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November 5, 2015

Ms. Marlene H. Dortch
Secretary
Federal Communications Commission
445 12th Street, SW
Washington, DC 20554

Re: RM-11681; IB Docket No. 12-340; IBFS File Nos. SAT-MOD-20120928-00160; SAT-MOD-20120928-00161; SES-MOD-20121001-00872

Dear Ms. Dortch:

LightSquared hereby submits the attached report, titled "Assessment of the 1675-1680 MHz Band" (herein, "1675-1680 Assessment Report"), which outlines the methods by which the 1675-1680 MHz band can be successfully shared between the National Oceanic and Atmospheric Administration (NOAA) and a commercial wireless network. The report provides an overview of existing analyses addressing NOAA's uses of the band and describes LightSquared's recent inquiry into NOAA data products and services received by non-NOAA end users. LightSquared's investigation of non-NOAA end users was limited in scope because the universe of users was unknown, though we think the proxy we selected was useful, and the response we received from the group polled was incomplete. Thus, we believe the topic would benefit from additional input. LightSquared therefore requests that the Commission issue a Public Notice seeking comment on the attached report, use cases surrounding these data products and services, the potential impact of commercial operations in the band on non-NOAA users, and available technologies or alternatives to address any such impacts. The purpose of the public notice would be to gather information that would enable the Commission to move forward with a notice of proposed rulemaking on this band early in 2016 and thereby fulfill the Administration's objective as stated in the President's Budget of making this band available for commercial use, and also further the President's goal of allocating 500 MHz of government spectrum to private sector use.[1]

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[1] *See* Memorandum on Unleashing the Wireless Broadband Revolution, 2010 DAILY COMP. PRES. DOC. 556 (June 28, 2010); *see also* Jason Furman & Megan Smith, *How to Avoid Spectrum Crunch*, WALL ST. J. (Jan. 22, 2015, 6:64 PM), http://www.wsj.com/articles/jason-furman-and-megan-smith-how-to-avoid-spectrum-crunch-1421970841.

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The 1675-1680 Assessment Report first provides an overview of the 2013-2014 study performed by Alion Science and Technology (Alion) concerning the compatibility of commercial wireless operations with NOAA's uses of the 1675-1680 MHz band. The Alion study, which was recommended by NOAA and funded by LightSquared, concluded that compatibility is achievable through the relocation of certain NOAA radiosondes and the establishment of defined protection and coordination zones.[2] The Alion study thus showed that it was possible to obtain the substantial public interest benefits resulting from shared access to the band.

Following discussions with NOAA on this topic in June 2015, LightSquared began assessing the methods by which non-NOAA users access NOAA's data products and services, and this assessment included direct outreach to many non-NOAA users. As set forth in the 1675-1680 Assessment Report, LightSquared's preliminary assessment indicates that commercial LTE wireless operations in the 1675-1680 MHz band would have little or no impact on many non-NOAA users and that reasonable alternative means exist for any users that might be impacted to obtain NOAA's data products and services. LightSquared's assessment was limited for the reasons set forth above, and the company expects additional useful information will be gained through the Commission's notice-and-comment process. It is important to note that this analysis is relevant specifically to non-NOAA users who are capable of receiving data directly from NOAA satellites. Non-NOAA users who instead receive data from NOAA over the Internet or otherwise will not be impacted as NOAA's capability of collecting and distributing data will not be impaired. The 1675-1680 Assessment Report then evaluates the impact of spectrum sharing on certain non-NOAA users' receipt of data products and services originating in the 1675-1680 MHz band and adjacent bands.

A Public Notice on this topic also could assist the Commission as it weighs the public interest benefits that could be achieved through shared government and commercial use of the spectrum against the cost of mitigating any potential impact to non-NOAA users. The consumer welfare benefits realized by enabling commercial uses of this 5 MHz of additional spectrum would be lower wireless prices for consumers, more services by wireless companies, and greater opportunities for innovation.[3] While the Commission's notice-and-comment process will enable a fuller analysis, our preliminary analysis indicates that the total cost for any non-NOAA users who may be impacted by commercial operations in the band to receive NOAA's data products and services by alternative means likely would be a small fraction of that amount. When the Commission performs its cost/benefit analysis based on even the most conservative of these estimates, we expect the Commission will find that enabling commercial use of the band could generate a significant public interest benefits at relatively modest costs to accommodate non-NOAA users.

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[2] *See* Letter from John P. Janka to Marlene H. Dortch, RM-11681 (Jan. 30, 2014) (submitting Alion Task 1 Report); Letter from Jeff Carlisle to Marlene H. Dortch, IB Docket No. 12-340, RM 11-11681 (Apr. 14, 2014) (submitting Alion Task 2 Reports).

[3] *See* Giulia McHenry & Coleman Bazelon, *Valuing Spectrum: From DC To Daylight* (Mar. 31, 2014), *available at* http://ssrn.com/abstract=2418734.

We expect the Public Notice and comment process will assist in discovering which entities—if any—might find that useful services derived from NOAA operations would be disturbed in a material way by allowing the band to be used commercially. If there is any such harm and if there are any such entities, the Public Notice process will allow all stakeholders to discuss whether, for example, the terms and conditions of obtaining the license for commercial use of the band should include reimbursement of the cost to receive NOAA's data products by alternative means. In particular, LightSquared expects that the Commission will benefit from public input on the following questions:

1. Which entities directly access NOAA's data or services delivered via satellite that could be impacted by commercial transmissions over the 1675-1680 MHz band?

2. What types of NOAA's data or services do such entities receive directly from NOAA (as opposed to indirectly over the Internet), in what manner is that information received directly, and for what purpose? How frequently is NOAA's data or services accessed?

3. What other sources do such entities rely on for similar data or services? Does the entity have a broadband Internet and/or fiber optic connection to its facilities? If yes, please describe.

4. What frequencies do such entities use to directly access NOAA's data or services delivered via satellite? How have such entities been impacted by commercialization of nearby bands (*e.g.*, AWS-3)?

5. Are such entities planning changes in operations as a consequence of the AWS-3 auction? If so, please describe the nature of those changes, the estimated expense, and whether those changes will obviate the need for reliance on the 1675-1680 MHz band. If not, please explain what effect, if any, operations in the AWS-3 band will have on the ability of such entities to access NOAA's data products and services originating in the 1675-1680 MHz band and adjacent bands.

6. With respect to any data or services that could be impacted by commercial transmissions over the 1675-1680 MHz band, what alternative methods are available to access such data or services?

7. What are the benefits and drawbacks of using alternative methods to receive NOAA data and services? What is the cost to access such data or services using alternative methods? How do these costs compare to the public interest benefits stemming from commercial use of the band?

LightSquared respectfully requests that the Commission issue a Public Notice in response to the attached report in order to better understand the potential impact of commercial use of the 1675-1680 MHz band on entities who receive NOAA's data products and services.

This Public Notice is the logical next step to put the Commission in a position to move forward with a partial reallocation of this spectrum for commercial use.

Respectfully submitted,

/s/Gerard J. Waldron
Gerard J. Waldron
Paul Swain
Counsel to LightSquared

Attachment

Assessment of the 1675-1680 MHz Band

Spectrum Sharing Between NOAA and Commercial Wireless Network

Preservation of NOAA Functional Requirements

Continued Provision of Data Products and Services to Non-NOAA End-Users

LightSquared

August 31, 2015

DC: 5824179-3

Executive Summary

This report outlines the methods by which the 1675-1680 MHz band can be successfully shared between NOAA and a commercial wireless network, preserving NOAA's existing uses of the band and enabling the continued provision of data products and services to non-NOAA end users. The President's Budget for the past three years has identified the 1675-1680 MHz band as designated for commercialization, and this policy goal was endorsed last year by the U.S. Congress. The purpose of this report is to set out a technical roadmap for how the FCC can move forward with this vital mid-band spectrum to make it available in the short-term for nationwide broadband use.

Part 1 of this report provides background information on the nearby 1670-1680 MHz band, the 1670-1675 MHz portion of which has been shared between NOAA and a commercial licensee since 2003, with LightSquared operations commencing in 2013.

Part 2 contains an overview of the 2013-2014 study performed by Alion Science and Technology concerning the compatibility of commercial wireless operations with NOAA's uses of the 1675-1680 MHz band. The publicly-available Alion study, which was requested by NOAA and funded by LightSquared, concluded that compatibility is achievable through the relocation of certain NOAA radiosondes and the establishment of defined protection and coordination zones.

Part 3 evaluates the impact of spectrum sharing on certain non-NOAA users' receipt of data products and services originating in the 1675-1680 MHz band and adjacent bands. These non-NOAA users were raised as a potential concern by NOAA in June 2015. Upon learning the extent of this potential concern, LightSquared began assessing the methods by which non-NOAA users access NOAA's data products and services, including through direct outreach to many non-NOAA users. Although additional insight will surely be gained through the FCC's public notice-and-comment process, LightSquared's preliminary assessment indicates that commercial LTE wireless operations in the 1675-1680 MHz band would have little-or-no impact on many non-NOAA users, and that reasonable alternative means exist for users that could potentially be impacted to obtain NOAA's data products and services.

Part 4 sets forth LightSquared's conclusion, based on the extensive data and information discussed herein, that the 1675-1680 MHz band can be successfully shared between NOAA and a commercial wireless network.

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Defined Terms

AWS-3	Advanced Wireless Services-3
CDA	Command and Data Acquisition telemetry link
CSMAC	Commerce Spectrum Management Advisory Committee
DCPR	Data Collection Platform Report
DCS	Data Collection System
DRG	Direct Readout Ground Station
GIFS	Global Telecommunications System Internet File Service
GOES	Geostationary Operational Environmental Satellite
GOES-NOP	Current Generation of GOES Satellite (in operation beginning in 2010)
GOES-R	Next Generation of GOES Satellite (first launch scheduled for 2016)
GRB	GOES - Rebroadcast
GTS	Global Telecommunications System
GVAR	GOES - Variable
HRIT	High Rate Information Transmission
LRIT	Low Rate Information Transmission
LTE	Long Term Evolution (commercial wireless standard)
MDL	Multi-Use Data Link
SD Link	Sensor Data Link

Appendices

Appendix 1	Sample Information Request to Non-NOAA Users
Appendix 2	List of Entities Contacted

1 Current Spectrum Sharing with NOAA in 1670-1675 MHz Band

The 1670-1675 MHz band is a shared spectrum band with NOAA's Sensor Data Links ("SD Links") operating from 1673.4 MHz to 1678.6 MHz. This spectrum sharing requires the commercial operator to coordinate its operations with NOAA for a distance of 100 kilometers from the Wallops Island, VA and Fairbanks, AK NOAA receive earth stations and 65 kilometers from the Greenbelt, MD receive station. With respect to NOAA facilities, coordination is also required for 1670-1675 MHz stations operating above 2kW EIRP within 1.3 kilometers of a NOAA radiosonde receive station which currently operate in the 1675-1683 MHz band.

LightSquared currently operates a network on the 1670-1675 MHz spectrum with 51 sites in operation as of September 30, 2013. LightSquared is in the midst of a major network expansion, which will result in approximately 200 operating sites by October 2015.

2 Evaluation of Spectrum Sharing with NOAA in 1675-1680 MHZ Band

At NOAA's request, LightSquared in 2013 commissioned a comprehensive engineering assessment to determine the feasibility of a commercial wireless operator sharing the 1675-1680 MHz band with NOAA and the technical and operational parameters under which such operation could occur. Ultimately the question was whether NOAA facilities could be adequately protected and what size and number of protection or coordination zones would be required to accomplish that objective. Alion Science and Technology conducted the engineering assessment in 2013 and 2014, concluding that NOAA facilities could be adequately protected by relocating certain NOAA radiosondes and establishing defined protection and coordination zones. An overview of the assessment is set forth below.

2.1 Vendor Selection and Work Product

2.1.1 Sponsoring Party

NOAA was interested in exploring the spectrum sharing concept; however, it did not have the necessary funds to commission such a study. It was ultimately determined that, assuming LightSquared was able and willing to fund such a study, the best course of action would be to utilize a third-party engineering firm that was familiar with NOAA's operational requirements and possessed the necessary expertise and tools to conduct an analysis to NOAA's satisfaction.

2.1.2 Vendor Selection

At NOAA's suggestion, LightSquared contacted Alion Science and Technology. Alion is an experienced engineering firm that has previously conducted significant work for NOAA in a variety of areas, including preparation for the upcoming launch of services over the new GOES-R satellite. Alion also was actively involved in the Commerce Spectrum Management Advisory Committee's ("CSMAC") work in assessing potential impacts to NOAA operations from the AWS-3 spectrum band.

2.1.3 Work Product

In May and June of 2013, LightSquared, Alion and NOAA personnel worked jointly to formulate the scope of work for the study in order to ensure that the final product met the needs of the stakeholders.

The Alion work was initiated with a kick-off meeting at NOAA headquarters in Silver Spring, MD on July 1, 2013. Several members from the Alion, LightSquared and NOAA teams that would be working on this analysis attended this meeting.

Weekly conference calls with the work team were held throughout the period of performance, with in-person meetings held approximately once-per month, usually at the Alion facility in Annapolis Junction, Maryland. During the course of the project there were a total of 12 different Alion engineers involved in the analysis and preparation of the work product. The workgroup also included approximately eight employees and contractors, at various times, participating from each of LightSquared and NOAA.

Work continued through the end of 2013 into 2014 with the Phase 1 Alion report completed on January 28, 2014; the Phase 2 report completed on February 28, 2014; and the Phase 2A report completed on April 14, 2014. LightSquared filed all reports with the FCC, and these are part of the FCC's public records[1]. NOAA informed LightSquared that it had provided NTIA with copies of the Alion reports as well.

2.2 Evaluation of Radiosonde Operations

2.2.1 Description

Radiosondes contain various temperature and atmospheric sensors and are attached as a payload to NOAA weather balloons. These balloons are typically launched twice-daily by NOAA at approximately 102 locations throughout the United State, Pacific Islands and the Caribbean. During its time in the air, the radiosonde transmits its data recordings back to the earth station from which it was launched using the 1675-1683 MHz band which is divided into several channels. During the majority of a radiosonde's flight, the telemetry is received by a NOAA ground station with a parabolic dish capable of rotating 360 degrees in the horizontal plane in order to track the radiosonde while in flight.

Radiosonde operation in the 1675-1680 MHz band would not be compatible with sharing that band with a commercial wireless operation due to mutual interference between the two uses. Additionally, the more intensive use of the band above 1680 MHz with the GOES-R deployment would cause radiosonde operations to shrink from 1675-1683, to just 1675-1680 MHz in order to prevent interference to GOES-R operations. This reduced spectrum occupancy would potentially have operating impacts on radiosonde telemetry. This spectrum constraint, combined with the opportunity to share 1675-1680 MHz with a

[1] See: http://apps.fcc.gov/ecfs/document/view?id=7521069436 ("Alion Task 1 Report") and http://apps.fcc.gov/ecfs/document/view?id=7521098269 ("Alion Task 2 Report" and "Alion Task 2A Report")

commercial operator, led to the examination of alternate spectrum for radiosonde operations.

The prime option for relocation of radiosonde operations was the 400.15 to 406 MHz band, which is already allocated for radiosonde operation and is the primary band used internationally for such operations[2]. This band has two primary benefits. First, because it is widely used internationally, improved cost efficiencies in the purchase of radiosonde transmitters using this band could be realized. Second, because of the improved propagation properties relative to the 1675-1683 MHz band, a much simpler receive system can be employed which uses fixed mount directional antennas instead of a tracking parabolic antenna.

The feasibility of relocating radiosondes to this band focused on potential impacts to existing operations in the 400.15 to 406 MHz band from radiosondes, as well as the corresponding impact to radiosonde receive stations from other transmitters in this band.

2.2.2 Evaluation of Impact to Existing Uses from Radiosondes

The Alion Report assessed the licensed uses of spectrum in and around the 400.15 to 406 MHz band, identifying the following services for its analysis:

- Land Mobile Radio Systems
- Medical Implant Communications Systems
- Wind Profile Radars
- Data Collection Platforms
- Search and Rescue Satellite (SARSAT)

The Alion report showed that operation of radiosondes in the 400-406 MHz band would not conflict with the operation of the above systems[3].

2.2.3 Evaluation of Impact from Existing Uses to Radiosondes

The report also considered whether the radiosonde receive locations would experience harmful interference from other permitted operations in the 400.15-406 MHz spectrum band. For this analysis, Alion considered the same sources as above, but this time evaluated the transmitter characteristics versus the defined characteristics of a new radiosonde receive station in this band. The Alion report showed no conflict between existing operations and the future reception of radiosonde signals[4].

2.2.4 Sufficiency of available spectrum to support radiosonde operations

Finally, Alion performed detailed, site-specific analyses at each radiosonde receive location to ensure that there was sufficient unoccupied spectrum available to support radiosonde

[2] See 47 C.F.R. § 2.106.
[3] Alion Task 1 Report, pages 11-21.
[4] Id. Pages 37-38.

operations. This analysis showed that at each location, there was enough available spectrum to support at least four 300 KHz channels; a number that is sufficient to support operations[5].

With the analysis of the 400.15-406 MHz environment complete, Alion concluded that relocation of radiosondes from 1675-1683 to 400.15-406 MHz was indeed feasible (Alion Phase 1 Report, page 39)[6].

2.2.5 Relocation Plan Part of AWS-3 transition

Shortly after the completion of the Alion Reports, NTIA informed the FCC that NOAA radiosondes would be relocated out of the 1675-1683 MHz band; a process which was estimated in the report to be complete after a period of 72 months[7].

2.3 GOES NOP Operations[8]

2.3.1 Description

NOAA operates a group of Geostationary Operational Environmental Satellites (GOES) which serve a variety of functions related to the collection of weather data and the dissemination of data and alerts. The current generation of GOES satellites (GOES NOP) was first launched beginning in 2006 and came into operational service in 2010[9]. NOAA is proceeding with the next generation of GOES satellites with the expected launch of GOES-R in 2016[10]. GOES NOP provides data and alerts to NOAA and other users via several streams, including the SD Link, Command and Data Acquisition link, Multi-Use Data Link, GOES-Variable, Data Collection Platform Report, Emergency Managers Weather Information Network and the Low Rate Information Transmit. Each of these services is discussed in greater detail below.

2.3.2 SD Link

The Sensor Data Link ("SD Link") is the downlink channel for NOAA to send Imager and Sounder data collected by the GOES satellites back to NOAA earth stations for further processing. This data is received by NOAA earth stations in Wallops Island, VA, Greenbelt, MD and Fairbanks, AK. It occupies 5.2 MHz of spectrum from 1673.4 to 1678.6, thus overlapping portions of both existing 1670-1675 MHz commercial operations and any future commercial spectrum sharing in the 1675-1680 MHz band.

When allocating commercial spectrum in the 1670-1675 MHz band, the FCC established a license condition requiring the coordination of commercial cell site placement between the licensee and NOAA for any sites that would be within 100 kilometers of the Wallops Island, VA and Fairbanks, AK NOAA earth stations and within 65 kilometers of NOAA's Greenbelt, MD earth station. LightSquared constructed one site in Baltimore, Maryland that lies within this protection zone and has successfully coordinated its operation with NOAA. LightSquared

[5] Id. Page 39.

[6] Id. Page 40

[7] NTIA Notice of Estimated Relocation or Sharing Costs and Timelines for the 1695-1710 MHz and 1755-1780 MHz Bands, May 13, 2014, Attachment B1

[8] Link description information summarized from NTIA fast track report.

[9] http://www.osd.noaa.gov/Spacecraft%20Systems/Geostationary_Sat/GOES_N/GOES_N.html

[10] http://www.nesdis.noaa.gov/flyout_schedules.html

has also voluntarily coordinated its site that is located in Norfolk, Virginia, which is outside of the FCC-established protection zone. This was undertaken after LightSquared and NOAA jointly concluded that, due to atmospheric conditions occurring primarily during the summer months, this site was occasionally interfering with NOAA's Wallops Island ground station reception of SD Link data. As a result of cooperative assessment activities, LightSquared implemented (with NOAA's concurrence) a modification to its Norfolk site.

In assessing the protection zones needed for sharing the 1675-1680 MHz band, NOAA contended that the protection zones established by the FCC for the 1670-1675 MHz band[11] were insufficient. As such, NOAA requested that Alion use models and assumptions that would fully account for unusual atmospheric effects known as *thermal ducting* which can produce anomalous propagation – causing signals to travel beyond the limits assumed in typical propagation models (e.g., beyond line-of-sight).

These assumptions, combined with the co-channel operation between SD-Link and commercial wireless sites, produced protection zones that were many times larger than the ones created by the FCC for operation in the 1670-1675 MHz band.

Figure 1 - SD Link Protection Zone Distances[12]
In Kilometers

	Alion Report[13]	FCC 1670-1675 MHz Rules[14]
Fairbanks, AK	208	100
Greenbelt, MD	434	65
Wallops Island, VA	450	100

2.3.3 MDL and CDA

The CDA is the Command and Data Acquisition telemetry link which provides information to NOAA ground controllers on the status, configuration and health of the GOES payload and subsystems. The CDA is a .16 KHz channel from 1693.992 to 1694.008 MHz. The Alion report defined protection zones for CDA at the Wallops Island, Greenbelt and Fairbanks NOAA facilities.

The MDL is the Multi-Use Data Link and is used by NOAA to diagnose instrument and spacecraft interactions. This link is received at the NOAA earth station in Omaha, NE in addition to the Wallops Island, Greenbelt and Fairbanks NOAA earth stations. The MDL is a 400 KHz channel from 1681.278 to 1681.678 MHz. The Alion report defined the protection

[11] See 47 C.F.R. §1.924(g)(1) and "NOAA GOES Sensor Data Downlink Coordination Zones for Proposed Transmitters in the 1670 to 1675 MHz Frequency Band," Department of Defense Joint Spectrum Center, December 2005. JSC-CR-05-122.

[12] Unless otherwise specified in this report, where there is more than one receive site at a specific NOAA facility, the receiver with the maximum separation distance is listed.

[13] The protection zones defined in the Alion report are irregularly shaped. The values in the table represent the distance from the relevant NOAA site along the longest single radial calculated.

[14] 47 CFR §1.924(g)(1)

zone for MDL at that Omaha NOAA facility. Protection zones were not defined for MDL at Wallops Island, Greenbelt and Fairbanks since the zones for the MDL would have been smaller than, and completely encompassed by, the zones already defined by Alion for the SD-Link at these locations[15].

Because these links are not co-channel to the 1675-1680 MHz band, the protection zones are substantially smaller in size compared to those for the SD Link at similar locations.

Figure 2- MDL and CDA Protection Zone Distances
In Kilometers

NOAA Facility	Alion Report
Fairbanks, AK	6 (CDA)
Greenbelt, MD	5 (CDA)
Omaha, NE	6(MDL)
Wallops Island, VA	35 (CDA)

2.3.4 GVAR

GOES Variable (GVAR) is the GOES Variable link which primarily serves a data transport function that sends processed weather data and images to multiple NOAA locations nationwide via the GOES satellite network. GVAR data is streamed over a 4.22 MHz channel from 1683.59 to 1687.81 MHz. GVAR will ultimately be replaced by the GOES – Rebroadcast (GOES-GRB) GRB service which will become available when GOES-R comes into operational service. The stations evaluated and the maximum separation distance calculated in the Alion report for NOAA GVAR reception are listed in Figure 3 below.

Figure 3 - GVAR Protection Zone Distances
In Kilometers

NOAA Facility	Alion Report
Greenbelt, MD	3
Miami, FL	9
Monterey, CA	4
Omaha, NE	6
Suitland, MD	17
Wallops Island, VA	16

2.3.5 DCPR 1

DCPR is the Data Collection Platform Report transponder on the GOES satellite. DCPR is a relay link for readings from environmental sensors across the country (such as stream, temperature and wind gauges), which are transmitted to NOAA to be included in its models for weather forecasting and the issuance of alerts and warnings. These readings are sent from the individual gauges to the GOES satellite in the 401-402 MHz band. For the downlink,

[15] The SD-Link protection zones are larger since the SD-Link is co-channel to 1675-1680 and the MDL is not.

NOAA has been assigned two 400 KHz channels for DCPR: DCPR 1 from 1694.3 to 1694.7 MHz and DCPR 2 from 1694.6 to 1695 MHz. There is a 1 MHz overlap of the channels and the Alion report assessed only DCPR 1[16] [17].

Figure 4 - DCPR Protection Zone Distances
In Kilometers

NOAA Facility	Alion Report	CSMAC-Modeled Assumptions
Fairbanks, AK	6	
Greenbelt, MD	5	
Omaha, NE	15	
Pearl Harbor, HI	12	
Rock Island, IL	27	
Sacramento, CA	17	
San Juan, PR	58	
Sioux Falls, SD	25	
St. Louis, MO	12	
Vicksburg, MS	15	
Wallops Island, VA	24	

2.3.6 EMWIN/LRIT

Alion noted in its report that the Emergency Mangers Weather Information Network and the Low Rate Information Transmit downlinks were not included in its report because these links do not have NOAA users[18]. Alion largely took direction from NOAA regarding which links were to be examined for the report.

2.4 GOES R Operations

2.4.1 Description

GOES-R is the first satellite in the next-generation of GOES services and is scheduled for launch in early 2016[19]. The operation of the GOES-R satellite will initiate a reconfiguration of NOAA's satellite spectrum to accommodate new features and services available through the new generation of weather satellites. As such, some services will be changed, consolidated and/or relocated in the spectrum band. Some of the spectrum relocation is also necessary in order to accommodate sharing with wireless carriers which will operate AWS-3 commercial LTE networks with uplinks in the 1695-1710 MHz band.

[16] Alion Task 2 Report, Page 6.
[17] Because DCPR slightly overlaps the 1675-1680 MHz band and DCPR 2 does not, the DCPR 1 is the limiting case since it would result in a larger protection zone than that which would be calculated for the adjacent-band DCPR 2 link.
[18] Id.
[19] www.nesdis.noaa.gov/flyout_schedules.html

There will be an extended period during which the new and previous generations of GOES satellites operate simultaneously[20]. The new GOES-R will occupy either the GOES-EAST or GOES-WEST orbital slot, with a current-generation satellite continuing to occupy the remaining slot until such time as it is replaced. The timing for replacement of the remaining GOES NOP satellite is scheduled for 2020[21], and the satellites will provide different services on different frequencies during the intervening time period.

2.4.2 SD Link

The GOES-R satellite and subsequent satellites in its generation will not transmit SD Link data in the current allocation as it is done in the current generation of GOES services. The remaining legacy GOES satellite will continue to utilize the existing SD Link allocation until it is replaced by a newer-generation satellite which is expected in 2020[22]. LightSquared is not aware of any pending requests for new government uses of the current SD-Link spectrum once the existing GOES use is terminated.

2.4.3 GRB and DCPR

GOES Rebroadcast (GRB) is a service that will be initiated by NOAA once the GOES-R satellite becomes operational; it will eventually replace the existing GVAR service. GRB will provide considerably more real-time and processed data compared to what is currently transmitted over the 4.22 MHz GVAR channel. GRB will provide data streams from the GOES Advanced Baseline Imager (which provides data on cloud formation, atmospheric motion and land surface temperature, etc.[23]), the Geostationary Lightning Mapper, space environment and solar data.[24] The GRB channel will be 12 MHz wide, from 1680.6 MHz to 1692.6 MHz.

DCPR will not undergo any major change in its structure or characteristics, other than to relocate the two channels to 1679.7 - 1680.4 MHz (the two 400 KHz DCPR channels overlap by 0.1 MHz).

For the GRB and DCPR analysis, the Alion report noted that, "NOAA and LightSquared agreed that an exceedance factor of 50% should be utilized in cases where aggregate interference from multiple sites is being assessed." This is also consistent with the methodology previously employed by CSMAC in assessing potential interference to NOAA operations from the AWS-3 band.

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[20] Id.

[21] Id.

[22] Id. "GOES-S" is scheduled to be launched in 2017, with it being placed into on-orbit storage until its scheduled in-service date in 2020.

[23] http://www.goes-r.gov/spacesegment/abi.html

[24] http://www.goes-r.gov/users/grb.html

Figure 5 - GRB and DCPR-1 Protection Zone Distances (GOES-R)

In Kilometers

NOAA Location	Alion Report
Anchorage, AK	14*
Boise, ID	39
Boulder, CO	50
Cincinnati, OH	40
College Park, MD	38
Columbus, MS	34
Fairmont, WV	66**
Ford Island/Pearl Harbor, HI	19
Kansas City, MO	53
Miami, FL	25
Monterey, CA	15
Norman, OK	41
Omaha, NE	24**
Rock Island, IL	21**
Sacramento, CA	92
San Juan, PR	36
Sioux Falls, SD	46
St. Louis, MO	70
Stennis Space Center, MS	52
Suitland, MD	42
Vicksburg, MS	37
Wallops, VA	49
White Sands, NM	6*

Note: except where otherwise noted, the aggregate interference analysis utilized the cell site location data that was supplied to CSMAC Working Group 5.

* Due to the remote nature of certain site locations, WG-5 cell site location data was insufficient for aggregate analysis (too few sites), alternate cell site location information did not have cell sites in this area either. Thus, aggregate analysis could not be performed for these remote locations. Results from Alion Strong Signal Analysis are listed in these instances (See Alion Task 2 Supplement, Table 10).

** Alternate cell site location information was utilized as the CMSAC site database had too few sites in the surrounding area to perform a valid aggregate analysis.

2.4.4 EMWIN and HRIT

The Emergency Managers Weather Information Network (EMWIN) will share spectrum with the High Rate Information Transfer. The services will jointly use the spectrum band from 1693.807 to 1694.393 MHz. Consistent with its approach for the GOES NOP services, the Alion report did not include evaluation of EMWIN and HRIT for GOES-R as NOAA indicated there are no NOAA users utilizing these services.

3 Evaluation of Non-NOAA Uses of 1675-1680 MHz Band

At a meeting with NOAA and NTIA held on June 22, 2015, NOAA expressed concern about the ability of non-NOAA users who make use of NOAA's satellite signals for free to access data and alerts to continue to receive these data streams through alternate sources should the spectrum be shared with commercial entities. After learning of this concern, LightSquared developed a plan to identify how non-NOAA users access NOAA's data and weather-related warnings and the alternate means that exist to obtain this data should users' ability to access these streams using NOAA's satellite signals be diminished. LightSquared's preliminary assessment, which has included direct outreach to many non-NOAA users, suggests that commercial wireless operations in the 1675-1680 MHz band would have little-or-no impact on most non-NOAA users. For non-NOAA users who could potentially be impacted, LightSquared's assessment indicates that in many cases alternative means are available to obtain NOAA's data products and services. The collection of additional information through public notice-and-comment is likely to produce additional useful information regarding these non-NOAA users.

3.1.1 Outreach Activities

On July 9, 2015, LightSquared's regulatory counsel, Covington & Burling ("Covington") sent a letter to 101 companies and organizations who had submitted comments in a previous FCC inquiry focused on the use of the 1675-1710 MHz band (a form of the letter is attached as Appendix 1)[25]. This letter asked users to answer questions about their use of the band, any potential impact they saw from commercial transmissions in the 1675-1680 MHz band, as well as other methods they may use to gain access to this data. Subsequently, Covington sent a letter to four additional companies and organizations who had not submitted comments to the FCC but who LightSquared learned might have interests in the 1675-1680 MHz band. The entities contacted by Covington are listed in Appendix 2.

3.1.2 Responses

As of the filing of this report, Covington has received substantive replies from 22 of these entities. Many of these responses provided useful information on how NOAA data is received and utilized by third parties and has helped inform LightSquared's evaluation of potential alternatives to the reception of data streams and services directly from NOAA's satellites in cases where commercial operation in the 1675-1680 MHz band may impact reception of these services.

3.1.3 Interviews

Several entities that were contacted by LightSquared agreed to have a follow-up phone discussion to delve more deeply into the user's functional requirements, how those are met today and any challenges that may be created associated with the sharing of the 1675-1680 MHz band with commercial users. The relevant information obtained through these interviews has been incorporated into this report.

[25] Letters were sent to the person and address listed in the entity's response to FCC Office of Engineering and Technology Public Notice DA 10-35. Eleven letters were initially returned to Covington, which then was able to re-send eight of them with updated contact information.

3.1.4 Initial Findings

As a result of these outreach activities, this report makes several preliminary findings about how users today gain access to NOAA data and services. These findings are based on the small sample size that was dictated by the response rate of the group surveyed, as well as the completeness of their responses. It is not suggested that these findings alone can be the basis for determining the overall impact on end users, but would be a useful starting point for further comment that could be solicited by agencies examining this issue.

- Many users are accessing the data over the Internet today
- Entities utilizing services near the 1695 MHz band may not have not taken action with respect to mitigating the impact to their reception due to the commercialization of AWS-3
- Several respondents that were located outside of the US are receiving NOAA data streams; because of their location, they will not be impacted by spectrum sharing

3.1.5 Services

Through these outreach activities, and based on previous discussions with NOAA, several services were identified that are of interest to non-NOAA users. The specific services are DCPR/DCS, GVAR/GRB and EMWIN. The sections below describe each of these services as well as the potential impact of commercial uses in nearby spectrum bands.

3.1.5.1 DCPR/DCS

As mentioned previously in this report, the DCS/DCPR service is a means by which NOAA can collect weather and environmental data from thousands of sensors across the United States for use in forecasting models and for the issuance of weather advisories and warnings. There are a wide variety of sensors in use, some of which include surface temperature, precipitation, wind speed and water level/flow rates.

These gauges are placed into operation by a variety of entities including the federal and tribal governments, state and local governments as well as utilities and water management agencies. These users utilize one or more NOAA services in order to get efficient access to the data produced by these remote sensors. Some users retrieve this data from internet services enabled or hosted by NOAA or the US Geological Survey, while others obtain this data directly through the DCPR satellite downlink.

It is worth noting that there is some confusion within the DCS user community about the ability for remote sensors to continue sending data to NOAA if the 1675-1680 MHz band is shared with a commercial entity. Users have expressed concern about commercial operations restricting the ability of sensors to upload data to NOAA through DCS/DCPR. This concern has no basis. There is no impact at all to the uplink operations, which are located at 400 MHz, from spectrum sharing of the 1675-1680 band. Moreover, NOAA's ability to receive the downlink is maintained through the establishment of the protection zones in the Alion report. These steps also preserves NOAA's ability to continue to redistribute this data in a variety of means which is explained more fully later in this report. The only potential issue is with any users that utilize the DCPR downlink as the primary means to read their own sensor data.

3.1.5.2 GVAR/GRB

As discussed in section 2.4.3 above, the process of transitioning from the GVAR to the GRB service will begin once the GOES-R satellite is placed into full operation. Today, a small number of private forecasting services and university research institutions utilize GVAR to transport data that is used to create their own private forecasting models, provide specialized weather forecasts for private customers, or to conduct a wide variety of atmospheric research projects.

In order for users to receive the new GRB data stream, once it becomes available, these entities will have to replace much of their current receive equipment in order to continue to receive data transported via the GOES system. Components that these entities will need to replace include antennas and receiver hardware, as well as upgraded processing systems that are capable of processing higher volumes of data compared to GVAR[26].

The GRB channel will be approximately 12 MHz in width, centered on 1686.6 MHz[27]. Not only will this channel be in close proximity to the 1675-1680 MHz band, significantly it also will be less than 2.5 MHz away from the commercial AWS-3 uplink channel of 1695-1700. NOAA's GRB receive stations will be protected from AWS-3 with protection zones that were defined during the CSMAC process and ultimately adopted by the FCC.

It is not known how private users of the GVAR/GRB are preparing for the launch of AWS-3 services, since there are no protection zones defined for non-Federal facilities. However, whatever adaptations private users are making to avoid interference from AWS-3 operations presumably would also be useful in avoiding conflicts from operations in the 1675-1680 MHz band (as well as from the authorized existing and expanding use of the 1670-1675 MHz band).

Such conflicts typically are avoided by installing sharp filters in the receive stations' RF front end. However, given the close spectral position of AWS-3 and GRB (less than 2.5 MHz), this may not be feasible. Since protection zones were not established for non-NOAA facilities, the only practical solution may be for private entities to receive NOAA data through an alternate means: either a different satellite frequency (not necessarily operated by NOAA) or transported over a fiber optic network.

If private users receiving this data are not taking steps to prepare for the introduction of commercial service in the AWS-3 band, then they will likely experience disruption to their data reception due to AWS-3, independent of what occurs in the 1675-1680 MHz band.

3.1.5.3 EMWIN

EMWIN is a tool used by state and local governments and related public safety agencies as a means to receive weather-related warnings issued by NOAA that are specific to defined geographic areas. Through the use of EMWIN and third-party products, public

[26] www.goes-r.gov/users/grb.html
[27] http://www.goes-r.gov/users/grb.html

safety agencies can be quickly notified if there is a weather-related warning that has been issued for their locality.

When GOES-R becomes operational, EMWIN will begin its migration from 1692.7 MHz today to 1694.1 MHz. It is not expected that end users will have to replace or upgrade equipment as part of this switch.

Given its spectral separation from the 1675-1680 MHz band (approximately 14 MHz), out of band emissions from the commercial operator can be limited such that end-users receiving EMWIN directly from the GOES satellites would not be impacted by sharing of the 1675-1680 MHz band[28]. Disruptions due to the initiation of commercial service over the AWS-3 uplink at 1695 MHz could impact EMWIN reception via the GOES satellite. It is not known how this is being addressed within the EMWIN user community.

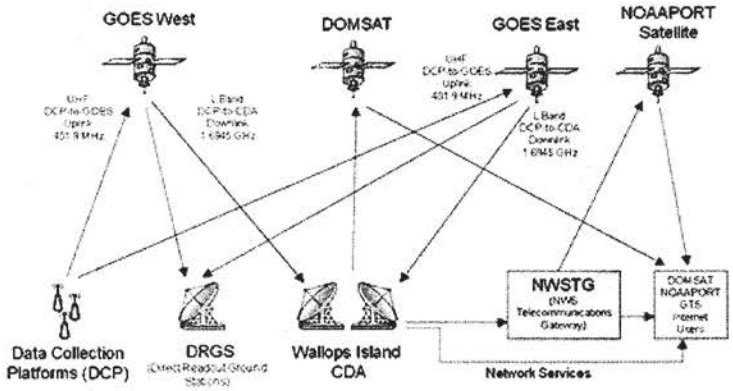
3.1.6 Alternate Means

There are a variety of means by which these private users can obtain NOAA data from non-GOES sources, and these sources are fully supported by NOAA today. These means are described in greater detail in the following sections, along with additional options that may not be supported by NOAA currently.

3.1.6.1 DOMSAT

DOMSAT is a NOAA-sponsored and supported service that rebroadcasts DCP data over the SES Americas SES-1 geostationary satellite operating at 101 degrees west on 11997.525 MHz. This data is provided on a no-fee, unencrypted basis to end users. Receiving equipment consists of a 1 meter dish which is approximately 1/5th the size that is required to receive the DCPR signal directly from a GOES L-Band satellite.

Figure 6 – DOMSAT in Relation to the Overall NOAA DCS Architecture



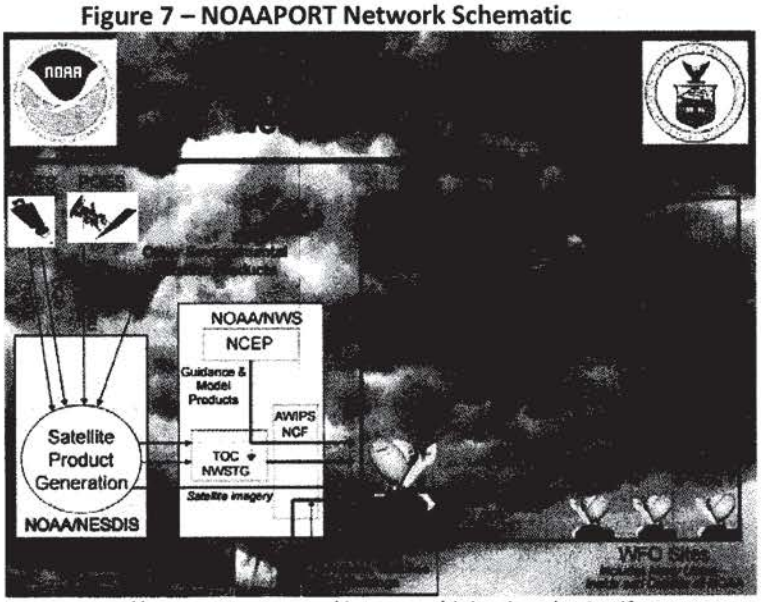
Source: http://www.osd.noaa.gov/Spacecraft%20Systems/Ground_Systems/GOES%20DCS/goesdcs.html

[28] At relatively close distances to the antennas of a 1675-1680 MHz base station, EMWIN users could experience interference due to OOBE, just as EMWIN users are susceptible today to such OOBE from a variety of other existing wireless operators in various spectrum bands.

3.1.6.2 NOAAPORT

NOAAPORT is a NOAA-provided service that provides DCP messages as well as imagery data, weather bulletins and other NOAA products. NOAAPORT data is distributed over the SES-1 satellite at 3995.85 MHz[29]. The satellite signal is received via an approximately 3.7 meter dish installed at the end-user location. Transmitting over the C-Band, NOAAPORT has the advantage that its signal is not susceptible to rain-fade. NOAAPORT data is processed by NOAA prior to distribution over the SES-1 satellite, which introduces latency of up to several minutes from the initial uplink of the data from the ground sensor, to distribution of that data to the end-user.

Figure 7 – NOAAPORT Network Schematic



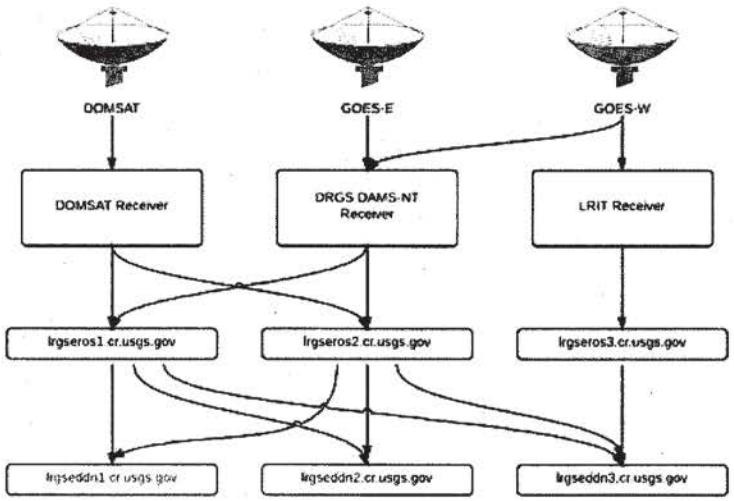
Source: http://www.nws.noaa.gov/datamgmt/slide_show/NP2.pdf

3.1.6.3 USGS EDDN

The United States Geological Survey, in cooperation with NOAA, operates the Emergency Data Distribution Network, to distribute DCS data to end users worldwide. Data is received by USGS using a Direct Readout Ground Station (" DRGS") in Sioux Falls, SD. Data is accessed by registered end-users over internet connections. There is no fee for this service.

[29] Source: http://www.nws.noaa.gov/datamgmt/slide_show/NP2.pdf. Frequency data current as of February 2014; presentation noted that frequency may change after pending system upgrade.

Figure 8 - Schematic of EDDN Network



Source: http://eddn.usgs.gov/eddnoverview.html

3.1.6.4 GTS/GIFS

NOAA's Global Telecommunications System ("GTS") Internet File Service ("GIFS") is a highly reliable internet source of meteorological products[30]. GIFS is designed and operated to provide weather data (including EMWIN warnings) to other World Meteorological Organization member countries. The publicly-available documentation of this service is not sufficient to assess whether or not this system could be useful to entities that rely on NOAA data within the US. However, because the GIFS program is able to reliably deliver large amounts of data over the internet, its architecture and operation could be a useful platform for any enhancement of NOAA capabilities that may be warranted in order to provide private users with NOAA data without relying on satellite transport of data.

3.1.6.5 GOES HRIT Equipment Upgrade

Beginning with the GOES-R satellite, the EMWIN transmissions will be combined with the new High Rate Information Transmission ("HRIT"), which replaces the previous LRIT, low rate service. This will move EMWIN from 1692.7 MHz to the HRIT channel which is centered on 1694.1 MHz. This 14 MHz separation from the 1675-1680 MHz channel will allow for the introduction of improved filters that will be able to improve the resiliency of EMWIN devices relative to the 1675-1680 MHz channel. Ideally, this retrofit would occur at the same time that whatever additional measures necessary to protect the EMWIN service from the AWS-3 band at 1695 MHz are implemented.

3.1.6.6 Private Network

Private networks are ideal for transporting large data streams such as those associated with the new GRB link in GOES-R, without utilizing or improving large amounts of spectrum needed for reception of NOAA data by private users. Optical/Fiber routes and

[30] http://www.nws.noaa.gov/iscs/nwsgtsfs.html

networks could be established connecting NOAA earth station facilities with the end users that are consumers of this data. This could take the form of point-to-point connections, or rings connecting multiple users along a shared route. Cooperative Networks

The University Corporation for Atmospheric Research (UCAR) is a consortium of colleges and universities focused on research and training in the atmospheric and related earth sciences[31]. UCAR today operates the Unidata IDD program, which disseminates large amounts of near-real-time meteorological earth observations to 260 universities via the internet. According to a 2006 NOAA and NASA presentation, Unidata IDD was at that time delivering products similar to those transported over the NOAA GVAR stream (e.g. satellite, radar and derived product imagery) to its user community[32]. This presentation also noted that the Unidata IDD network at that time was capable of "over 500 Mbps (5.4 TB per day) of data to downstream sites during a three day trial without introduction of product latency."[33] The GRB service will be transmitted at a data rate of 31 Mbps[34], which is well below the 500 Mbps rates tested in the Unidata study.

The Unidata IDD network is an example of the type of content delivery networks that are functioning today to disseminate meteorological data. This report does not delve into whether or not this specific content delivery network could be adapted to accommodate the GRB data stream, other than to point out that the ability to reliably transmit large amounts of data, with very low latency has already been proven and could be brought to bear for the task of transporting GRB data to private users. Of course, money center banks, financial markets, and other highly sophisticated users with little tolerance for latency have been using these kinds of networks for years.

3.1.6.7 Private satellite rebroadcast

There have been use cases identified by certain end users that require the real-time distribution of DCS data without the risk of potential outages to which other transport mediums may be susceptible (e.g. rain fade with 12 GHz DOMSAT, network outages with internet connections, etc.). In cases such as these, alternative private satellite retransmission should be explored. There is a large variety of options available to end-users wishing to utilize the commercial sector for such services and it would be feasible for NOAA to uplink its DCS data to one or more private satellites selected by the user community just as it does for the DOMSAT service today.

3.1.6.8 Co-Location at NOAA facilities (research)

One end-user interviewed for this report used the discrete GOES-EAST and GOES-WEST streams in order to advance technology to identify DCS uplinks that were improperly transmitting in the same timeslot, thus causing data corruption. This research required

[31] http://www2.ucar.edu/about-us

[32] "GOES-R Data Distribution" presented by Thomas Renkevens (NOAA/NESDIS/OSD), 4th GOES-R Users' Conference, Broomfield, CO. May 2, 2006. Slide 19.
http://www.goes-r.gov/downloads/GOES_Users_ConferenceIV/Presentation%20slides/GUC4_session4_pr_Renkevens.ppt

[33] Id. at slide 20.

[34] http://www.goes-r.gov/users/grb.html

access to the individual data streams eliminating the DOMSAT option which combines the two data streams together into a single transmission. To the extent this entity could no longer collect this data from its primary location due to the implementation of a commercial wireless network, the ability of researchers such as these being able to co-locate their receiving equipment inside established NOAA facilities (and their corresponding geographic protection zones) would be a reasonable solution that should be studied further.

Figure 9 – Summary of Potential Impacts and Alternatives

	Likelihood of Interference from 1675-1680	Solution via Improved Filtering?	Current Alternate Delivery Methods	Other Alternate Delivery Methods	Potential AWS-3 Impact?
DCS/DCPR	High	No	1 2 3	4 8 9	Low
GVAR/GRB	High	No	7 (GVAR)	6	High
EMWIN	Low	Yes		1 2 5 8	High

Alternate Delivery Method Key

1 DOMSAT
2 NOAAPORT
3 USGS EDDN
4 GTF/GIFS
5 HRIT Receiver Upgrade
6 Private Network
7 Cooperative Network
8 Private Satellite
9 Co-Location

4 Conclusions

The data and information discussed herein indicates that the 1675-1680 MHz band can be successfully shared between NOAA and a commercial wireless network. With respect to NOAA's use of the band, the detailed reports prepared by Alion Science and Technology in 2014 (i) describe the specific means by which NOAA's radiosondes could be relocated to avoid any interference from commercial operations, and (ii) set forth recommendations for defined protection and coordination zones that would ensure that commercial operations are compatible with NOAA facilities remaining in the band.

With respect to non-NOAA users, LightSquared's study of the data and services received by non-NOAA private users and its discussions with many such private users suggests that commercial operations in the band would have little-or-no impact on many non-NOAA users, and that a number of sound and efficient alternative options are available to non-NOAA users who could potentially be impacted. A public notice-and-comment process would undoubtedly produce additional useful information regarding non-NOAA users' receipt of data and services in the 1675-1680 MHz band and nearby bands, as well as information regarding other alternative means by which such data and services may be received.