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10 April 2017

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

RE: Written *ex parte* submission in RM-11681; IB Docket No. 11-109; IBFS File Nos. SES-MOD-20151231-000981, SAT-MOD-20151231-00090, SAT-MOD-20151231-00091

Dear Ms. Dortch:

The potential for rulemaking related to the 1675-1680 MHz portion of spectrum is of significant concern to America's weather enterprise, including those businesses, trade groups, scientific organizations, academic institutions, and government agencies responsible for providing meteorological research and services.

Who We Are

The mission of the American Meteorological Society (AMS) is to advance the atmospheric and related sciences, technologies, applications, and services for the benefit of society. The AMS is the nation's premier scientific and professional organization promoting and disseminating information about the atmospheric, oceanic, hydrologic sciences, with 13,000 members, including scientists, researchers, educators, broadcast meteorologists, and other professionals in the fields of weather, water, and climate. (See www.ametsoc.org)

The mission of the American Geophysical Union (AGU) is to "promote discovery in Earth and space science for the benefit of humanity." AGU galvanizes a community of Earth and space scientists that collaboratively advances and communicates science and its power to ensure a sustainable future. With over 60,000 members, AGU is a leader, collaborator, and sought after partner for scientific innovation, rigor, and interdisciplinary focus on global issues. (See www.agu.org)

The Space Science and Engineering Center (SSEC) of the University of Wisconsin-Madison is a research and development center focusing on geophysical research and technology to enhance our understanding of the atmosphere of the Earth and other planets in our Solar System. The SSEC data center, one of the longest standing archives of meteorological satellite imagery in the world, is designed to acquire environmental satellite data from around the world in real time (i.e., as measurements are taken), which allow SSEC scientists to collaborate with key government warning and forecast centers to ensure the very latest techniques and products are available to our national frontline meteorologists. (See ssec.wisc.edu)

Importance of Sharing Weather Data

A long standing and successful public-private partnership, America's weather enterprise has a history of working with the National Oceanic and Atmospheric Administration (NOAA) on mechanisms for collecting and sharing a wide variety of government foundational weather and environmental data, including geostationary satellite observations of the weather to enable timely forecast and warnings to businesses and the public. These warnings save lives, protect property and enhance the American economy. Ligado Networks LLC, herein referred to as Ligado, continues to urge the FCC through its filings to proceed with rulemaking in the 1675-1680 MHz portion of the spectrum. Ligado's premise is that the arrangement between NOAA and its partners and stakeholders, herein referred to as non-NOAA users, for collecting and distributing observations via satellite-delivery network can be altered to use the Internet without impacting public safety. This is a false, misguided and dangerous approach.

Importantly, non-NOAA users who make use of geostationary satellite data include the academic community, America's Weather Industry, state and local government users, non-profit organizations and also other federal agencies outside of NOAA. These users are located in a variety of US states and territories.

Ligado suggests that non-NOAA users expressing concern about the availability of weather satellite data over the Internet do not understand "how these sorts of enterprises access the Internet"[1]. This is perplexing because the timely receipt of weather data, particularly government weather data, is often necessary to support the core business objectives of non-NOAA users providing commercial services or provisioning data to third party consumers. Non-NOAA users can and do receive weather data via multiple means and redundant access methods to ensure its consideration in the weather analysis, forecasting, and warning generation process, including over the Internet. But the reason that alternative delivery is important is precisely because satellite-based delivery was designed to achieve higher availability than even the best Internet connectivity and cloud services provide today.

In its filings to date[2] Ligado has consistently underestimated the availability requirement for weather satellite data. They most recently provided the FCC an overview of enterprise-quality

[1] *See* Presentation of Ligado Networks LLC, RM-11681 at pgs. 3 & 4 (Mar. 1, 2017) ("The Non-NOAA Users Are Sophisticated Enterprises with Reliable Access to the Cloud").
[2] *See* Reply Comments of Ligado Networks LLC, RM-11681 at 23-16 (Aug. 11, 2016) ("Ligado Reply Comments").

Internet connectivity options for businesses in an apparent attempt to ameliorate any concerns of non-NOAA users about timely access or receipt to weather satellite data served via a cloud service. A thorough assessment of the facts proves that this overview of options simply does not provide a suitable alternative for non-NOAA users, as detailed below.

New Generation Geostationary Weather Satellite

The first satellite in NOAA's Geostationary Operational Environmental Satellite R-Series (GOES-R) was launched in November 2016[3]. In the coming years, subsequent satellites in the series will launch to provide continuous imaging capabilities over the Americas and adjacent oceanic portions of the Western Hemisphere for approximately the next two decades. GOES-R represents a tremendous upgrade over the current U.S. constellation of geostationary weather satellites, both in terms of the nature of the data it collects and how users receive that data. And in some places, satellite data is the only source of information meteorologists have for making a forecast and generating critical warnings. The GOES-R series of satellites promises to make satellite data as indispensable to the generation of forecasts and warnings as weather radar, in a complementary manner.

NOAA, recognizing the needs of its partners in the weather enterprise, established the Ground Segment Project Functional and Performance Specification (F&PS) for the GOES-R series. The F&PS contains specific benchmarks related to the operation of the GOES-R series satellites and receipt of their data. It requires the GOES-R Rebroadcast (GRB) service, with a center frequency of 1686.6 MHz, to have an availability of 99.988% over a 30-day period[4]. This availability ensures no more than five minutes of down time in a one-month window, essentially the time it takes to capture one image of the contiguous United States and ten mesoscale sectors. Mesoscale sectors, captured at 30-second intervals, cover an area of approximately 1000 by 1000 km in order to rapidly scan evolving or threatening weather conditions.

Routine and consistent imagery is necessary for meteorologists because early indicators of thunderstorm or volcanic eruption severity are often revealed through the initial cloud growth. Determining the rate of this initial cloud growth (e.g., how quickly a cloud is building vertically in the atmosphere), requires imagery at a fixed short interval. (These new "movie-like" images are most reliability disseminated in the shortest possible time via the GRB broadcast.) This new capability will be used to improve aviation and maritime safety and most certainly save lives and help to protect property throughout the GOES-R satellite's coverage area.

Thus, in order for a Content Delivery Network (CDN) to meet that reliability for GRB users, the combined availability of the cloud service and associated Internet connectivity and data delivery would have to be at least 99.988% each month. This is a particularly high bar, but the United States government has made the substantial investment in the GOES-R series to enable this capability, not only for NOAA users, but also for non-NOAA users. Examining top-tier network services and data storage solutions suggests why this investment was made in the best interest of American taxpayers.

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[3] NOAA, http://www.goes-r.gov/

[4] NOAA, http://www.goes-r.gov/resources/docs/GOES-R_GS_FPS.pdf

However, this discussion of the content dissemination services, and availability requirements should not lose sight of the fact that GOES GVAR and GOES-R GRB ground receiving stations would likely receive significant disruptive interference from proposed Ligado systems due to the much higher power and proximity of commercial systems. This is a similar problem to that expressed by Iridium, who is concerned about interference to their receive terminals as shown in http://www.satellitetoday.com/telecom/2017/03/31/iridium-ligado-dispute-spectrum-heats/?hq_e=el&hq_m=3384344&hq_l=3&hq_v=927d8a9611

Availability of Terrestrial and Cloud Networks

In their letter to the FCC on 1 March 2017, Ligado provides examples of business and enterprise network services from major telecommunications companies. In our analysis of these recommended service providers, we considered the information that Ligado cited or was otherwise publicly available. We did not conduct an independent analysis, nor do we stipulate to know that non-NOAA users are geographically located such that access to suitable business and enterprise network services is available, practical, or affordable. We maintain that non-NOAA users are diverse in their network service demands, and strongly disagree that all non-NOAA users are "sufficiently large enterprises" because they can afford a one-time cost of an antenna and associated site and installation activities.

Additionally, not all users are situated at the access points for commercial distribution networks, requiring users to procure added connectivity for the "last mile" from the cloud services access point to their actual premises. The availability of this "last mile" connectivity, which is subject to failure under a variety of situations, including severe environmental conditions, must also be factored into whether an end user can obtain the required information when needed.

Both AT&T[5] and Verizon[6] have competitive Service Level Agreements (SLAs) that target a minimum of 99.5% packet delivery in North America, which is well below 99.988%. In fact, it is over 40 times worse. Even in practice, the online statistics that Verizon publically provides show that the established GRB target is not met the majority of the time. In the period from February 2016 through January 2017, the last month for which data was available as of this writing, only three of the twelve months (25%) exceeded a packet delivery of 99.988% in North America[7].

Furthermore, this shortcoming only applies to the network service segment of the CDN. In fact, a cloud service will have a separate SLA and can only decrease the total target for the combined network and cloud service availability. As one example, Amazon's Elastic Compute Cloud (EC2) SLA has a 99.95% availability target over one month[8], not only below the 99.988% established GRB target but allowing for a much more substantial single disruption. Each 0.05% of availability is equivalent to just over 20 minutes each month.

[5] AT&T, https://www.business.att.com/content/productbrochures/dedicated-internet-brief.pdf
[6] Verizon, http://www.verizonenterprise.com/products/networking/dedicated-internet-services/
[7] Verizon, http://www.verizonenterprise.com/about/network/latency/
[8] Amazon Web Services, https://aws.amazon.com/ec2/sla/

Safety of Life and Property Depend Upon Availability of Satellite Data

In practice, while Amazon's cloud services are commonly used, and highly recognized for their reliability, they are not infallible. On 28 February 2017, Amazon's Simple Storage Service (S3), which has a SLA-defined target availability of 99.9% (allowing for a monthly outage of over 40 minutes) experienced a failure that lasted several hours[9]. Later that day, tornadoes ravaged the U.S. Midwest, leading to several casualties[10]. Considering the average tornado warning lead-time of 13 minutes[11], had thunderstorms formed earlier and the weather enterprise committed to a cloud service that failed to deliver, the threat to life and property for people and businesses putting their trust in America's weather enterprise would have grown substantially.

Service	Outage Allowed based on cloud service (30 days)	Service Availability Target (%)	Combined Availability with Terrestrial "Last Mile" Internet Delivery (%)
GOES-R GRB Broadcast	5 minutes	99.988%	No Change
Amazon EC2 Service	20 minutes	99.95%	99.93%
Amazon Simple Storage	40 minutes	99.9%	99.88%

Table 1: A Comparison of the GRB Broadcast to Cloud Services[12]

Table 1 provides a comparison of the outage times allowed in a 30-day period. The GOES-R functional and performance specification only allows approximately 5 minutes of outage, whereas some of the commercial systems allow over 40 minutes outage in a 30 –day period. Additionally, these various commercial services are not specified to the user's location, driving the necessity for "last mile" connectivity (i.e., the neighborhood infrastructure). Even if an end user subscribed to multiple Internet providers (multi-homing), as was suggested by Ligado, often multiple sources utilize the same infrastructure or same conduits as competing services. One failure can impact them all.

The consequence of failing to achieve availability metrics is much greater for time-sensitive weather information than other commercial uses, precisely because time is of the essence when lives and property are at risk. Outages of even a few minutes, let alone a few hours, could dramatically alter derivative information that the weather enterprise provides to customers and

[9] Amazon Web Services, https://aws.amazon.com/message/41926/
[10] Storm Prediction Center, http://www.spc.noaa.gov/climo/reports/170228_rpts.html
[11] NOAA, http://www.noaa.gov/stories/tornadoes-101
[12] The availability of data delivered by a cloud service is also compounded by the availability of the Internet between the content delivery network (CDN) and the user, assuming a generous 99.99% availability for both the CDN network services and end user network (so called "last mile"). The 99.99% availability may not be available or achievable for all end users and does not include packet delivery reliability, or account for exceptions to the SLA, such as natural disasters, which would inevitably lower availability.

partners. Returning to the GOES-R F&PS, NOAA requires a restoration of GOES-R series GRB functionality, or any function that supports it in the ground system, within five minutes. This requirement complements the 99.988% availability of the GRB service. In contrast, Comcast's mean time to restore service as established in their service-level objectives is four to six hours[13], similar to the amount of time Amazon Web Services required to resolve their S3 outage.

In four to six hours, tropical cyclones can veer off track, tornadoes can form and dissipate, and volcanoes can have explosive eruptions, threatening life and property. It is for this reason that NOAA has made multiple methods for data access possible, and why interference or interruption to any data provided over GRB would be encumbering to the work of weather professionals and ultimately perilous for Americans. While Ligado claims that they have demonstrated a prototype of a CDN that ameliorates the concerns of the non-NOAA users, we are unaware of any attempt to independently verify its performance in practice over a substantial period of time, and with GRB data, which only became available on 1 March 2017, the date of their latest filing. GRB data comes at a substantially higher data rate, 31 Mbps[14], compared to the current GOES delivery. Ligado has also not demonstrated the cost of the CDN with the high availability constraints of a commercial weather data and information provider; this is a cost that, under their proposal, would eventually be passed off onto the users of such a service.

During Hurricane Sandy, power outages and flooding disrupted mobile coverage for cellphones, television, home telephones and Internet services throughout the Northeastern states[15]. Verizon Wireless, AT&T, Inc., Sprint Nextel, and T-Mobile USA were encountering wireless service problems, as well as cable operators Cablevision Systems Corp, Comcast Corp and Time Warner Cable during and after the hurricane. Sandy disrupted the energy and transportation infrastructure throughout the mid-Atlantic region. The storm left 8.5 million customers without power[16]. The (then) chairman of the FCC, Julius Genachowski, and the FCC Public Safety and Homeland Security Bureau Chief commented initially that 25% of both cell sites and cable services had failed[17]. A CDN with Internet "Last Mile" would likely fail to deliver data to affected end users and decision makers under these conditions.

Time Sensitive Data for Flood Warning

Tide gages of the National Ocean Service and USGS provided data that documented inundation throughout the affected Hurricane Sandy region. Storm surge flooding was reported in New

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[13] Comcast, https://cdn.wcdc.business.comcast.com/~/media/business_comcast_com/PDFs/Dedicated%20Internet/EthernetDedicatedInternetServiceTechnicalDescriptionSLS56937Rev814pdf.pdf?rev=afb5cefe-7680-464e-ac2b-5050daf4e3ce

[14] NOAA, http://www.goes-r.gov/users/grb.html

[15] Reuters, Inc., "Update 3 – Hurricane Sandy disrupts Northeast US telecom networks," Tuesday October 30, 2012 http://www.reuters.com/article/storm-sandy-telecommunications-idUSL1E8LUEFU20121030

[16] FEMA, "Hurricane Sandy FEMA After-Action Report", July 1, 2013 https://www.fema.gov/media-library-data/20130726-1923-25045-7442/sandy_fema_aar.pdf

[17] https://apps.fcc.gov/edocs_public/attachmatch/DOC-317139A1.pdf

York, and in New Jersey, Connecticut, Rhode Island, Massachusetts, New Hampshire, Maine, Delaware, Maryland, The Carolinas, Georgia, Florida and Virginia.[18] This gage data is relayed via GOES Data Collection System (DCS)[19], which on GOES-16 and the newest generation of NOAA geostationary satellites would be in-band to the proposed Ligado services. A CDN and Internet "last mile" combination would likely fail to deliver data to affected end users and decision makers in a serious flooding situation.

Conclusion

We urge pause and recommend that the FCC not proceed with rulemaking in the 1675-1680 MHz portion of the spectrum. A rulemaking at this time without a clear and reliable alternative to important data transmissions that GOES-R will facilitate would pose certain irresolvable challenges to the weather enterprise engaged in serving public safety interests. We are confident that a review of the facts surrounding the availability of network and cloud services, weather satellite data requirements of America's weather enterprise, and a commitment to the American public's interest in accurate and reliable warnings of threatening weather outweigh the benefit of making this spectrum available for mobile broadband. The spectrum allocated for important weather information has already been consolidated in size[20], which must accommodate the weather enterprise's diverse needs for federal spectrum now and in the decades ahead. America's weather enterprise is united in opposition to further regulatory action related to spectrum that includes or is adjacent to the GRB frequency centered at 1686.6 MHz or in-band to the GOES-R DCS from 1679.7 – 1680.4 MHz.

[18] NOAA's National Hurricane Center, "Tropical Cyclone Report – Hurricane Sandy 22 – 29 October 2012" 12 February 2013 http://www.nhc.noaa.gov/data/tcr/AL182012_Sandy.pdf

[19] In October 2016, flooding in North Carolina as a result of Hurricane Matthew resulted in 28 fatalities in that state, of which 17 were associated with vehicles that were swept off flooded roadways. Five fatalities in South Carolina were attributed to flooding. More than 600 roads had to be closed in North Carolina, including portions of Interstates 40 and 95. [USGS report on Peak State and Streamflow Data]

[20] The FCC sold 1670 - 1675 MHz at auction 46 in May 2003, indicating that this 5 MHz was to be shared on a co-primary basis with the Federal Government. http://wireless.fcc.gov/auctions/default.htm?job=auction_factsheet&id=46 and the FCC sold Block A1: 1695 - 1710 MHz at auction 97 (for about $2.4B) as part of the AWS-3 sale. http://wireless.fcc.gov/auctions/default.htm?job=auction_factsheet&id=97 This means that NOAA has already shared 50% of the spectrum (e.g., 20 MHz out of the 40 MHz) they were/are authorized to use in the 1670-1710 MHz band.

Sincerely,

Dr. Keith Seitter, Ph.D.
AMS Executive Director

Christine W. McEntee
AGU Executive Director

Dr. Steven Ackerman, Ph.D.
Interim SSEC Director
University of Wisconsin—Madison

cc:
The Honorable Wilbur Ross, Secretary of Commerce
Benjamin Friedman, the Acting Under Secretary of Commerce for Oceans and Atmosphere and NOAA Administrator
Office of the Assistant Secretary of Communications and Information and NTIA Administrator
The Honorable John Thune, Chairman, Senate Commerce, Science and Transportation Committee
The Honorable Bill Nelson, Ranking Member, Senate Commerce, Science and Transportation Committee
The Honorable Roger F. Wicker, Chairman, Subcommittee on Communications, Technology, Innovation and the Internet, Senate Commerce, Science and Transportation Committee
The Honorable Brian Schatz, Ranking Member, Subcommittee on Communications, Technology, Innovation and the Internet Senate Commerce, Science and Transportation Committee
The Honorable Dan Sullivan, Chairman, Subcommittee on Oceans, Atmosphere, Fisheries, and Coast Guard, Senate Commerce, Science and Transportation Committee
The Honorable Gary C. Peters, Subcommittee on Oceans, Atmosphere, Fisheries, and Coast Guard, Senate Commerce, Science and Transportation Committee
The Honorable Roy Blunt, Subcommittee on Aviation Operations, Safety and Security, Senate Commerce, Science and Transportation Committee
The Honorable Maria Cantwell, Subcommittee on Aviation Operations, Safety and Security, Senate Commerce, Science and Transportation Committee
The Honorable Richard Shelby, Chairman, Subcommittee on Commerce, Justice, Science, and Related Agencies, Senate Appropriations Committee
The Honorable Jeanne Shaheen, Ranking Member, Subcommittee on Commerce, Justice, Science, and Related Agencies, Senate Appropriations Committee
The Honorable Greg Walden, Chairman, House Energy and Commerce Committee
The Honorable Frank Pallone, Ranking Member, House Energy and Commerce Committee
The Honorable Marsha Blackburn, Chairman, Communications and Technology Subcommittee, House Energy and Commerce Committee
The Honorable Michael Doyle, Ranking Member, Communications and Technology Subcommittee, House Energy and Commerce Committee
The Honorable John Shimkus, Chairman, Environment Subcommittee, House Energy and Commerce Committee
The Honorable Paul Tonko, Ranking Member, Environment Subcommittee, House Energy and Commerce Committee
The Honorable Andy Biggs, Chairman, Subcommittee on Environment, House Science, Space and Technology Committee
The Honorable Suzanne Bonamici, Ranking Member, Subcommittee on Environment, House Science, Space and Technology Committee
The Honorable Doug Lamborn, Chairman, Subcommittee on Water, Power and Oceans, House Natural Resources Committee
The Honorable Jared Huffman, Ranking Member, Subcommittee on Water, Power and Oceans, House Natural Resources Committee
The Honorable John Culberson, Chairman, Subcommittee on Commerce, Justice, Science, and Related Agencies, House Appropriations Committee
The Honorable José Serrano, Ranking Member, Subcommittee on Commerce, Justice, Science, and Related Agencies, House Appropriations Committee
The Honorable Jim Bridenstine
The Honorable Tammy Baldwin