ a "dynamic channel selection" process implemented by monitoring and assigning channels in response to the local, temporally changing, interference environment. In principal, this is very much analogous to the SVRT channel selection process employed by the Iridium system today (where, here, the satellites represent the local "access point").

Question 5. Please provide estimates of your total number of paying subscribers in: January 2001, January 2002, January 2003, and September 2003 and of the number of paying US subscribers for the same dates.

The total Iridium paying subscriber figures are summarized in the table below. Iridium commenced (re-launched as the new, post-bankruptcy licensee) commercial service in March 2001; thus, this response does not contain data for paying subscribers in January 2001.

	1/1/2002	1/1/2003	9/1/2003
Total Iridium Subscribers	30,219	57,963	82,085

It should be noted that as a non common carrier Iridium does not sell services or products directly to end customers but rather to service partners that, in turn, work with dealers interfacing with the actual Iridium user communities. Hence, Iridium does not have insight into customer specifics. As discussed in the response to question 12, Iridium currently supports all Iridium subscribers from the Iridium gateways located in the United States.[9] Hence, all of the public switched traffic currently traverses the U.S.-based gateways and could be considered U.S.-homed subscribers to Iridium.

As described in Iridium's NPRM filing, it is the number of call minutes and the distribution (both geographical and temporal) which most significantly impact Iridium system capacity—not the number of subscribers. As described in the response to question 6 herein, Iridium has experienced tremendous call loading due to regional conflicts, seasonal business users, and rural telephony services. The regional traffic loading due to these activities has far out paced the subscriber growth numbers and is a far more appropriate indicator of spectrum usage.

Question 6. With respect to the following Iridium system technical parameters: (1) FDMA channel spacing, (2) TDMA duplex timeslots, (3) frequency reuse factor, and (4) required guard band, have there been any changes from those values given on pages 46 and 47 of Motorola's Report on Band Segmentation and Sharing in the Report of MSS Above 1GHz Negotiated Rulemaking, dated April 6, 1993? If so, please provide any new values for these parameters along with an explanation of the reason for the change.

The analysis contained in the referenced document,[10] while providing useful insights into the relative capacities of TDMA/FDMA vs. CDMA MSS systems under the

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[9] The U.S. based gateways are located in Tempe, Arizona and Hawaii.

[10] Motorola's *Report on Band Segmentation and Sharing, excerpt from the Report of MSS Above 1GHz Negotiated Rulemaking* (April 6, 1993) ("*April 1993 Report*").

condition of "uniform geographic loading," is not directly germane to Iridium's current regional (spectrum limited) capacity issues. In fact, as Iridium has relayed (both prior to and throughout this formal preceding), the nature of Iridium's current traffic loading, and Iridium's predicted future traffic distributions, result in localized capacity limitations[11] – not system-wide capacity limitations. These localized capacity limitations are a direct result of Iridium's current limited L-band operating bandwidth. Moreover, these limitations cannot be solved by any means other than additional L-band spectrum.

Specifically, the referenced Motorola TDMA/FDMA 1993 capacity analysis (Motorola analysis) was predicated on the condition of uniform loading throughout the (59-beam) CONUS region, and is therefore an unrealistic predictor of the (real-world) condition of dense, localized traffic loads. Under localized loading conditions, for example, the single load-servicing satellite is completely unable to take advantage of the frequency "reuse factor"[12] as defined/employed in the referenced capacity analysis.[13] As such, the multiplicative frequency-reuse capacity improvement factor "B/C" (or total beam count divided by the beams-per-reuse-cluster) is irrelevant to the case of dense localized traffic loads. In the Motorola analysis, this capacity improvement factor accounts for a multiplicative capacity enhancement of 9.833 (i.e., 59/6).

In fact, if the CONUS capacity analysis, as presented therein, is more closely examined, implicit in the capacity formula is the assumption that each of the 59 beams

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[11] In this context, localized refers to dense regional loading that is confined to one (or just a few) beams, as was the case in the Middle East during the spring/summer 2003 timeframe.

[12] The "cell cluster size" (or "reuse factor") defines how many times a given frequency channel can be reused by the satellite. Per the cited example, a reuse factor of six indicates that any given frequency can be (approximately) reused in every sixth beam.

[13] *April 1993 Report* at 46.

(the beams assumed to cover CONUS) would carry only 65 simultaneous connections (i.e., 3854 calls carried by 59 uniformly loaded beams = 65.3 calls per beam, or 392 calls per six-beam reuse cluster). In fact, Iridium has experienced many days during this past year during which the Iridium satellites have been able to carry in excess of 200 calls per beam in regions of dense localized traffic (as was the case in the Middle East), while simultaneously operating with only 55% of the duplex channel bandwidth that was assumed in the Motorola analysis (as will be further discussed below).

Taking the referenced analysis to the next logical step and, assuming that an additional heavy volume of traffic is presented by a geographical region equivalent in size to that of a single beam, the only way to add additional channels to the peak-traffic beam would be to "borrow" channels from each of the five remaining (under-loaded) beams in the six-cell reuse cluster. The end result of a heavy, localized traffic load is the situation where there is no traffic present in any of the adjacent beams in the reuse-cluster, and the entire localized load is carried by a single beam. Adjusting Motorola's traffic capacity analysis for this (real world) phenomenon, the entire channel complement of five co-cluster beams x 65.3 channels per beam is "dynamically borrowed" from the adjacent co-cluster beams for reassignment to the loaded beam. Under these peak localized loading conditions the end result is a single-beam maximum capacity of 6x65.3 = 392 calls.

As an aside, it should be noted that the assumption that all 392 channels can be redirected to the single loaded beam is not accurate, since it does not allow for the various system overhead channels that are always present in all active beams. As is the case in a GSM TDMA/FDMA cellular system, these non-traffic carrying, system overhead channels include broadcast channels, acquisition channels and handoff channels, none of which can be redirected to the (loaded) beam in question.[14] The above 392 calls/beam capacity result is thus an overly optimistic (single-beam) number.[15] It should, however, be noted that the number of system overhead channels is constant with the amount of operating bandwidth. Accordingly, any increase in Iridium's licensed operating bandwidth would serve to increase the system's achievable spectral efficiency as the new bandwidth would be entirely available for additional traffic handling capacity.

As noted above, the referenced Motorola analysis was predicated on 8.25 MHz of *duplex-channel* bandwidth, and Iridium is currently limited to 4.65 MHz of duplex channel bandwidth.[16] Given this, and taking the above analysis to its next logical extension, in order to arrive at a single beam capacity number that is relevant to Iridium's current operating bandwidth, the above 392-call single-beam (spectral) capacity limit must be prorated by the ratio of 4.65 MHz to 8.25MHz. This operating-band proration results in an adjusted, per-beam capacity limit (or, alternately, six-beam cluster limit) of 221 calls/beam (or 221 calls/cluster).

Finally, as previously discussed herein, forty of the co-cluster (system overhead) channels cannot be dynamically reassigned to the beam experiencing the heavy, localized

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[14] In fact, the current design of the Iridium satellite hardware requires that each co-cluster beam maintain a baseline of eight frequency channels that are used for system broadcast, new acquisitions, and beam-to-beam or satellite-to-satellite handoffs. By design, these 40 channels (5 co-cluster beams x 8 baseline channels per beam) can not be reassigned to the loaded beam.

[15] Furthermore, as discussed in Iridium's original comments in this proceeding, there are several satellite-design imposed features that affect the system's flexibility in reassigning all channels to any single beam. These hardware constraints have been fully documented in the previous filing.

[16] The remaining 0.5 MHz in Iridium's current 5.15 MHz band is, as required by the design of the current satellite hardware, used exclusively for simplex (paging and ringing) services, leaving only 4.65 MHz for duplex (i.e., voice and data) traffic. Of note is the fact that this simplex band was not accounted for in Motorola's earlier analysis.

load. The above single-beam capacity result must be adjusted downward by this, resulting in a final single-beam capacity limit of 181 calls/beam. Notably, Iridium has, in fact, documented cases of individual beam loading in excess of 200 calls in a single beam. This result was only achieved by violating the 6-beam cluster limit, which is allowed for in the SVRT design – but only when required to service beam-to-beam (or inter-satellite) handoffs for currently in-progress calls. That is, by design, the system will attempt, by (nearly) any means necessary, to find a channel to keep an in-progress call alive – even at the cost of decreasing overall system performance.[17]

Given all of the above considerations, Iridium's current (spectrum limited) capacity, as experienced under peak loading conditions, is consistent with Motorola's previous analyses – when correctly adjusted for the dense, localized loading conditions representative of real world conditions.

Of particular note is the fact that the Iridium system's ability to dynamically "borrow channels" from adjacent beams (i.e., beams located within the beam cluster) is a direct result of the system's unique SVRT dynamic channel allocation software currently in operation on the Iridium satellites (see SVRT description contained in response to question 4). Absent this very unique capability, the per-beam capacity would be more closely aligned with the original 65 channels identified by the Motorola uniform loading analysis – but adjusted downwards by the ratio of 4.65 MHz to 8.25 MHz – which would result in a per-beam capacity of 37 channels.

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[17] This tradeoff, however, has the undesirable side-effect of simultaneously reducing call quality and increasing dropped call rates (exactly the situation that was experienced in the Middle East theater in the spring/summer 2003 timeframe). This performance tradeoff was deemed necessary given Iridium's current limited bandwidth.

The dense, localized loading condition discussed herein is exactly the situation that the Iridium system has previously experienced and will continue to experience in the future (under a variety of real marketplace scenarios). Under these circumstances it is not the satellite that is fully loaded, it is the single beam (or beams) serving the region(s) of peak traffic.[18] Under this dense, real-world loading scenario, there is no means by which to add additional channels, except to employ more L-band spectrum – which is the subject of the current proceeding.

Most importantly, it is this type of regionally dense loading profile that reflects a significant percentage of Iridium's current and future real-world traffic. Similarly dense regional loading conditions can be the result of natural (or man-made) disasters and emergencies, regions of military conflict, wireless MSS local loop applications (serving remote regions with inadequate wireline infrastructure), and heavy seasonal traffic in remote areas that are underserved by commercial cellular/wireless services (e.g., Alaska or maritime fishing traffic).

Furthermore, it is in precisely these types of market applications that Iridium's unique global service is oftentimes the communication means of last (and only) resort. Iridium's reputation as a provider of reliable, global communications is predicated on Iridium's ability to meet such challenging service scenarios, and access to adequate operating spectrum is critical to Iridium's ability to meet such challenges.

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[18] In fact, under this real-world loading scenario, there is sufficient satellite capacity remaining on each of the exterior beams outside of the loaded beam-cluster since they are, by definition, far enough removed to reuse the frequency channels that are (fully) in use in the loaded region.

Specifically addressing the parameters cited in question 6, the referenced document provides the following technical design parameters:[19]

1) FDMA channel spacing = 41.67 kHz

2) TDMA duplex timeslots/timeframe = 2 (for 4.8 kbps vocoder)

3) Frequency reuse factor (cell cluster size) = 6 and,

4) Required Doppler guard band = 37.5 kHz.

It should be noted that the referenced Doppler Guard band is not required between adjacent traffic channels. Rather, this guard band is required only at the edges of the operating band, specifically to compensate for the 7 km/sec orbital motion of the Iridium satellites. Since all traffic channels originating from the same satellite are Doppler shifted by the same amount, the Iridium system is fully capable of utilizing any/all adjacent channel frequencies – without intermediate Doppler guard bands.

Of the listed parameters, there have been no material changes to the numbers listed. However, as discussed previously, there have been modifications to certain system operational aspects of the Iridium system. The following discussion summarizes the (operational) changes in the Iridium system relative to the parameters presented in the referenced Motorola report.

<u>TDMA Timeslots per Frame</u>: As previously discussed in Iridium's comments[20] dated July 11, 2003, the Iridium system is currently operating in 2.4 kbps vocoder mode (as opposed to 4.8 kbps vocoder mode). This is achieved by assigning one TDMA

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[19] *April 1993 Report* at 46-50.

[20] Comments of Iridium Satellite, LLC, IB Docket No. 02-364 at 28 -29 (filed July 11, 2003).

timeslot per TDMA frame, per connection (vs. two TDMA timeslots per TDMA frame, per connection when operated in 4.8 kbps vocoder mode).

The Iridium system was, however, originally designed to support real-time switching between 2.4 and 4.8 kbps vocoding, as a function of satellite/system loading. In fact, the satellite hardware is fully capable of supporting this two-vocoder mode of operation today. However, Iridium understands that, after the assignment of 5.15 MHz of operating bandwidth to the Iridium system, Motorola eliminated the two TDMA timeslot, 4.8 kbps vocoding mode from the system's software design in order to preserve the scarce system bandwidth.

Unfortunately, this step (albeit necessitated by the current authorized operating bandwidth) has resulted in a reduced voice quality (as compared to the 4.8 kbps vocoder mode), and a reduced data rate for all users of Iridium's various data service offerings. As discussed in Iridium's reply comments,[21] an increase in Iridium's authorized operating band would enable Iridium to fully implement the originally intended full-rate (4.8 kbps) voice, and 2X data services, thereby putting Iridium on a more equal basis with its direct MSS competition.

Frequency Reuse Factor: As a direct result of the limited (5.15 MHz) L-band spectrum assigned to the Iridium system in its original operating license, the system's channel management process was modified from a static, table-based implementation to a more spectrally efficient, dynamic channel management process (termed SVRT). This (software) change was initiated in 1996 and was fully implemented by the date of commercial activation (November 1, 1998). As previously stated in the current filing

[21] Reply Comments of Iridium Satellite, LLC, IB Docket No. 02-364, at 7 (filed July 25, 2003).

(see response to question 4), this costly modification was incorporated to realize an enhanced spectral efficiency throughout the Iridium system.

This software modification had the indirect result of enabling the system to implement a variable sized "frequency reuse" factor during the channel assignment process. Specifically, when the system is lightly loaded, the satellites are assigned channels (frequency/timeslot pairs) that have frequency reuse factors which, in effect, result in a wider spacing between reuse beams (i.e., a larger cell cluster size), which in turn results in a lower rate of reuse – but only under light loading conditions. However, as the number of channels grows, and spectral resources become scarce, the system is able to dynamically alter the effective "reuse factor" in real time through the SVRT channel management software.

At the limits of heavy loading, the current system is fully capable of meeting the previously specified six-cell cluster size, but now the system can deliver this reuse factor to any region of the world that is experiencing a heavy, instantaneous offered load and, furthermore, is capable of doing so at any time of the day. The originally envisioned predetermined "static table-based" channel management process was incapable of altering the channel reuse factor "on-the-fly." Rather, under the originally envisioned channel management process, the number of channels assigned to any beam (at any given point in the orbit) was predicted days ahead of time (based on historical traffic loading), and resource allocation tables (containing a predefined number of channels) were uploaded to the satellite pre-defining channel allocations for an entire 24 hour period. The current SVRT dynamic channel management algorithms represent a significant improvement relative to Motorola's original (static) channel management design.

It should be noted, however, that, as the regional offered load continues to grow, the satellites ultimately reach a point where no suitably de-conflicted channels can be found, and additional calls are then denied service. This is exactly the phenomenon that occurred during the March-May, 2003 timeframe in the Middle East region. In this circumstance the offered load simply exceeded the number of de-conflicted channels available to the system; and, consequently, many hundreds of thousands of attempted calls were ultimately denied service.

Question 7: How many simultaneous satellite calls can Iridium handle for CONUS, for the Middle East, and for all the satellites?

As described in detail in Iridium's response to question 6, the number of simultaneous satellite calls Iridium can handle for CONUS (or any other geographic region) is highly dependent on the distribution of those calls. This section will describe the loading condition assumptions and the varying ability of the system to handle this traffic within the currently allocated 5.15 MHz of L-band spectrum. Clearly within the Iridium system, a maximum number of subscribers can be accommodated if the subscriber traffic load is evenly distributed throughout the geographic region. Specifically, if the load is equally distributed through-out the CONUS region, the Iridium system can support approximately 1,705 satellite calls. This number was calculated with the following assumptions. Approximately 59 satellite spot beams would support traffic within the CONUS region. This 59 beam load would be distributed across multiple satellites as each satellite provides only 48 beams. Given the analysis in the response to question 6, each beam could support approximately 28.9 calls per-beam in a uniformly distributed traffic load across the 59 beams. The 28.9 call loading figure is based upon the 4.65 MHz L-band spectrum with 1 MHz utilized for overhead functions (satellite handoff, access, etc).[22]

However, the above "uniform geographic loading," is not directly germane to Iridium's current (spectrum limited) capacity condition, which results from geographically dense regional traffic. It is this regional traffic that has grown tremendously on the Iridium system and has overwhelmed the available spectral capacity of the system.

The number of simultaneous satellite calls Iridium can handle in the Middle East, CONUS, or any other geographic region where dense, localized traffic loads exist is driven by the single load servicing satellite capacity. The loading in the Middle East is typically concentrated in several adjacent beams. The analysis in response to item 6 provided a single beam-cluster capacity of 181 calls within 5.15 MHz. As this limit is exceeded, acquisition failures, increased call drops and other performance degradation occurs. Depending upon the geographic distribution of these localized dense regions relative to the satellite pass, each satellite can potentially support multiple localized dense regions. For example, many satellite pass geometries over the Middle East have included 2 specific dense, localized traffic loads on opposite sides of the satellite. With this specific loading scenario it is estimated that the dual load-servicing satellite capacity is approximately 576 calls. Loading is based on the 362 calls (two beam-6 beam cell, localized loads) and 214 calls distributed across the remaining 36 beams. Note that this assumes that the beams outside the two dense regions are uniformly distributed. If all of

[22] This 1 MHz utilized for overhead functions is static; thus, the system is even more efficient as service spectrum is increased.

the traffic were concentrated in the dense localized regions within the overall region, then the maximum traffic loading supported with 5.15 MHz would be 362 calls. The answer, therefore, to the question as framed is a range—from 362 up to 1705 simultaneous traffic channels—depending upon the distribution of the Iridium subscribers.

Given the variability of each satellite's capacity dependent on the geographic distribution of the supported traffic, combined with the additional complexities of the satellite constellation plane geometry relative to the affected region, results in an extremely ambiguous constellation capacity figure. More significantly, the germane capacity element as previously described is the regional capacity. The regional hotspots caused by regional conflicts, rural telephony services to an under-served area, seasonal zones created by fishing fleets, and similar regional events and activities are just a few examples of this geographically dense need for Iridium services. This geographically dense service growth has placed severe demands on Iridium's spectral resources.

Question 8. How does Iridium control the volume of uplink user traffic when all, or nearly all, TDMA timeslots have been filled for a particular satellite? Was this volume control in place prior to April 7, 2003? Was this volume control in place after April 11, 2003?

Each Iridium satellite has a flow control mechanism that enables the satellite to broadcast a non-available control message to the subscriber equipment when the satellite loading level reaches a specified resource limit. Flow control capability has been present on all of the Iridium satellites since the inception of service. Unfortunately, the flow control threshold was configured at a level inconsistent with the available satellite resources when presented with the spectral demands of the highly dense regional traffic loading.

As described in detail in Iridium's response to questions 4 and 6, the satellite on-board SVRT software will attempt to identify an available channel when a call request is received. When attempting to process acquisition requests, if a channel of sufficient spectral quality cannot be found, the satellite will ignore the Acquisition Request and this denial event will be recorded by an on-board counter.

As previously reported,[23] in early April, 2003, this counter began recording many tens of thousands of acquisition denials per day--to the point where the regional traffic had significantly exceeded the spectrum available to the satellites. On April 11, the tremendous regional traffic load had so over loaded the SVRT processor that numerous satellite reboots were occurring, raising serious concerns within Iridium that satellite damage might occur if this condition persisted. Late in the day on 11 April, pursuant to special temporary authority (STA) from the FCC, Iridium began uploading an additional 1.25 MHz into the constellation and simultaneously lowered the flow control level on the satellites to prevent the severe processor over-loading that had occurred earlier that day. While the additional spectrum assisted in better handling of the presented traffic, and the refined flow control reduced the satellite reboot events, only after the introduction of a second 1.25 MHz channel on 26 April, pursuant to a subsequent STA, did the satellite access denials and satellite performance return to acceptable levels.[24] It should be noted that no other parameter was introduced on 26 April other than the additional spectrum. The flow control mechanism and level remain currently active on the satellite

[23] Letter from Peter D. Shields, Wiley, Rein & Fielding LLP to Thomas S. Tycz, FCC, at 2 (Apr. 25, 2003); May 8 *Ex Parte* Letter, Attachment, at 4.

[24] May 8 *Ex Parte* Letter at 3-4.

constellation. If additional spectrum is available to the constellation, then this flow control limit can be increased to reflect the increased resources available to support subscriber traffic.

Question 9. What are the maximum inter-satellite data rates between an Iridium satellite and its co-plane satellites and adjacent-plane satellites?

Both of Iridium's relay subsystem architectures (i.e., the crosslink and feederlink architectures) were designed to fully support a traffic loading commensurate with 10.5 MHz of L-band spectrum. Furthermore, this "10.5 MHz reference design" was not changed or modified (in any way) in response to Iridium's original operating license, which allow for a bandwidth allocation limited to 5.15 MHz. Thus, the current crosslink and feederlink architecture remains (as it always has been) fully capable of relaying the enhanced traffic capacity that would result from an augmentation in Iridium's operational band to 10.5 MHz.

In this regard, it is clear that Globalstar's speculation that "other factors such as satellite power, or satellite cross-link capacity limitations or other network limitations, rather than spectrum allocation, must be the true limiting factor(s) on Iridium capacity"[25] is simply wrong. The Iridium system Ka-Band crosslink (and feederlink) hardware provides a wealth of telemetry information that allows Iridium's engineering staff to perform real-time monitoring and long-term trending of link utilization and other performance statistics. Since commercial activation of the Iridium system in 1998, Iridium's engineers have continued to analyze the performance of the entire Ka-band network (crosslinks and feederlinks) and, contrary to Globalstar's unfounded assertions,

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[25] *See* Joint Reply Comments of L/Q Licensee, Inc., Globalstar, L.P.,and Globalstar USA, L.L.C., IB Docket No. 02-364 (July 25, 2003), Technical Appendix, Pt II.2.a.

there simply is no system capacity constraint in the Iridium system—with the one glaring exception of the limitation in available L-band spectrum/traffic channels.

Globastar's repeated attempts to "reverse engineer" the Iridium system continue to demonstrate a complete lack of understanding regarding the (remarkable) degree of engineering analysis and design present in the system. Each satellite subsystem (e.g., power, crosslink, feederlink, L-band) was designed to support a traffic loading consistent with 10.5 MHz of operational bandwidth.

In answer to the specific questions posed, the instantaneous burst bit rate for each of the four Iridium satellite Ka-band crosslinks is 12.5 Mbps. Due to the fact that these links operate in a half-duplex mode, and accounting for framing data and protocol overhead, the effective maximum achievable data rate on each of the four inter-satellite crosslinks is 5.12 Mbps for the co-plane links and 5.27 Mbps for the adjacent-plane links.

Iridium understands that Motorola extensively evaluated the crosslink network under the condition of a system loading consistent with 10.5 MHz of operating band, and assuming the above Ka-band crosslink capacity numbers, and concluded that this cross link capacity was, in fact, "over-engineered," and provided a generous margin against worst case system loading conditions. The current crosslink design remains unchanged with respect to the reference Ka-band design employed by Motorola in these earlier analyses.

Question 10. What percentage of time are intersatellite links available for adjacent-plane satellites?

The Iridium crosslink architecture is designed to ensure that each of the sixty six in-service satellites[26] is always in active contact with each and every ground element.[27] While the cross-plane (i.e., adjacent plane) crosslinks are not utilized at the northern and southern extremes of the orbit, the satellites remain fully connected by virtue of their in-plane crosslinks. Furthermore, the entire crosslink network operates as a packetized network, which allows for instantaneous route changes in response to changes in the currently active crosslinks, regardless of where in the network the connectivity change occurs. Thus, the route from any satellite to the any ground site is adapted throughout its 100-minute orbit in such a way as to ensure continuous contact with each and every ground element – regardless of the underlying crosslink connectivity.

The response to the specific questions posed is as follows. Individual adjacent-plane Ka-band crosslinks on the 44 active Iridium satellites in the non-seam planes (i.e., planes 2 through 5) are active for approximately 53.8 minutes per orbit, or approximately 53.6% of the time. Individual adjacent-plane Ka-band crosslinks on the 22 active Iridium satellites in the counter rotating seam planes (i.e., planes 1 and 6) are only active for half of that amount of time,[28] or approximately 26.9 minutes per orbit, or approximately 26.8%

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[26] It should be noted that, in addition to a full complement of operational (in-service) satellites, Iridium currently has 13 on-orbit spares, fully capable of being brought into active service, if/when needed. Since these on-orbit spare do not carry traffic they are not a part of the active crosslink network (they are, however, monitored by numerous feederlink contacts per day).

[27] These ground elements include both Gateways and Tracking, Telemetry and Control (TT&C) stations.

[28] The inter-satellite crosslinks can not operate "across the seam" (i.e., between planes 1 and 6) due to the extremely fast relative velocities involved. Note, these "cross-seam" satellites are traveling in opposing directions resulting in a relative velocity of nearly 14 km/sec. However, the artifacts associated with this seam were fully incorporated into all of the capacity analyses performed on the system.

of the time. Furthermore, each and every in-service Iridium satellite is always fully connected to the crosslink/feederlink relay network through its in-plane crosslinks. During the system design phase these percentages were carefully evaluated to ensure that traffic on the cross links, both in-plane or cross-plane, would not become congested even during worst case peak loading conditions.

It should again be emphasized that the crosslink network is currently being operated in a manner exactly consistent with the original Motorola capacity analyses. Accordingly, the current network connectivity and capacity is fully capable of supporting an offered traffic load consistent with 10.5 MHz of L-band spectrum.

Question 11. What are the maximum satellite-to-gateway earth station data rates in both the uplink and downlink directions from a single satellite?

The Iridium satellite-to-gateway Ka-band maximum burst data rates are 3.125 Mbps in both directions (uplink and downlink). Accounting for framing and protocol overhead constraints, the effective maximum achievable data rate is 2.75 Mbps. This rate could be simultaneously supported on each of the satellite's four feeder link antennae to up to four separate gateways if required due to geographic proximity of individual gateway sites.

Question 12. How many operational antennas are at the Tempe and Hawaii gateways?

There are three operational antennas at the Hawaii gateway. There are also three operational antennas at the Tempe, Arizona gateway. In addition, there are two operational antennas at the auxiliary Iridium facility in Chandler, Arizona. This auxiliary facility provides a full range of Iridium service capabilities and is currently used for system test and to provide call support if required. There are four operationally ready antennas at the Fucino, Italy, Iridium gateway facility.

Question 13. How many active gateways does Iridium have? That is, are the gateways in Tempe AZ and Hawaii gateways the only active gateways?

In addition to the Tempe and Hawaii gateways, the Fucino, Italy gateway has been fully restored to commercial service configuration and capability and is a ready backup facility to ensure continuity of service or accommodate traffic overflow from another gateway if necessary. In addition, there are plans to reactivate the gateways in Russia, China and India.

Question 14. How many simultaneous calls can each of the gateways handle?

The call-handling capacity of each gateway is a strong function of the type of traffic supported. Calls handled by the Iridium system that either originate or terminate within the Public Switched Telephone Network (PSTN) consume the greatest gateway capacity, while the lesser overhead associated with handling calls between individual Iridium Subscriber Units (ISU) consumes the least gateway capacity. Depending on the mix of traffic on a given gateway, a single Iridium satellite-to-gateway Ka-band link can support a maximum of up to approximately 10,000 simultaneous calls. In addition, Iridium could potentially assign two satellite feeder link antennae to a single gateway site, thereby doubling the capacity supporting up to approximately 20,000 simultaneous calls per gateway site. As described in the response to question 13, while Iridium plans to utilize additional gateways as necessary to accommodate increasing aggregate traffic demands, it is the geographically dense, regional traffic that creates the most stress on the Iridium system capacity. While these regional demands do not overwhelm an individual Iridium gateway's capacity, as described in the response to question 6, they are presently overwhelming the spectral resources available to the Iridium satellites.