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Ms. Magalie Roman Salas
Secretary
Federal Communications Commission
445 Twelfth Street, SW
Washington, DC 20554

RE: IB Docket No. 99-67 **EX PARTE PRESENTATION**

Dear Ms. Salas:

This letter is submitted on behalf of L/Q Licensee, Inc., Globalstar, L.P., and Globalstar USA, Inc. (formerly known as AirTouch Satellite Services U.S., Inc.) (collectively, "Globalstar"). On July 21, 1999, Globalstar filed reply comments in the above-referenced docket, which included a critique of the comments previously submitted by LSC, Inc.

In an ex parte filing dated July 31, 1999, LSC, Inc., submitted a "rebuttal" to Globalstar's critique, which attempts to find fault with Globalstar's technical rationale supporting the out-of-band emissions limits proposed by the Commission for Mobile-Satellite Service ("MSS") systems operating in the 1610-1626.5 MHz band. LSC, Inc., claims that there were major factual errors in Globalstar's Technical Appendix attached to the "Joint Reply Comments," and that adoption of the proposed out-of-band emission limits could threaten service to receivers operating with the Global Positioning System ("GPS").

In response to LSC, Inc., Globalstar hereby submits a critique of LSC, Inc.'s rebuttal. As demonstrated in the attached Technical Statement, LSC, Inc.'s rebuttal fails to contradict the positions taken by Globalstar in the "Joint Reply Comments." Indeed, none of LSC, Inc.'s rebuttal points provides any basis for rejection or modification of the out-of-band emissions limits proposed in the Notice of Proposed Rulemaking for MSS systems operating in the 1610-1626.5 MHz band. As Globalstar has demonstrated in this proceeding, the proposed out-of-band

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emissions limits provide more than adequate protection for GPS receivers in the operational environments discussed by LSC, Inc.

Pursuant to Section 1.1206(b)(1) of the Commission's Rules, two copies of this letter with the enclosure are submitted for the record of the proceeding identified above. Please direct any inquiries regarding this matter to the undersigned.

Respectfully submitted,

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Enclosure

Technical Statement

In Reply to LSC, Inc., Ex Parte Dated July 31, 1999

IB Docket No. 99-67

In an ex parte filing dated July 31, 1999, LSC, Inc., submitted a "rebuttal" to the Reply Comments of L/Q Licensee, Inc., Globalstar, L.P., and Globalstar USA, Inc. (formerly known as AirTouch Satellite Services U.S., Inc.) (collectively, "Globalstar"), filed on July 21, 1999. The LSC rebuttal is narrowly focused on one aspect of the Globalstar Reply Comments filed on July 21, 1999 – Globalstar's support for the proposed emissions limits and our discussion of earlier comments filed by LSC. LSC claimed that there were major factual errors in Globalstar's Technical Appendix as filed with the Federal Communications Commission in the above-referenced docket. However, as discussed below, none of LSC's seven points supports such an allegation. Moreover, none of LSC's points provides any basis for rejection or modification of the out-of-band emissions limits proposed in the NPRM for Mobile-Satellite Service ("MSS") systems operating in the 1610-1626.5 MHz band.

I. Reliability of GPS in a ground mobile environment

LSC states that "GPS works quite well in the ground mobile environment, as evidenced by millions of current users," and argues that Globalstar's interpretation of RF propagation data from LSC's web site is inappropriate.

Response: In the Technical Appendix to the Globalstar Reply Comments, Globalstar explained that the "continuous availability [of GPS signals] at a given receiver is ***not*** guaranteed by any policy statement of the US, and indeed such continuous availability is impossible to achieve in practice. GPS receivers fail completely inside tunnels, parking garages, buildings, and even certain outdoor settings such as deep canyons or city streets with high buildings, or even a city street wherein the GPS user is surrounded by high trucks with metal sides."[1]

These are true statements despite LSC's protestations to the contrary. And while millions of recreational and non-safety related users may find GPS useful with its known operational constraints, this ***is not*** a scientific or rigorous statement about GPS availability in a ground mobile environment. Indeed, Globalstar's point is that the statistical availability of GPS in a ground mobile environment is quite

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[1] Globalstar, Reply Comments, Technical Appendix, ¶ 1.1.

low compared to that achieved in civil aviation. However, the ground mobile user community has found means to mitigate the outages or live with them.[2]

In its Reply Comments, Globalstar made the point that protection limits for GPS should be based on a rational assessment of operational need and realistic system designs, i.e., following the analytic model employed in RTCA/SC-159. While this process may be hampered at this time by a lack of documentary requirements for ground-based uses, it seems clear that mobile user terminals associated with GMPCS systems will have no measurable impact on GPS operational availability in a ground mobile environment, at the emissions levels currently proposed by the Commission, and hence no further reduction in emissions limits is warranted for the ground mobile environment.

LSC also complained that it was inappropriate to use RF propagation data from its web site. But, contrary to LSC's assertion, its web site ***does*** specifically reference foliage attenuation for GPS. The web address is:

http://ourworld.compuserve.com/homepages/loganscott/spreadsheets.htm#GPS

This site contains a spreadsheet, VG_GPS_FOLIAGE.xls, plotting signal attenuation as a function of elevation angle, forest height and horizontal distance from forest. And while the diversity and multipath data on the LSC web site were generated for cellular systems rather than GPS, RF propagation characteristics are primarily influenced by the RF frequency and propagation path, and not, in general, by the service application. GPS operates at 1575 MHz whereas the diversity and multipath data from the LSC web site was baselined at 1900 MHz. So the LSC data applies fairly well to both low angle-of-arrival GPS signals and terrestrial cellular signals.

In any event, Globalstar's comments were not premised simply on LSC's RF propagation model, but rather, on the real-world environment in which GPS receivers must operate in terrestrial applications.

II. <u>Phase lock capability for multiplex GPS receivers</u>

LSC claims that GPS multiplex receivers have the ability to maintain phase lock, contrary to a comment by Globalstar.

Response. This is a complicated issue that involves a number of considerations besides simple theoretical feasibility. LSC is correct that at least two U.S. patents describe means to maintain phase lock in a multiplexed architecture. This

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[2] For example, in-car navigation systems typically rely on various means of dead-reckoning and map matching in order to mitigate signal outages.

technology has been implemented in a limited number of receivers.[3] Historically, however, the vast majority of receivers which might be termed "multiplexing receivers," i.e., since they shared a limited number of receiver channels across a larger number of satellites, did not use this technology. The technology referenced by LSC may be termed a "fast multiplex," whereas the more common technology was an even lower-performance concept termed "slow multiplex" or "sequencing." The "slow multiplex" or "sequencing" receiver did not maintain phase lock from one measurement cycle to the next, but it had the virtue of less complexity in other aspects of the receiver design, and lower cost. These receivers achieved adequate performance for many consumer applications and were produced in large numbers.

It should be noted that the multiplex technologies, both slow and fast, are essentially obsolete at the present time. A limited number of extremely low-cost products may remain on the market (e.g., at least one product by Garmin), but virtually all receivers currently available rely on semiconductor devices which provide 6 or even 12 channels on a single chip.[4]

The GPS industry has developed a wide range of receiver designs with a wide range of performance constraints and capabilities, including many single-channel and two-channel receivers which navigated acceptably without retaining phase from one measurement cycle to the next. Therefore, Globalstar's original point remains valid. Furthermore, given the SNR performance degradation due to the signal power division of multiplex receivers, they would appear to be inappropriate for safety-of-life applications. This is especially true given the pace of industry development. The GMPCS industry should not be penalized for a lower performing GPS receiver design.

III. Space Vehicle signal strength at zenith

Globalstar noted, in its original Reply Comments, that as a space vehicle ("SV") moves higher in the sky, received signal strength increases (4 dB at zenith).[5] LSC notes that GPS signal strength actually decreases at zenith.

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[3] The TI4100, for example, used a fast multiplex architecture, a very stable oscillator (~ 10^{-11}), and very rapid and precise restoral techniques to maintain phase tracking in a sampled-data sense from one measurement cycle to the next. This increased the cost of other elements of the receiver and also led to the SNR performance penalty noted by LSC.

[4] Single-channel units may also be used effectively for time transfer, but these will be ignored as we are concerned with receivers designed for navigation.

[5] Globalstar, Reply Comments, Technical Appendix, ¶ 2.1.

Response. LSC is technically correct in terms of the "slope of the curve" at zenith, although there are other factors LSC has not considered and our original point is still valid from a practical standpoint. The minimum GPS signal strength near the Earth's surface is -160 dBW, and the GPS space segment accounts for all necessary factors to achieve this minimum level at elevation angles greater than 5 degrees. ICD-GPS-200C indicates a 2 dB variation in received signal strength as a function of SV elevation angle, with signal strength minima of -160 dBW at 5 degrees and zenith, and a peak signal strength of -158 dBW at 40 degrees elevation.

However, this is based on a constant 2 dB atmospheric loss which is not realistic over the range of elevation angles assessed (i.e., between 5 and 90 degrees).[6] The atmospheric loss term accounts for gaseous absorption (troposphere), ionospheric absorption and low-angle fading. These loss terms are negligible at zenith, but in aggregate can amount to 1.5 to 2 dB loss at low elevation angles (hence the 2 dB consideration given in ICD-GPS-200C). When this additional variability is considered, the actual range of variation is 3.5 to 4 dB with a peak at 40 degrees elevation (rather than zenith). The signal strength at zenith may be expected to lie midway between the extremes.

Other factors affecting received signal strength include the variation in antenna gain of the receiving antenna (which typically experiences a 5-7 dB enhancement at zenith) and the transmit margin of the GPS SVs themselves. None of these factors require a modification to the basic point in the Globalstar Technical Appendix: ***Typical signal levels at the GPS receiver processor may be 5-10 dB higher than LSC's minimum worst-case.***

IV. Likelihood of a 30 degree roll angle for a GPS receiver, and functionality inside closed vehicles

LSC notes that some GPS receivers are "mounted" by "throwing them on the dashboard", and also claims that GPS receivers work quite well inside most vehicles with no special provisions.

Response. The roof of a typical automobile or safety vehicle (ambulance, fire truck, police car, etc.) introduces significant shadowing and blockage to signals at L-band. The problem is exacerbated in an urban environment where line of sight may be significantly obscured by buildings and other vehicles. A receiver "thrown on the dash" may be effectively limited to only a small portion of the sky, considering blockage by the vehicle structure as well as its own antenna gain profile (e.g., an antenna on its side might effectively eliminate half of the sky to the right or left of

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[6] There is also a loss term for satellite attitude error, which we will not address in this response.

vehicle centerline). This has significant implications for service availability. While a GPS receiver "thrown on the dash" may work to a limited degree, perhaps even "quite well" for normal recreational use, its performance cannot be guaranteed. Consider the design of a reasonably high-performance in-car navigation system available as optional equipment on some new cars today. In order to achieve consumer acceptability, the in-car navigation system involves a well-engineered receiver with an antenna correctly mounted on the roof or trunk, and also includes dead-reckoning and map matching features to mitigate the inevitable signal outages (which can persist for many seconds). This is for consumer use in a non-safety application. We may expect that a system engineered for a safety application would involve these features as a minimum.

LSC's protestations point to a basic flaw in its analysis. On the one hand, it argues that terrestrial receivers are entitled to extremely high levels of protection from unwanted emissions, which can only be justified on the presumed basis of extremely high levels of required service and signal availability. On the other hand, it expects such levels of protection to be provided even when equipment is "installed" in partially blocked environments. Any protection level for unwanted emissions for terrestrial receivers must be based on a realistic model of the environment in which reception is required and an analysis of the rationale for a certain level of signal reliability, neither of which has been specified by LSC.

V. Receiver processing and Dilution of Precision

LSC states that, "[g]iven [signal] track[ing], the availability of signals with large angular separations is a much more significant factor [than signal strength] in determining navigation accuracy."

Response. The LSC rebuttal does not contradict Globalstar's position. Globalstar stated: "When there are more than four SVs under track, ... the Kalman filter ... tends to emphasize the strongest and most stable signals and de-emphasize the weakest and least stable signals." This is true. As the number of satellites under track increases, overall geometry typically improves and the contribution of any single satellite, particularly a satellite low on the horizon, is typically diminished. The Kalman filter is then better able to balance the measurements based on signal strength (or equivalently, the measurement noise), and possibly other measures of expected error,[7] so as to minimize overall navigation error. With 6-8 satellites in view, there is likely to be good geometry with satellites high in the sky (e.g.,

[7] These might include, for example, the expected variance of residual ionospheric error and the expected variance of multipath error, both of which are accentuated at low elevation angles.

elevation angle greater than 10 degrees). In this case, a single satellite at 5 degrees would not be expected to significantly improve the geometry, and might be received with 10 dB lower power than other satellites in view. The Kalman filter would then effectively de-emphasize the weak and unstable signal (as it should). This would not happen in every case, but it would occur in the majority of cases. Hence, the use of the word "tends" in our original comments.

VI. Possible receiver improvements noted by Johns Hopkins APL

LSC dismisses Globalstar's comments about the findings in the Johns Hopkins Applied Physics Laboratory report[8] by stating that most of the techniques for improving GPS receivers discussed therein involve "several thousands of dollars and several pounds of weight."

Response. It only takes one good low-cost solution to solve the problem. Referring to Table 5-2 of the Hopkins report, we note two solutions for under US$100, each potentially offering 40 dB or more of improvement. Two other candidates were listed without cost estimates. One of these – direct measurement processing – may have been a reference to the extremely low-cost, near-real time approach being commercialized by SnapTrak. There are other solutions which were not included in the Hopkins report. For example, vector tracking of all signals in view instead of scalar tracking of each individual signal. This is expected to be extremely low cost since it is merely a different way of processing the measurements (the performance gain is expected to be on the order of 5-10 dB).

We reiterate our original position – GPS and GNSS receivers ***are not*** all the same,[9] technology ***does*** matter, and there are numerous technologies reaching maturity which may dramatically enhance the overall robustness of GPS receivers intended for safety-critical applications, and do it at extremely low cost.

VII. LSC's example "safety of life" applications

LSC disagrees with Globalstar's statement that the terrestrial GPS uses set forth in LSC's original comments generally do not implicate "safety of life" concerns.

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[8] GPS Risk Assessment Study, The Johns Hopkins University Applied Physics Laboratory, VS-99-007, January 1999.

[9] The U.S. GPS Industry Council measured essentially a 10 dB variation between receivers, with the consumer and in-car receivers demonstrating the greatest robustness.

Response. We stand by our original comments. LSC has not provided any information to support the claim that a more critical application than aeronautical approach and landing exists, or that human safety in terrestrial uses is in any way threatened by the Commission's proposed limits. On the contrary, the LSC comments fail to provide any documented requirements, or even a detailed engineering discussion of hypothesized applications and threat scenarios, sufficient to demonstrate a reasonable threat to ground mobile uses. LSC's postulated threat scenarios are unrealistic, and cannot form the basis for any deviation from the NPRM proposals.

Engineering Certification

I hereby certify that I am the technically qualified person responsible for preparation of the foregoing "Technical Statement in Reply to LSC, Inc., Ex Parte Dated July 31, 1999" (IB Docket No. 99-67); that I am familiar with Part 25 of the Commission's Rules and the rules and policies proposed for Global Mobile Personal Communications by Satellite in the Notice of Proposed Rulemaking, FCC 99-37 (released March 5, 1999); that I have prepared the information contained in the Technical Statement; and that it is complete and accurate to the best of my knowledge and belief.

Signed this 11th day of September ___, 1999.