BEFORE THE
Federal Communications Commission
WASHINGTON, DC 20554

In the Matter of

LightSquared Subsidiary LLC IB Docket No. 11-109

Technical Working Group Report

In re the Application of

LightSquared Subsidiary LLC File No. SAT-MOD-20101118-00239

Request for Modification of its Authority for an Ancillary Terrestrial Component

To: The Commission

COMMENTS OF LOCKHEED MARTIN CORPORATION

LOCKHEED MARTIN CORPORATION

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SUMMARY


As Lockheed Martin explains below, the TWG Report confirms that LightSquared cannot operate a terrestrial mobile broadband service in the 1525-1559 MHz and 1626.5-1660.5 MHz mobile-satellite service (“MSS”) and MSS ancillary terrestrial component (“ATC”) bands without causing harmful interference to receivers and devices operating with the Global Positioning System (“GPS”) and other radionavigation-satellite service (“RNSS”) systems – including the FCC-licensed Lockheed Martin Regional Positioning System (“RPS”) – in the 1559-1610 MHz RNSS band. The TWG Report also confirms that no mechanism exists that would enable LightSquared to mitigate the harmful interference revealed by the testing program. Because LightSquared’s Recommendation and LightSquared’s three-pronged proposal for partial use of the MSS/ATC downlink band for terrestrial mobile broadband service are not supported by the TWG data or the conclusions reached by all TWG participants other than LightSquared and its affiliates, the Commission must reject the Recommendation and rescind the conditional waiver in LightSquared.
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LightSquared Subsidiary LLC

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Request for Modification of its Authority for an Ancillary Terrestrial Component

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COMMENTS OF LOCKHEED MARTIN CORPORATION


1 Public Notice, Comment Deadlines Established Regarding the LightSquared Technical Working Group Report, IB Docket No. 11-109, DA 11-1133 (released June 30, 2011) (“TWG Public Notice”). Lockheed Martin urges the Commission to confirm that all filings in IB Docket No. 11-109 will be included in the record of the application and application for review proceedings in File No. SAT-MOD-20101118-00239.


As Lockheed Martin explains below, the results of the detailed studies presented in the TWG Report are compelling. The TWG Report confirms that LightSquared cannot operate a terrestrial mobile broadband service in the 1525-1559 MHz and 1626.5-1660.5 MHz mobile-satellite service ("MSS") and MSS ancillary terrestrial component ("ATC") bands without causing harmful interference to receivers and devices operating with the Global Positioning System ("GPS") and other radionavigation-satellite service ("RNSS") systems – including the Lockheed Martin Regional Positioning System ("RPS") – in the 1559-1610 MHz RNSS band. The TWG Report also shows that all participants on the TWG other than LightSquared and its affiliates agree that no mechanism exists that would enable LightSquared to mitigate the harmful interference revealed by the testing program. Because neither LightSquared’s Recommendation nor its three-pronged proposal for partial use of the MSS/ATC downlink band for terrestrial mobile broadband service are supported by the TWG data or the conclusions reached by all TWG participants other than LightSquared and its affiliates, the Commission must reject the LightSquared Recommendation and rescind the conditional waiver in LightSquared.

1. INTRODUCTION.

Lockheed Martin is engaged in the research, design, development, manufacture and integration of advanced technology systems, products and services across a broad range of areas for both commercial and government customers. Lockheed Martin is the only Commission licensee of space stations operating in the 1559-1610 MHz (or “L1”) RNSS band. The two Lockheed Martin RPS satellites and their associated earth stations provide a service integral to the Federal Aviation Administration’s (“FAA”) overall Wide Area Augmentation System (“WAAS”). The WAAS provides augmentation of GPS signals throughout the entire National

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4  Lockheed Martin operates geostationary RNSS space stations using the 1559-1610 MHz and 1164-1215 MHz RNSS bands. See FCC Call Signs S2371 and S2372. The RPS satellites – one at 107.3° W.L. and the other at the nominal 133° W.L. orbital location – were launched in 2005, and are the only FCC-licensed RNSS spacecraft.
Airspace System (“NAS”) to improve the accuracy, availability, and integrity of the GPS space-based positioning, navigation, and timing (“PNT”) service.

Since March 2011, Lockheed Martin has worked as a member of the TWG to address harmful interference issues to GPS receivers and GPS-dependent systems and applications from LightSquared’s proposed non-integrated terrestrial network in portions of the 1525-1559 MHz band. With Lockheed Martin’s support and approval, the TWG Report concludes that LightSquared’s proposed terrestrial mobile broadband operations will cause harmful interference to GPS receivers and applications. This conclusion is unanimous for all GPS receiver types tested for terrestrial operations in the “upper 10 MHz” of the 1525-1559 MHz band, and thus, requires the Commission to conclude that terrestrial operations in that portion of the band should not be allowed.\(^5\) This includes combined upper channel and lower channel operations of the type proposed for testing in LightSquared’s three-phase deployment plan.\(^6\)

Late in the TWG testing process, LightSquared introduced the potential for terrestrial mobile broadband operations using only the “lower 10 MHz” of the 1525-1559 MHz band as a potential way to mitigate and resolve the harmful interference that LightSquared’s planned deployment in the “upper 10 MHz” would cause GPS receivers. Given the timing of the proposal, the TWG studies and testing in the “lower 10 MHz” of terrestrial mobile broadband operations were much more limited. Nevertheless, those TWG results showed that there would be harmful interference into a significant number of GPS receivers across many device types and

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\(^5\) See e.g., TWG Report at 15 (Aviation Sub-Team reports that LightSquared’s proposed deployment of a terrestrial mobile broadband system into the mobile-satellite service band at 1525-1559 MHz would cause the “complete loss of GPS operations” for airborne receivers).

\(^6\) Id. at Appendix O.1.
deployment scenarios, and no TWG sub-team was able to conclude that operation only on the lower 10 MHz would not cause harmful interference to GPS devices.\(^7\)

Neither LightSquared’s Recommendation nor in particular, its three-pronged proposed solution are supported by the TWG Report. As Lockheed Martin demonstrates below, i) LightSquared’s proposal to reduce output power is not meaningful, as the TWG tested LightSquared transmissions at the 32 dBW EIRP/sector level now being proffered in the Recommendation;\(^8\) ii) the idea of a standstill has no basis in the record to create any expectation that LightSquared can protect GPS receivers while operating on the upper 10 MHz channel of the 1525-1559 MHz band; moreover, the idea that GPS receivers do not today use “appropriate filtering” is just inaccurate;\(^9\) and, iii) each TWG sub-team (or in some cases all sub-team participants other than LightSquared and its affiliates) concluded that a “lower 10 MHz-only” LightSquared operation either would cause harmful interference to GPS or require additional testing.\(^{10}\)

The Commission, through proper procedures, should reject LightSquared’s Recommendation, rescind the conditional waiver, and otherwise ensure that the conclusions reached from the work of the TWG and further studies/tests be codified in its rules governing ATC use in the L-band.

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\(^7\) It is noted that there is potential for interference to non-GPS services from LightSquared’s use of the lower 10 MHz that were not in the scope of work of the TWG.

\(^8\) See infra, at Section 3.A.

\(^9\) See infra, at Section 3.B.

\(^{10}\) See infra, at Section 3.C.
2. THE TWG REPORT CONFIRMS THAT LIGHTSQARED’S PROPOSED TERRESTRIAL BROADBAND SERVICE IN THE 1525-1559 MHz BAND WOULD CAUSE HARMFUL INTERFERENCE TO RPS.

A. LM RPS System.

The LM RPS System is an integral part of the WAAS developed by the FAA to augment the GPS, in order to improve the accuracy, integrity, and availability of space-based radio-navigation for enhanced safety of flight throughout the NAS. WAAS uses a network of ground-based reference stations to measure small variations in the GPS satellites' signals. Measurements from the reference stations are then routed to master stations, which generate and send the WAAS signal to the RPS satellites that broadcast messages to WAAS-enabled GPS receivers on end-user aircraft that improves the GPS service performance, which is required for the use of GPS throughout the NAS providing increased data accuracy.

As the service Lockheed Martin provides over the RPS satellites incorporates the GPS signals in the 1559-1610 MHz band, disruption of the GPS L1 signal has the potential to cause harmful interference to the RPS system. The RPS satellites broadcast a WAAS signal in the 1559-1610 MHz band that is used by GPS aviation receivers and specially-enabled WAAS receivers on aircraft for use in air navigation and air traffic control. The earth stations that uplink the signal to the RPS satellites each include a very sensitive GPS/WAAS receiver with a much higher gain antenna than is found in the typical GPS receiver. As such, these receivers are very sensitive to interference. If signal reception is disrupted, these antennas are unable to perform a safety critical function to uplink the proper signal for broadcast from the WAAS RPS satellites on the L1 signals. Interference to this L1 signal on Lockheed Martin’s RPS satellites would cause the feedback control loop – utilized in the ground station, which very closely controls the uplink signal – to produce erroneous data. This erroneous data would then be operated upon by the feedback control loop and result in an incorrect uplink signal that would be broadcast from
the Lockheed Martin RPS satellite. This erroneous RPS broadcast would not be able to be immediately detected by Lockheed Martin, by the FAA’s WAAS monitor, or by the end-user aircraft, and would thus likely result in the introduction of a substantial safety hazard to a significant portion of the, and potentially the entire, National Airspace System. Once the interference situation is detected, the uplink transmission to the satellite would be terminated immediately, and unless a backup ground station were available, the broadcast transmissions that are required to enable use of GPS in the National Airspace System would also cease.

This means that any interference to the reception and use by aircraft in flight of the signals broadcast by the Lockheed Martin RPS satellites significantly reduces the efficiency of the National Airspace System and quite possibly endangers safety of life and property.

B. **TWG Report Conclusions.**

The TWG Report represents the culmination of a significant undertaking by all TWG participants. The leadership of the TWG and the entities participating in the seven TWG sub-teams organized and executed a comprehensive set of studies in a very short amount of time. The TWG Report confirms that LightSquared’s proposed deployment plan would result in harmful interference to GPS receivers and GPS-dependent applications in all deployment scenarios. RPS receivers were tested in the Aviation Sub-team and are also addressed in the High Precision Sub-team section of the report, since like high-precision GPS receivers, the RPS receivers are wide-band compared to other types of GPS receivers. The details of the testing methodology, criteria and results are contained in Section 3 of the TWG Report and are not repeated here.

The Aviation Sub-team specifically tested the Novatel G-II WAAS Ground Reference Station operated by Lockheed Martin for the RPS system. These receivers are provided by the FAA to Lockheed Martin and are specifically designed for use in the FAA’s WAAS. The RPS
receivers were tested in the same manner as other aviation receivers. It is important to note that the WAAS receivers require a higher level of signal fidelity and a higher carrier-to-noise (‘‘C/N0’’) ratio, compared to other GPS receivers, to perform their unique function of generating the RPS signal. Degradation in the signal fidelity and C/N0 ratio results in inferior performance, which in turn degrades the ability of the RPS satellite service to perform its ranging function and decreases the availability of GPS as a means of air navigation throughout the National Airspace System.

The Aviation Sub-team concluded that all three phases of LightSquared’s currently proposed deployment plan in the upper 10 MHz of spectrum are incompatible with all aviation GPS receivers and would result in a complete loss of GPS operations below 2000 feet above ground level (AGL) over a large radius from the metro deployment center. In other words, if LightSquared were permitted to commence terrestrial broadband operations, GPS-based operations would become unavailable over entire regions of the country at any normal operational aircraft altitude. This would result in an endangerment to safety of life and property and significantly reduce the efficiency of the National Airspace System, and therefore cannot be allowed.

The Aviation Sub-team considered potential mitigation techniques, e.g., GPS selectivity filtering, and limitation of LightSquared operations to the lower 10 MHz of the 1525-1559 MHz band with a maximum EIRP of 32 dBW, to determine if LightSquared’s terrestrial service could coexist with existing and currently proposed aviation GPS operations. The sub-team’s conclusion was that current mitigation techniques were not practicable or sufficient to resolve interference from LightSquared terrestrial mobile operations in the top 10 MHz of spectrum.

With regard to filtering, the Aviation Sub-team noted that the required technology was not even yet available in prototype, and certainly was not produced for testing either by the TWG or by RTCA, Inc. ("RTCA").\textsuperscript{12} The Aviation Sub-team also noted that the described filter would supply some of the rejection of the LightSquared terrestrial signal that is required, but not all, and would require more input power than is currently provided by fielded GPS receivers.\textsuperscript{13}

With respect to the potential limitation of LightSquared’s terrestrial mobile operation to the “lower 10 MHz” of the 1525-1559 MHz band as a way to mitigate and resolve the harmful interference that LightSquared’s planned deployment would cause, the TWG results showed that there would be harmful interference into a significant number of GPS receivers across many device types and deployment scenarios (including into high precision GPS receivers of the type Lockheed Martin uses at its WAAS reference stations).\textsuperscript{14} In the case of GPS receivers used in aviation, the TWG’s Aviation Sub-team concluded that a compatibility finding for terrestrial mobile broadband operations using the lower 10 MHz of the 1525-1559 MHz band and GPS receivers used in aviation could not be made without further testing.\textsuperscript{15} This is especially true for the RNSS receivers used in the RPS system, given the significant interference from terrestrial

\begin{footnotes}
\item[12] TWG Report at 53. RTCA is a private, not-for-profit corporation that develops consensus-based recommendations regarding communications, navigation, surveillance, and air traffic management (CNS/ATM) system issues.
\item[13] TWG Report at 53. The Aviation Sub-team recited additional facts that required a determination that filtering is not a viable mitigation technique for aviation receivers. \textit{Id}.
\item[14] See, e.g., TWG Report at 293 (High Precision, Timing, and Network Sub-teams’ participants recognize that LightSquared transmitter operation at 32 dBW EIRP on the lower 10 MHz channel would harmfully interfere with GPS receivers). To the extent that there was not unanimity in the sub-teams’ report on this issue, disagreement was over the extent to which future receivers could be modified to protect themselves from the harmful interference. \textit{Id}.
\item[15] TWG Report at 51. The testing that the Aviation Sub-team relied upon was performed by RTCA, Inc.’s Special Committee 159 on the Global Positioning System, and is included in “Assessment of the LightSquared Ancillary Terrestrial Component Radio Frequency Interference Impact on GNSS L1 Band Airborne Receiver Operations.” DO-327, released by RTCA on June 3, 2011. The potential for further testing of the lower 10 MHz option stems from a potential negative margin for acquisition of satellite signals caused by a LightSquared transmitter operating on the lower 10 MHz-only channel.
\end{footnotes}
operation in this band to precision GPS receivers and the receiver front-end architecture of the RPS and precision GPS receivers.

The most promising mitigation technique identified was for LightSquared to use spectrum outside of L-band, e.g. S-band, for terrestrial operations. The Aviation Sub-team said that this relocation away from the 1525-1559 MHz band “could eliminate all interference effects” with aviation GPS receivers.

As a final matter, Lockheed Martin notes that the TWG Report reached conclusions that are consistent with contemporaneous studies from the National Space-Based Positioning, Navigation, and Timing Systems Engineering Forum (“NPEF”) and RTCA. The NPEF Report, “Assessment of LightSquared Terrestrial Broadband System Effects on GPS Receivers and GPS-Dependent Applications” (“NPEF Report”), was adopted on June 1, 2011, and a public version of the NPEF report was submitted into the record of the instant proceedings on July 6, 2011.

The TWG’s Aviation Sub-team used the data generated in RTCA’s study (see note 15 above) of the impact of LightSquared’s proposed mobile broadband transmissions on GPS receivers used in aviation (including ground-based GPS receivers associated with the WAAS) as the basis for the Aviation Sub-team’s report in the TWG Report.

As the NPEF Report is included in the record, Lockheed Martin notes that it shares a concern the NPEF Report raises on the potential increase in interference to Aeronautical Mobile Telemetry (“AMT”) flight test operations in the band directly below 1525 MHz that would result

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16 See, e.g., TWG Report at 26 (“NASA notes that one mitigation technique that would resolve interference to both space-based and terrestrial high precision GPS receivers is to relocated high power terrestrial operations to a different frequency band”), id. at 19 (GPS participants on General Location/Navigation Sub-team state that “[t]he only option for coexistence with GPS is for LightSquared to move to another frequency band”).

17 Id. at 52.

from LightSquared terrestrial mobile broadband operations in the 1525-1559 MHz band – particularly in the lower 10 MHz of that band (i.e., adjacent to the AMT band). As others in the aerospace industry sector, Lockheed Martin relies heavily on the L-band AMT spectrum for its development and testing of aeronautical equipment.

3. THE COMMISSION MUST REJECT THE “SOLUTION” LIGHTSQUARED OFFERS IN ITS RECOMMENDATION.

As described below, the recommendations by LightSquared individually or taken as a whole do not resolve the interference issues outlined in the TWG Report.

A. LightSquared’s Proposal to Operate at Lower Power than the FCC Authorization Lacks Value.

LightSquared’s recommendation to operate at a maximum power level of 32 dBW is neither new or a concession on LightSquared’s part. Although this maximum EIRP level is lower than the 42 dBW maximum EIRP level the FCC authorized in March 2010, a maximum EIRP level of 32 dBW was used by the TWG sub-teams in their analyses and testing of interference from LightSquared’s proposed terrestrial mobile broadband transmitters to GPS receivers, and as such should have been the level that LightSquared was seeking to operate its terrestrial service. As indicated above, the TWG Report clearly shows that there will be harmful interference to GPS receivers and applications if terrestrial operations are allowed at the 32 dBW EIRP level. Terrestrial mobile broadband operations at the level authorized last year would only result in further deterioration of the performance of GPS receivers and applications documented in the TWG Report. Therefore, the starting point for consideration of terrestrial EIRP levels in

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19 NPEF Report, public version, at 9-2 (noting that an earlier coordination agreement between the Aerospace and Flight Test Coordinating Council “and MSV, predecessor to LightSquared, did not contemplate the extensive terrestrial deployment now reflected in LightSquared’s current plan. Any consideration of moving LightSquared farther down in the MSS allocated band should also consider the potential impacts to AMT operation, both in terms of increased potential interference and the additional coordination burden that would be placed on military and other Federal agency frequency managers and Federal test facilities”).

L-band is not the 42 dBW level, but rather the 32 dBW level originally put forward by LightSquared into the TWG. In addition, it is important to keep in mind that the use of lower EIRP levels as a means to mitigate interference to some types of GPS receivers would lead to increasing interference into others due to a higher aggregate interference from a larger number of LightSquared transmitters that would be needed to provide the same coverage. This effect was not meaningfully considered by the TWG, and would need to be taken into account (and properly reflected in Commission rules and procedures along with the limits applicable to any power level/deployment scenario that will enable any LightSquared operation in the 1525-1559 MHz band for terrestrial mobile broadband operation).

B. There Is No Basis for a Temporary “Standstill” in Terrestrial Use of the Upper 10 MHz Channel.

LightSquared’s proposal to agree to a “standstill” in terrestrial use of the upper 10 MHz frequencies is unfounded given the very clear results that are detailed in the TWG Report. All sub-teams were unanimous in their conclusion that any LightSquared terrestrial mobile broadband use of the upper 10 MHz band would lead to harmful interference to GPS receivers and applications, and no practical mitigation techniques to alleviate this interference in the near-future were identified by any of the sub-teams. Mitigation techniques to alleviate the interference to all types of GPS receivers would need to be researched, developed, tested and certified (in at least the case of aviation), resulting in a timeline that will likely be measured in decades rather than years. There certainly is no way that any mitigation technique for the upper 10 MHz band will be found appropriate and feasible in the short-term standstill period that LightSquared envisions in its Recommendation. The Commission should not even entertain the

\footnote{See, e.g., NPEF Report at 9-3.}
possible use of terrestrial operations in the upper 10 MHz until such time as LightSquared demonstrates that GPS receivers and applications will not be negatively impacted by such use.

It is worth mentioning at this juncture that a second major flaw in LightSquared’s “standstill” proposal stems from its erroneous assertion that GPS receivers do not today use “appropriate filtering.”22 GPS receivers incorporate state-of-the-art technology, and are designed and manufactured using state-of-the-art techniques. In the case of aviation, no receiver is permitted to be installed on an airframe unless it meets rigorous testing and certification standards. Moreover, receivers operating in the RNSS band at 1559-1610 MHz are designed to work in the spectrum allocation environment established in the domestic and international tables of frequency allocations – where there are no terrestrial mobile service allocations anywhere in our part of the world from 1525 MHz up through 1660.5 MHz. There was no operational difficulty with filtering or any other aspect of RNSS receivers until LightSquared’s effort to convert a mobile-satellite service allocation into a high-power terrestrial mobile allocation; by Commission rule,23 the problem is LightSquared’s sole responsibility to resolve.

C. **LightSquared Cannot Be Allowed to Commence Terrestrial Commercial Operations Only on the Lower 10 MHz Channel.**

LightSquared’s proposal that it be allowed immediately to start terrestrial operations using only the lower 10 MHz channel is again unfounded given the results of the TWG Report. The International Bureau emphasized in the *LightSquared* order that “any potential interference to GPS is a significant concern,” and stated that the condition prohibiting provision of terrestrial mobile broadband will not be complete until the harmful interference concerns have been

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22 See LightSquared Recommendation at 26-27.

23 See 47 C.F.R. § 25.255 (“[i]f harmful interference is caused to other services by ancillary MSS ATC operations, either from ATC base stations or mobile terminals, the ATC operator must resolve any such interference”).
resolved. The Bureau did not, and the Commission cannot, differentiate between GPS/RNSS receiver types. So although the use of the lower 10 MHz may alleviate interference into some GPS receivers, the TWG Report shows that a significant number of GPS receivers and application would be impacted by terrestrial operations in the lower 10 MHz. In particular, the TWG concluded that a potential issue regarding negative margin for aviation receiver acquisition of GPS satellite signals necessitated additional studies of the effects of lower 10 MHz-only LightSquared terrestrial mobile broadband service on GPS receivers used in aviation.

Under these circumstances, there is no basis for the approval of LightSquared’s proposal to allow immediate commencement of terrestrial mobile broadband operations on the lower 10 MHz of the 1525-1559 MHz band. Moreover, the Commission must ensure that operations in the lower band do not result in interference to other users in the lower adjacent band, including AMT.

24 *LightSquared*, 26 FCC Rcd at 585 (¶39) and 586-87 (¶ 43).
4. CONCLUSION

For the reasons provided above, Lockheed Martin urges the Commission to reject as insufficient the three-pronged “solution” in LightSquared’s Recommendation. The Commission must instead rescind the conditional waiver and rule that, based on studies to date, terrestrial mobile broadband services cannot be provided in the MSS frequencies licensed to LightSquared.

Respectfully submitted,

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