

**Before the  
FEDERAL COMMUNICATIONS COMMISSION  
Washington, DC 20554**

In the Matter of )  
 )  
Comment Sought to Update the )  
Record on Ligado’s Request That the )  
Commission Initiate A Rulemaking to ) RM-11681  
Allocate the 1675-1680 MHz Band For )  
Terrestrial Mobile Use Shared With Federal )  
Use )

**REPLY COMMENTS OF LIGADO NETWORKS LLC**

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**REPLY COMMENTS OF LIGADO NETWORKS LLC**

**I. INTRODUCTION AND SUMMARY**

Contrary to the clear statement in the President’s Budget over the past four years that the 1675-1680 MHz band should be shared with commercial uses,<sup>1</sup> and the bipartisan support of Congress<sup>2</sup>, the wireless industry<sup>3</sup>, and public interest groups<sup>4</sup> for the same policy goal, many comments submitted from those in the weather enterprise saw only problems with moving to a Notice of Proposed Rulemaking (“NPRM”) to reallocate and auction the 1675-1680 MHz band. The weather enterprise commenters urged the Commission to proceed with caution—ostensibly

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<sup>1</sup> See *Fiscal Year 2014 Analytical Perspectives, Budget of the U.S. Government*, Office of Management and Budget, at 228–229; *Fiscal Year 2015 Analytical Perspectives, Budget of the U.S. Government*, Office of Management and Budget, at 199; *Fiscal Year 2016 Analytical Perspectives, Budget of the U.S. Government*, Office of Management and Budget, at 215; *Fiscal Year 2017 Analytical Perspectives, Budget of the U.S. Government*, Office of Management and Budget, at 220.

<sup>2</sup> See S. Rep. No. 113-181, at 46–47 (2014).

<sup>3</sup> Comments of CTIA – The Wireless Association, RM-11681 (June 21, 2016), at 2.

<sup>4</sup> Comments of Public Knowledge and Open Technology Institute at New America, RM-11681 (June 21, 2016), at 1–2.

to allow time to study the issues presented by the possibility of sharing the spectrum—and to ensure that the operations of the National Oceanic and Atmospheric Administration (“NOAA”) are protected.<sup>5</sup> They did not suggest that it could not or should not be done; they merely urged the Commission to engage in a deliberate process. Ligado, too, supports such a process and urges issuance of an NPRM as the next and appropriate step in that process.

Ligado fully appreciates the importance of the vital weather information that NOAA provides to the Nation, and also acknowledges the weather enterprise, educational and research institutions, and other entities that depend on this necessary information to carry out their own important missions and to support others who similarly rely on weather-related data. Many of those who submitted comments expressed concerns that shared commercial use of the 1675-1680 MHz band could disrupt the 27,000 hydrology, seismic, and environmental sensors monitored by federal and state governmental agencies, could impair research and educational institutions that depend on NOAA data. Many also expressed concerns that an alternative distribution model for those non-NOAA users and the numerous organizations that derive information and services from those users is insufficiently reliable, robust, or cost-effective.

What Ligado has learned and explains in detail below is that the four dozen or so commenters somehow have developed a fundamental misunderstanding of how NOAA collects and distributes weather data. It is true that NOAA uses both uplink and downlink spectrum to collect and distribute data. But only very limited transmission of weather data occurs in the spectrum that is at issue in this proceeding, and these limited transmissions can be preserved through substantial protection zones and other license conditions.

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<sup>5</sup> See, e.g., Comments of American Meteorological Society, RM-11681 (June 20, 2016), at 3.

Because NOAA's operations can be protected, Vice Admiral Manson Brown, deputy administrator for NOAA, told Doug Smith, Chief Executive Officer of Ligado, in a meeting in April 2016 that NOAA would be able to support moving forward with the auction of this spectrum as set forth in the President's Budget, provided NOAA has enough time to be sure that the necessary steps are taken to protect NOAA's mission.<sup>6</sup> One of those steps is to explore whether those parties that use the data NOAA provides will still be able to access that data. That particular issue would be addressed by the creation and continued operation (by NOAA, the license winner, or an alternative suitable entity) of an alternative content delivery network ("CDN") to distribute the data.

This important statement from Vice Admiral Brown indicates the leadership of NOAA is committed to determining how the President's budgetary goal can be fulfilled. For that reason, it was troubling that at an American Meteorological Service ("AMS") meeting in July 2016, Beau Backus, a representative of the Aerospace Corporation, appeared to speak for NOAA and told the assembled group that "NOAA does not recommend sharing of 1675-1680 MHz."<sup>7</sup> It was equally troubling that NOAA staff earlier this year handed out a presentation, on NOAA letterhead, to Senate staff deliberately and explicitly arguing against any sharing of 1675-1680 MHz.<sup>8</sup> Moreover, despite the clear commitment conveyed by Vice Admiral Brown to try to resolve any concerns with the President's budgetary directive, NOAA staff has refused Ligado's

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<sup>6</sup> See Letter from Doug Smith, President and CEO, Ligado Networks LLC, to Vice Admiral Manson Brown, Deputy Administrator, NOAA (Apr. 20, 2016); Letter from Zachary Goldstein, Chief Information Officer and Director, High Performance Computing and Communications, NOAA, to Doug Smith, President and CEO, Ligado Networks LLC (May 12, 2016), submitted as Attachment A hereto.

<sup>7</sup> Beau Backus, Spectrum and the U.S. Weather Enterprise (July 21, 2016), *available at* <https://ams.confex.com/ams/2016AMSSCM/webprogram/meeting.html#Thursday1> (last visited Aug. 11, 2016).

<sup>8</sup> See Zachary G. Goldstein, NOAA Satellite Spectrum (Jan. 20, 2016), submitted as Attachment B hereto.

repeated attempts to discuss NOAA's spectrum and engineering concerns and how the proposal described below can be improved to meet NOAA's legitimate needs. While it has been difficult to identify and understand NOAA's concerns without their cooperation, Ligado has nonetheless made progress due to open and frank dialogue with the American Meteorological Society and others in the weather enterprise. Ligado has learned that a small number of real concerns exist—and practical, implementable solutions can resolve each concern if the Commission carefully crafts license conditions to impose on the licensee that protect NOAA's mission and operations.

After exercising its auction authority for twenty-three years, the Commission has deep experience in setting service rules and designating spectrum for auction. It is not new that a proposed new use of spectrum raises (or is thought to raise) interference concerns for an incumbent. What has worked in the past, and what can work here, is to have the license winner incur the obligation to address the interference issue with solutions that must be in place prior to deployment of the new spectrum. Examples include microwave relocation as part of the first PCS auction and the move of broadcast frequencies at a cost of up to \$1.75 billion in the current broadcast-to-wireless auction.<sup>9</sup> The merit of holding the auction first and then obliging the license winner to resolve the issues is obvious: this sequence creates a motivated problem solver who can provide and effectuate solutions. The current proposal to award by fee or auction the 1675-1680 MHz band is no different. Indeed, it is a perfect example of why the Commission should promptly—after four years of the President asking for action and Congress echoing that—issue an NPRM proposing the steps to be taken to award the terrestrial license.

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<sup>9</sup> See *Redevelopment of Spectrum to Encourage Innovation in the Use of New Telecommunications Technologies*, First Report & Order, 7 FCC Rcd. 6886, 6890–91 (1992); *Expanding the Economic and Innovation Opportunities of Spectrum Through Incentive Auctions*, Report & Order, 29 FCC Rcd. 6569, 6580–81 (2014).

Ligado respectfully submits that the NPRM should contain two proposed conditions on the license: *First*, NOAA’s earth stations should be protected as described in detail below. *Second*, NOAA’s data that is currently transmitted over this and adjacent bands to a very limited number of non-NOAA users should be made accessible to any and all users through the creation of a CDN. That CDN could be wholly paid for by the license winner or could remain fully within NOAA’s jurisdiction. Ligado’s proposal for such a CDN is described below.

With these conditions, all of NOAA’s activity, whether related to data acquisition or data distribution, will continue without disruption—either because it is already wholly unaffected by activity in this channel, or because it will be fully protected by the licensee, or because it will be transitioned over time to a fully functioning alternative. This proposal represents a vast improvement over the \$123,000 it now requires in up-front costs to access NOAA’s GVAR and GRB weather data.<sup>10</sup> It is clearly not in the public interest for such an important set of data—weather information—to be so poorly distributed. It is high time to broaden availability of this data, and the creation of a CDN will do just that. At the same time, shared use of the band can help unlock the potential of the next wave of broadband technology, including 5G and the Internet of Things (“IoT”), and generate billions of gross domestic product.<sup>11</sup>

The proposal to reallocate this band to shared use with the government and commercial sector is consistent with the President’s Budget for the past four years, is consistent with the views expressed by Congress in passing two omnibus appropriations spending bills, is consistent with the President’s goal of freeing 500 megahertz of spectrum for commercial use to meet

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<sup>10</sup> See *infra* Section II. B.

<sup>11</sup> Coleman Bazelon, *Putting Mid-Band Spectrum to Work: Sharing between Ligado Networks and its GPS Neighbors* (May 2016), at 15, *filed as attachment to Comments of Ligado Networks LLC, IB Docket No. 11-109* (May 23, 2016).

growing demand, is consistent with Chairman Wheeler’s goal of identifying spectrum to enable the U.S. to transition to 5G and thereby lead the global mobile economy and the development of IoT, is consistent with the request of a bipartisan group of Members from the House Commerce Committee to move this band promptly to auction, and is consistent with the public interest because it can be achieved in a manner that fully protects current users of the band and has the added benefit of making vital government weather information available to a much broader range of persons at a fraction of current costs.

## **II. THE PROPOSED SHARING OF 1675-1680 MHz WILL NOT IMPEDE NOAA’S OPERATIONS AND WILL NOT AFFECT NOAA’S DATA COLLECTION ACTIVITY.**

A high-water mark of misunderstanding regarding how NOAA’s operations would be affected by use of the 1675-1680 MHz band was a recent article in *Nature* magazine, which stated: “If Ligado’s application is granted, [the GOES-R] ‘rebroadcast’ service is likely to be interrupted — affecting forecasts of phenomena such as the spread of smoke during wildfires or the disruption of plane flights by volcanic ash.”<sup>12</sup> The article describes this situation as “untenable” and was accompanied by a drawing that contains the misinformation that in turn is echoed in the four dozen comments. Ligado agrees that it would be “untenable” to create a situation in which critical data, such as data that could help forecast the spread of smoke in wildfires, would be unavailable to those that need it. The problem with this claim is that nothing about sharing NOAA spectrum at 1675-1680 MHz means that this vital weather information

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<sup>12</sup> Alexandra Witze, *Mobile-phone Expansion Could Disrupt Key Weather Satellites*, *Nature* (July 12, 2016), [http://www.nature.com/news/mobile-phone-expansion-could-disrupt-key-weather-satellites-1.20249?WT.ec\\_id=NATURE-20160715&spMailingID=51828243&spUserID=MTQxNjYyMTQ4OTI2S0&spJobID=961919509&spReportId=O TYxOTE5NTA5S0](http://www.nature.com/news/mobile-phone-expansion-could-disrupt-key-weather-satellites-1.20249?WT.ec_id=NATURE-20160715&spMailingID=51828243&spUserID=MTQxNjYyMTQ4OTI2S0&spJobID=961919509&spReportId=O TYxOTE5NTA5S0) (“Nature Article”). The generic use of “rebroadcast” is a bit ambiguous, as it is not clear whether the author is referring to DCPR, GVAR/GRB, or both.

would be unavailable or affected.<sup>13</sup> More importantly, nothing in the record explains how sharing would cause the type of interruption described in the *Nature* article. First, GOES-R transmission to NOAA earth stations can and would be shielded by substantial protection zones, as defined by an engineering company recommended by NOAA, to guard against any such interference. Second, GOES-R DCPR will broadcast at 1679.7 and above, and not, as many commenters suggest, across the entire band being considered for sharing. Third, GOES-R has not even launched yet; it is scheduled to launch later this year. That means the Commission, NOAA, and the weather enterprise along with the license winner have several years before this spectrum would be actually utilized for commercial use. Ample time will be available to resolve concerns like this one, should it be necessary.

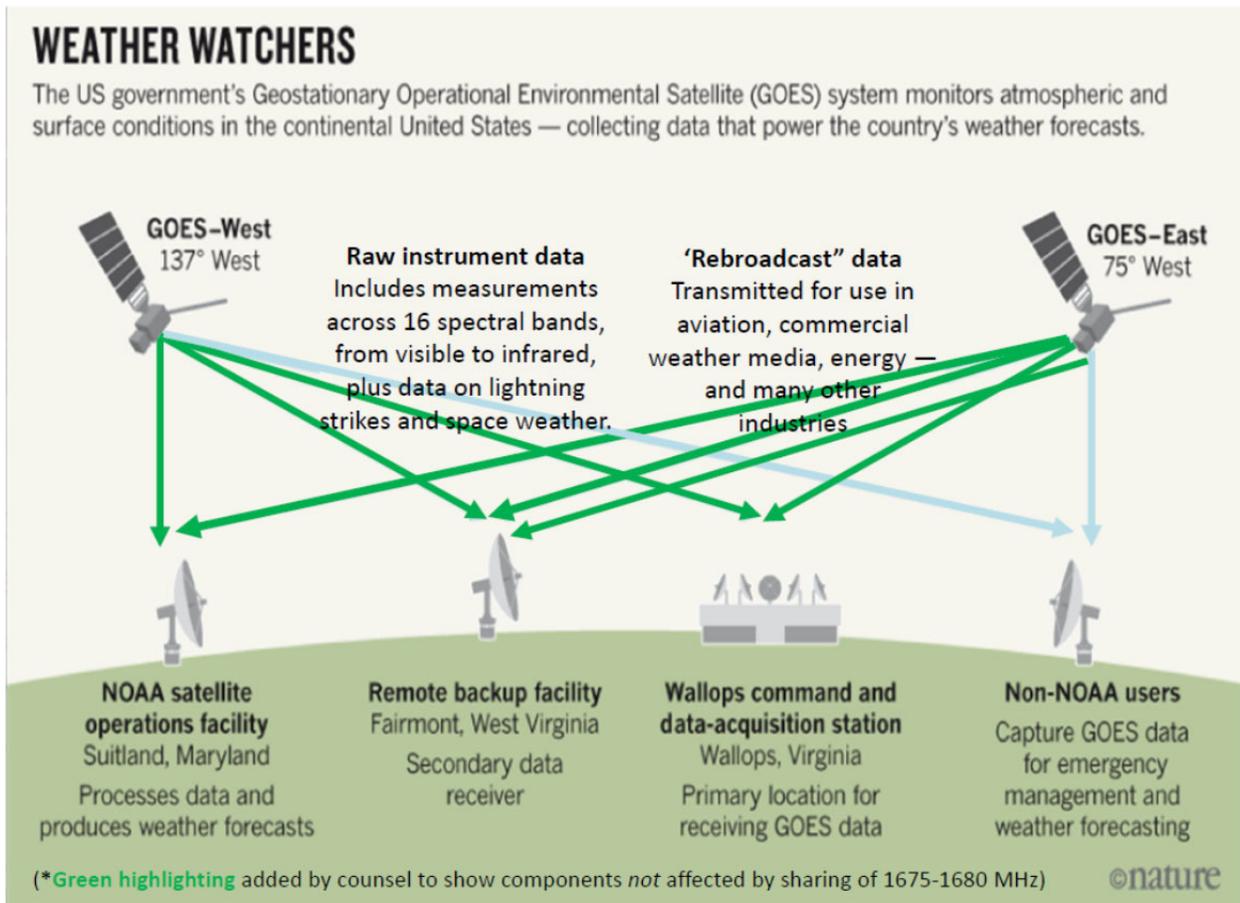
Perhaps some of the misunderstanding from the weather enterprise commenters stems from this misleading pictorial that accompanied the above-mentioned article.

In the version reproduced below, every transmission that will be unaffected by sharing the 1675-1680 MHz band with commercial uses is highlighted in green.<sup>14</sup>

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<sup>13</sup> It was suggested in the *Nature* Article that shared use of this spectrum will somehow put at risk the work of federal firefighters. As a recent blog post from NTIA explains, firefighters rely heavily on portable radios that use many frequencies—but none of them at 1675-1680 MHz. See Paige R. Atkins, *How Spectrum Enables Agencies to Fight Wildfires*, NTIA (July 25, 2016), <https://www.ntia.doc.gov/blog/2016/how-spectrum-enables-agencies-fight-wildfires>. Moreover, obviously the planes that transport firefighters do not receive data directly from a NOAA satellite, given the size demands of the satellite dish. And the proposed CDN will deliver weather information to the organizations that manage the planes.

<sup>14</sup> *Nature* Article, see *supra* note 12 (green highlighting shows components not affected by the sharing of the 1675-1680 MHz band).



This image is just another example of the misinformation that is being lobbed into the discussion without support or adequate explanation. Relatedly, it is also a perfect example of why an NPRM is necessary to resolve the confusion and set the record straight with regard to the actual implications of sharing this spectrum.

The only satellite signals that NOAA itself is authorized to use and which are relevant to the shared use of spectrum at 1675-1680 MHz are the downlink signals to NOAA earth stations (*i.e.* GOES-R DCPR, GOES-R GRB, GOES-NOP GVAR, and GOES-NOP SD Link). NOAA has not provided any evidence that these signals will experience interference if the Commission mandates protection zones around such stations. To the contrary, the engineering study by the firm recommended by NOAA in 2014, and submitted to the record, not only demonstrates that

operations in the 1675-1680 MHz band will be protected but also that NOAA services adjacent to the 1675-1680 MHz band can be protected by protection zones.<sup>15</sup>

Against these facts of how NOAA actually uses the 1675-1680 MHz band, and how its operations in the band will be protected, the short, repetitive comments that express concerns over the effect of commercial operations on both NOAA and non-NOAA users are off the mark and reflect a fundamental misunderstanding of how NOAA uses the spectrum. The following is typical of a sentence that can be found in many of the brief comments in the docket:

The [Harris County Flood Control District] has significant concerns regarding the Federal Communications Commission's (FCC) plan to share 1675-1680 Megahertz radio spectrum between a new terrestrial broadband wireless provider venture and long established federal, state, and local government meteorological and hydrological data providers. Within reliable signal transmission and reception to and from the GOES Data Collection System (DCS), the United States Geological Survey (USGS) hydrological data collection and distribution system would not function reliably to provide essential information.<sup>16</sup>

This and other similar, erroneous points are repeated frequently in the filed comments, many of which use curiously identical language to make the same incorrect arguments.<sup>17</sup> These commenters have been badly misinformed. As demonstrated below, the GOES Data Collection System referenced in the Harris County Flood District's comments has its uplink at *401 MHz*, and therefore will be completely unaffected by shared use at 1675-1680 MHz. Even a panelist

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<sup>15</sup> See *infra* Section II. B.

<sup>16</sup> Comments of Harris County Flood Control District, RM-11681 (June 21, 2016), at 1 (emphasis added).

<sup>17</sup> See, e.g., Comments of Canadian Shipowners Association, RM-11681 (June 17, 2016) at 2; Comments of Interlake Steamship, RM-11681 (June 6, 2016) at 2; Comments of VanEnkevort Tug & Barge, Inc., RM-11681 (May 17, 2016) at 2; Comments of Lake Carriers' Association, RM-11681 (May 16, 2016) at 2. All of these comments include the following language: "If the proposed spectrum sharing is allowed to proceed, interference is highly likely from terrestrial-based signals that are much stronger than those emitted from this satellite, which will likely disrupt critically important real-time information, particularly to non-government users."

speaking for NOAA admitted to this very fact at a recent AMS meeting.<sup>18</sup> Furthermore, the DCS downlink to NOAA and USGS earth stations—including the ones that supply data into the USGS EDDN network referenced by several commenters—will not be affected due to the large protection zones defined by the engineering firm recommended by NOAA.

Similar misrepresentations have been presented to Senate staff,<sup>19</sup> and NOAA has never provided any engineering or other evidence to substantiate these concerns. Now is the time to put misrepresentations aside. Each component of NOAA's activity, both data acquisition and data distribution, can continue to function effectively under the spectrum proposal—either because it will be wholly unaffected, or because it will be fully protected, or because it will be effectively replaced. In fact, not only will the proposed use of the 1675-1680 MHz band completely protect NOAA's use of the band and ensure a robust and effective distribution system of NOAA data to non-NOAA users, it also will promote NOAA's organizational mission by making vital weather information much more easily and widely available.

**A. NOAA Uses Spectrum Bands Mostly Other than 1675-1680 MHz to Collect and Distribute Data.**

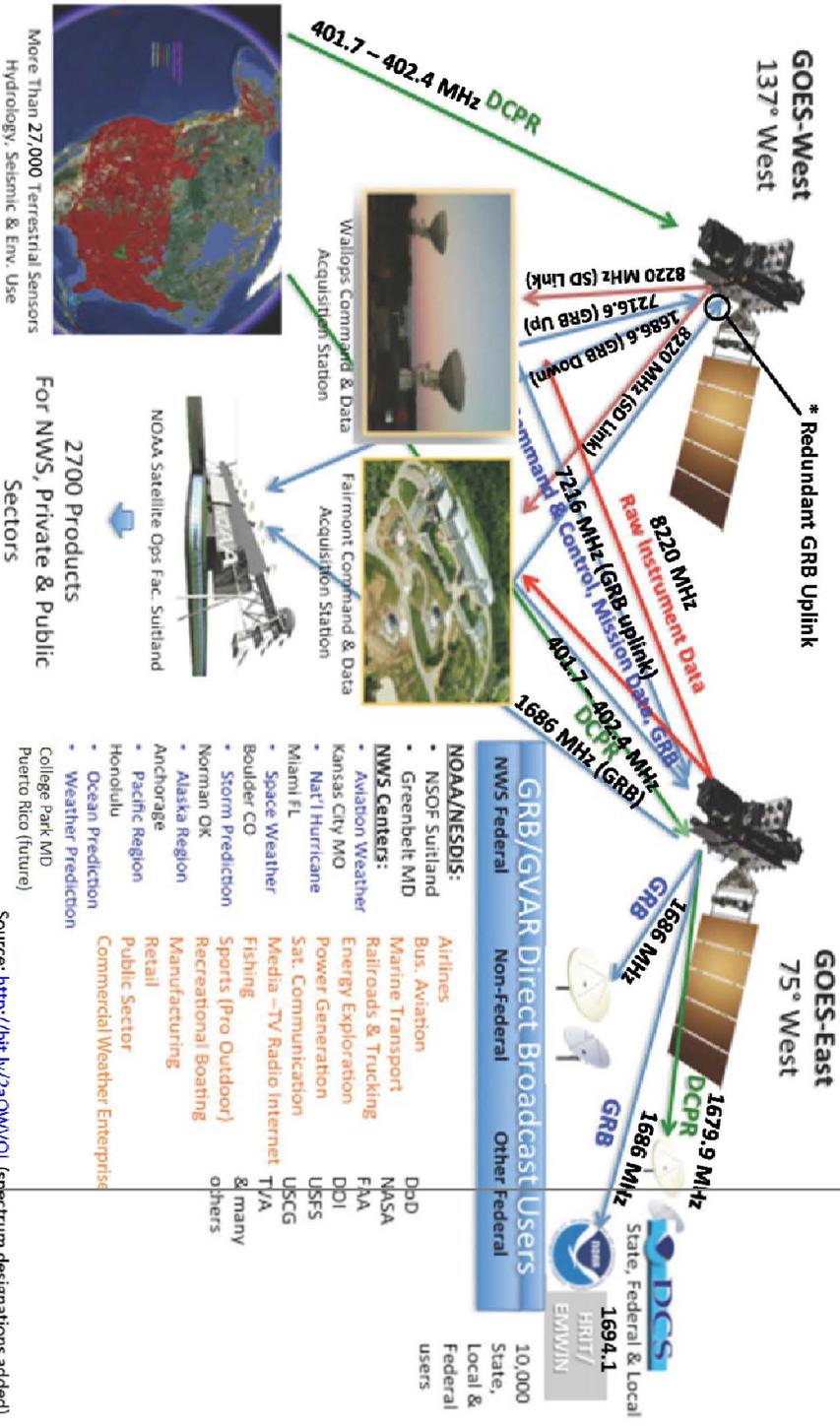
In response to commenters' significant and remarkably commonly-held misunderstandings regarding how NOAA uses the 1675-1680 MHz band, these reply comments outline in detail how NOAA acquires and distributes information—and, more specifically, how NOAA uses a variety of spectrum bands other than 1675-1680 MHz in that process—to demonstrate that many of the criticisms of the proposed sharing of the band lack any foundation.

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<sup>18</sup> See 2016 AMS Summer Community Meeting, American Meteorological Society, <https://ams.confex.com/ams/2016AMSSCM/webprogram/2016SCM.html> (last visited Aug. 11, 2016).

<sup>19</sup> See *supra* note 8.

# GOES-R Architecture



Source: <https://bit.ly/2aOWV0L> (spectrum designations added)

This diagram represents the various spectrum bands NOAA uses to transmit and receive weather-related data. The chart itself was part of a presentation made by a NOAA representative for a briefing to Congressional staff on May 26, 2015.<sup>20</sup> The spectrum annotations next to the arrows and the following discussion was gleaned from the attached spectrum chart created by Noblis, a non-profit science, technology, and strategy organization that works with many federal agencies.<sup>21</sup>

At a high level, NOAA engages in two activities in managing weather data: *data acquisition* and *data distribution*. Each of these two activities relies on both an uplink and a downlink spectrum band. For data *acquisition*, NOAA uplinks data collection system (“DCS”) data from the 27,000 hydrology, seismic, and environmental sensors mentioned in the comments to NOAA’s GOES satellites. This function occurs at *401 MHz*.<sup>22</sup> Accordingly, this function is not affected by a proposal to share the *1675-1680 MHz* band.

NOAA then downlinks this DCS data to authorized NOAA and U.S. government receive stations and to organizations who will receive a direct readout of this data. For GOES-R, NOAA will use spectrum at *1679.7 MHz*.<sup>23</sup> Under the uncontested engineering analysis in this record, the proposed protection zones around NOAA’s earth stations will ensure that this NOAA function continues unaffected. The non-NOAA users today have a variety of alternate means to access this data, including the NOAAPOINTS data network, the USGS’s EDDN network as well

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<sup>20</sup> Mark S. Paese, *Spectrum and the U.S. Weather Enterprise* (May 25, 2016), <https://www.ametsoc.org/ams/index.cfm/policy/the-capitol-hill-briefing-series/list-of-past-capitol-hill-briefings/radio-spectrum-for-earth-science-protecting-lives-property-and-commerce/paese-presentation/> (last visited Aug. 11, 2016).

<sup>21</sup> See Noblis, Goes R Frequency Plan, submitted as Attachment C hereto.

<sup>22</sup> *Id.*

<sup>23</sup> *Id.*

as NOAA's DOMSAT program. Additionally, the DCPR feed could be easily added into the proposed content delivery network described below, which was principally developed for the higher bandwidth GVAR and GRB services.

NOAA also downlinks GOES satellite sensor data to NOAA stations. For this function, NOAA uses a downlink at 1673.4-1678.6 MHz for the current generation of GOES satellites and will use a downlink at 8220 MHz for GOES-R.<sup>24</sup> Obviously, the operations at 8220 MHz are not affected by proposed sharing of the 1675-1680 MHz band. As for the downlink at 1673.4-1678.6 MHz, two comments are in order. First, this band overlaps with the 1670-1675 MHz band that Ligado currently leases and uses, and which Ligado already manages actively to guard against interference. Second, the designated protection zones will ensure these operations will encounter no impact. To be precise, the protection zones proposed for the 1675-1680 MHz band are several times larger than the existing protection zones for the 1670-1675 MHz band.

For data *distribution*, NOAA will process GOES-R Broadcast ("GRB") data and uplink it for distribution to other NOAA offices. For this function, NOAA will use spectrum at 7216 MHz.<sup>25</sup> Accordingly, this function is not affected by a proposal to share 1675-1680 MHz.

NOAA will then downlink GRB data (GVAR today) to NOAA stations, using spectrum at 1686.6 MHz.<sup>26</sup> The engineering record in this docket establishes that with the proposed protection zones, there will be no impact to this operation. Moreover, the CDN condition is designed to supply this data to non-NOAA users going forward.

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<sup>24</sup> *Id.*

<sup>25</sup> *Id.*

<sup>26</sup> *Id.*

NOAA also distributes weather data products to non-NOAA users through a variety of mechanisms. One mechanism NOAA uses is spectrum at 12 GHz to downlink to DOMSAT service.<sup>27</sup> This spectrum will not be affected by proposed sharing at 1675-1680 MHz.

Finally, and perhaps most interestingly, NOAA also provides various data products *terrestrially* using online distribution via NOAAPORT and USGS EDDN. These online delivery mechanisms obviously will not be affected by the proposed rulemaking. Indeed, the proposed content delivery network would use state-of-the-art technology to make NOAA's high-bandwidth data products directly available to a large number of Americans.

The chart below summarizes NOAA's various activities and how they rely on, or do not rely on, the 1675-1680 MHz band:

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<sup>27</sup> *Id.*

## NOAA's USE OF SPECTRUM

<b><i>What?</i></b>	<b><i>Which products?</i></b>	<b><i>Which spectrum band?</i></b>	<b><i>What will happen if 1675-1680 MHz is shared?</i></b>
Data is <i>uplinked</i> from public and private monitoring stations (DCS)	DCS (transmitted to GOES-R satellites)	401 MHz <i>uplink</i> to GOES satellites	<u>Nothing</u> -- spectrum is not affected.
Data is <i>downlinked</i> to various NOAA and USGS receive stations	DCS (NOAA, transmitted by GOES-R satellites)	1679.7 MHz <i>downlink</i>	<u>Nothing</u> -- designated protection zones ensure no impact from sharing.
GOES Satellite Sensor data is <i>downlinked</i> to NOAA stations.	GOES Satellite Sensor Data	GOES-NOP <i>downlink</i> at 1676 MHz ----- GOES-R <i>downlink</i> at 8220 MHz	<u>Nothing</u> -- designated protection zones ensure no impact from sharing. ----- <u>Nothing</u> -- spectrum is not affected.

## DATA DISTRIBUTION

<b><i>What?</i></b>	<b><i>Which products?</i></b>	<b><i>Where?</i></b>	<b><i>What will happen if 1675-1680 MHz is shared?</i></b>
Data is <i>distributed</i> to non-NOAA users	DCPR/DCS	12 GHz <i>downlink</i> to DOMSAT service ----- NOAAPORT and USGS EDDN online distribution ----- 1679.9 MHz <i>downlink</i> to roughly 100 privately-owned Direct Readout Ground Stations	<u>Nothing</u> -- spectrum is not affected. ----- <u>Nothing</u> -- Online distribution not affected. ----- <u>Could be affected</u> – remedy is CDN or use of NOAAPORT, EDDN or DOMSAT.
Data is processed by NOAA and <i>uplinked</i> to GOES for distribution to other NOAA offices.	GRB	7216 MHz <i>uplink</i>	<u>Nothing</u> -- spectrum is not affected.
Data is <i>downlinked</i> to NOAA stations	GRB	1686.6 MHz <i>downlink</i> to NOAA	<u>Nothing</u> -- designated protection zones ensure no impact.
Data is <i>downlinked</i> to non-NOAA users	GRB	1686.6 MHz <i>downlink</i>	<u>If affected</u> , remedy is CDN.

The above explanation and chart demonstrate that many of the concerns expressed by some commenters are misguided and indicate a fundamental misunderstanding of NOAA's spectrum use. For example, the International Association of Emergency Managers,<sup>28</sup> the American Association of Port Authorities,<sup>29</sup> Microcom,<sup>30</sup> the Interstate Council on Water Policy,<sup>31</sup> and the University of Alaska Fairbanks<sup>32</sup> all expressed concerns that NOAA's important data collection and data distribution activities would be affected by a proposal to share 1675-1680 MHz and that the 27,000 hydrology, seismic, and environmental sensors would suffer interference. But, as set forth in the attached chart by Noblis, much of that activity does not happen in the 1675-1680 MHz band.<sup>33</sup> And, NOAA's actual use of the band will be guarded by the protections zones. Furthermore, to the extent that non-NOAA users listen in on this band, the alternate delivery mechanisms in place today (NOAAPORT, EDDN, and DOMSAT) accommodate the needs of DCS users, while the CDN will accommodate the needs of users of the high bandwidth GVAR and GRB data streams.

Several comments specifically mention certain NOAA programs that rely on GOES/GOES-R DCS. For example, the American Association of Port Authorities explains that NOAA's Physical Oceanographic Real Time System ("PORTS") program information is transmitted over the GOES system in the 1675-1680 MHz band. Similarly, the Lake Carriers' Association, Interlake Steamship, VanEnkevort Tug & Barge, Inc., and the Canadian Shipowners

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<sup>28</sup> Comments of International Association of Emergency Managers, RM-11681 (June 20, 2016), at 2.

<sup>29</sup> Comments of American Association of Port Authorities, RM-11681 (June 2, 2016), at 2.

<sup>30</sup> Comments of Microcom Design, Inc., RM-11681 (June 17, 2016), at 4.

<sup>31</sup> Comments of Interstate Council on Water Policy, RM-11681 (June 20, 2016), at 2.

<sup>32</sup> Comments of University of Alaska Fairbanks, RM-11681 (June 20, 2016), at 2.

<sup>33</sup> See Attachment C.

Association all note that NWLON, a coastal observing network of more than 200 stations nationwide, is reliant on information transmitted over GOES DCS (and GOES-R DCS in the future) in the 1675-1680 MHz band. But this is just not so.

To reiterate: NOAA's ability to collect this vital data is unimpeded since the data is transmitted to the GOES satellites over a 401 MHz uplink channel.<sup>34</sup> Programs such as PORTS and NWLON that rely on NOAA DCS will, like all DCS data, downlink to NOAA receive stations over DCS 1679.9 MHz once GOES-R is operational. However, the data downlinked to NOAA over DCS is also re-distributed through various portals, including NOAA's own NOAAPORT service (which could be easily confused with, but is distinct from, the PORTS program), the NOAA DOMSAT service at 12 GHz and the U.S. Geological Survey's Emergency Data Distribution Network (EDDN). Thus, although Ligado's proposed deployment may affect *one method* through which entities receive information for these NOAA programs (*i.e.* direct reception from NOAA's GOES satellites), several other mechanisms exist through which the same information can be accessed. Moreover, this information also could be distributed through the proposed content delivery network.

**B. The 1675-1680 MHz Band Can Be Shared To Protect NOAA's Use of the Band and To Promote NOAA's Organizational Mission.**

Having established that the NOAA weather products actually potentially affected by shared use of the 1675-1680 MHz band represent only a small subset of the concerns raised in the comments, we now turn to a discussion of how NOAA actually operates in this and an adjacent band. As noted above, NOAA uses these bands to downlink data to its earth stations. After consultation with NOAA in 2014, Ligado arranged to have the engineering consulting firm

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<sup>34</sup> *Id.*

Alion Science and Technology (“Alion”), which was selected at NOAA’s suggestion, conduct an analysis—with NOAA’s significant and direct input—of how NOAA’s use of the 1675-1680 MHz band can be shared with a commercial user.<sup>35</sup> The Alion report, which was provided to NOAA and submitted to the record in February and April 2014, identifies and sets out the necessary parameters for effective protection of NOAA’s earth stations and appropriate coordination zones.<sup>36</sup> The protection zones around NOAA’s earth stations are several times larger than those imposed on the adjacent band licensee and will provide NOAA with more than adequate protection. The Alion study demonstrates that NOAA’s use of the 1675-1680 MHz and adjacent band will remain entirely protected by whichever commercial entity shares the 1675-1680 MHz band.

Non-NOAA users “listen in” on the services adjacent to the 1675-1680 MHz band; thus, they are not licensed users in this band but are essentially third-party beneficiaries of the spectrum allocation to NOAA. Moreover, the record shows that the licensed, first party beneficiary (NOAA) will be amply protected if the 1675-1680 MHz band is shared. To address any potential effects to the non-NOAA users listening in to NOAA’s data feed, Ligado has provided a detailed proposal for, and will begin testing of, a content delivery network to meet the

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<sup>35</sup> See Alion Science and Technology, *Assessment of the Potential for LightSquared Broadband Base Stations in the 1670-1680 MHz Band To Interfere with Select NOAA Legacy Ground Locations* (Feb. 2014) (“Alion Task 2 Report”), filed as attachment to Letter from Jeff Carlisle, Executive Vice President for Regulatory Affairs and Public Policy, LightSquared Subsidiary LLC, to Marlene H. Dortch, Secretary, Federal Communications Commission, RM-11681; IB Docket No. 12-340; IBFS File Nos. SAT-MOD-20120928-00160, SAT-MOD-201220928-00161, SES-MOD-20121001-00872 (Apr. 14, 2014). As previously explained, the Alion report concludes that both GOES and GOES-R can be protected against interference from shared commercial use of 1675-1680 MHz through the creation of protection and coordination zones and identifies and sets out the necessary parameters for those protection and coordination zones. The Commission should include these protection and coordination zones in its proposed rules for the band and require any licensee to adhere to them to protect this important aspect of NOAA’s operations.

<sup>36</sup> See *id.*

needs of these users. Over time, the CDN (discussed in further detail below) would provide a full substitute for these non-NOAA users. Ligado proposes that the Commission condition grant of the 1675-1680 MHz license on the auction winner developing (and if desired by NOAA, operating and funding) the CDN—a condition that must be met before the auction winner could use its spectrum.<sup>37</sup>

In addition to ensuring that NOAA’s actual operations are not affected, the CDN proposal will make NOAA’s valuable data available not only to a broad range of entities (well beyond the 100 or so non-NOAA users today), but also potentially to the entire country. This CDN proposal to democratize weather information actually advances NOAA’s stated mission. NOAA explains that its mission revolves around weather information distribution. Specifically, its mission statement provides: “To understand and predict changes in climate, weather, oceans, and coasts, *To share that knowledge and information with others*, and To conserve and manage coastal and marine ecosystems and resources.”<sup>38</sup> Yet, in spite of NOAA’s stated mission to share information, the current NOAA system for distributing this valuable GVAR and GRB data is expensive and encumbered.

The Department of Commerce has acknowledged that it can and should take steps to increase the availability and accessibility of NOAA’s data. As the Secretary of Commerce said:

NOAA gathers over 20 terabytes of data every day—more than twice the data of the entire printed collection of the United States

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<sup>37</sup> Some non-NOAA users have installed their own satellite receive systems in order to collect and process GVAR/GRB data streams. The CDN that would be the responsibility of the license winner is designed to address any potential effects to this distribution as well to potentially serve as a further source of distribution for the DCS/DCPR data stream (beyond the redistribution of the DCS data via NOAAPORT, EDDN and DOMSAT provided by NOAA and the USGS today).

<sup>38</sup> NOAA, *Our Mission and Vision*, available at <http://www.noaa.gov/our-mission-and-vision> (emphasis added); NOAA, *NOAA’s Next Generation Strategic Plan* (Dec. 2010), [http://www.ppi.noaa.gov/wp-content/uploads/NOAA\\_NGSP.pdf](http://www.ppi.noaa.gov/wp-content/uploads/NOAA_NGSP.pdf) (emphasis added).

Library of Congress. This environmental intelligence comes from a wide variety of sources, including Doppler radar systems, weather satellites, buoy networks and stations, tide gauges, real-time weather stations, as well as ships and aircraft. However, right now only a small percentage of this valuable data is easily accessible to the public. The demand for this data has increased, and it is imperative to find ways to effectively and efficiently distribute this data to decision makers and industries.<sup>39</sup>

Because NOAA's critical data can and should be shared, the Department has embarked upon a research project to determine exactly how this data can be shared with other potential end users, including the general public. The "Big Data Project" involves many of the biggest names in weather, technology, and business (including the Weather Channel, Amazon Web Services, and IBM) and recognizes that "open data could add more than \$3 trillion in total value annually to the education, transportation, consumer products, electricity, oil and gas, healthcare, and consumer finance sectors worldwide" and enable organizations "to develop new and innovative products and services to help us better understand our planet and keep communities resilient from extreme events."<sup>40</sup> The White House Office of Science and Technology Policy also has touted the value that can be generated by making NOAA data more widely available, stating that "industry saw great untapped economic potential in making NOAA's environmental data more accessible, and that this economic potential could far outweigh the data distribution costs."<sup>41</sup> In addition, NOAA itself is pursuing an Integrated Dissemination Program, which is meant to

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<sup>39</sup> Press Release, Department of Commerce, U.S. Secretary of Commerce Penny Pritzker Announces New Collaboration to Unleash the Power of NOAA's Data, (Apr. 21, 2015), <https://www.commerce.gov/news/press-releases/2015/04/us-secretary-commerce-penny-pritzker-announces-new-collaboration-unleash>.

<sup>40</sup> *Id.*

<sup>41</sup> Maia Hansen and Alan Steremberg, *NOAA's Data Heads for the Clouds*, The White House (May 4, 2015), <https://www.whitehouse.gov/blog/2015/05/04/noaa-s-data-heads-clouds>.

“[i]mplement a new, net-centric, weather information dissemination capability.”<sup>42</sup> The purpose of this Integrated Dissemination Program is to “[p]rovide common access for users to discover and retrieve NOAA weather data,” and “[p]rovide a standards-based, general Web Services capability positioned to support wider NOAA dissemination service needs.”<sup>43</sup>

The current situation, in which relatively few entities have direct access to the vital data transmitted by NOAA via satellite, is inconsistent with the Department’s own stated views and is hindering innovation and economic growth, as well as thwarting the national movement toward 5G and increased access to spectrum. Good reasons exist why so few entities access NOAA’s data. Chief among them: very high cost. According to Ligado’s Vice President of Spectrum Strategy and Technology Development, Maqbool Aliani, only a few companies manufacture the earth station receiver required for accessing this data, and the price for the smaller version of the earth station, which would receive only the current GVAR service and not the future GRB service, starts at \$52,330.<sup>44</sup> More capable versions of the earth station, such as the one Ligado is installing in Reston, Virginia to test the CDN, cost more than twice that amount. The total cost of the equipment and installation, not including construction, is \$123,661. This amount is borne today by *each individual user* that chooses to install its own GRB/GVAR receive system, even if that user is a non-profit or academic institution.

Logistical requirements for receiving NOAA data also could preclude many potential users who could afford the earth station. Installing the earth station, which is 14.8 feet in

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<sup>42</sup> Luis Cano, *NOAA NWS Integrated Dissemination Program (IDP)* (Mar. 21, 2014), at 6, *available at* [http://www.cio.noaa.gov/NOAALink/docs/IDP\\_Overview.pdf](http://www.cio.noaa.gov/NOAALink/docs/IDP_Overview.pdf).

<sup>43</sup> *Id.*

<sup>44</sup> Declaration of Maqbool Aliani at ¶ 4, submitted as Attachment D hereto.

diameter, requires 250 square feet of open space.<sup>45</sup> Clearly, this amount of vacant space and the entry cost of \$123,661 makes this vital NOAA data beyond the reach of most community colleges, many State and private colleges and universities, start-up companies, local governments, and the average American citizen who is, after all, paying for the collection of the data.

Finally, if an organization has the money and available space to site an earth station, it then must decipher the data, which is currently available in only an unstructured form.<sup>46</sup> As the Department of Commerce acknowledges, if this data were more widely available and interpretable, many “Big Data” entrepreneurs in the digital economy would likely be working to make this rich trove of weather data accessible and digestible to not just the few who access it today but to many, potentially 300 million, Americans.

The estimated 100 entities that today acquire GVAR data from NOAA have managed to negotiate this expensive and onerous procedure.<sup>47</sup> But this vital weather information reaches a tiny subset of the audience it could reach. The CDN proposal will expand the data’s reach to the entire American population. This approach stands consistent with NOAA’s mission statement and with the Administration’s Open Data Initiative.<sup>48</sup> For this reason, along with the ample protections for NOAA demonstrated above, we hope NOAA embraces a CDN as advancing the

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<sup>45</sup> *Id.* at ¶ 5.

<sup>46</sup> *Id.* at ¶ 3.

<sup>47</sup> Despite a number of requests to NOAA, we have been unable to identify the precise number. This estimate is based on conversations that counsel have had with non-NOAA users in the past month. Presumably the earth station manufacturers know this number with precision.

<sup>48</sup> See Executive Order 13642, *Making Open and Machine Readable the New Default for Government Information*, 78 FR 28111 (May 14, 2013) (“Government information shall be managed as an asset throughout its life cycle to promote interoperability and openness, and, wherever possible and legally permissible, to ensure that data are released to the public in ways that make the data easy to find, accessible, and usable.”).

public interest. This new data distribution will not cost NOAA a penny, and equally important, it will also be free to schools and libraries. The proposal therefore also enjoys the support of the Urban Libraries Council.<sup>49</sup>

**C. The Proposed CDN Requirement Will Provide a Robust and Effective Distribution System.**

This section describes in detail the proposal that the Commission require the 1675-1680 MHz band auction winner to establish and fund a content delivery network to provide over time a full substitute for the current earth station architecture. This CDN will provide in real-time to non-NOAA users the same data they receive now in an equally effective way, while also allowing new users to access the data for the first time.

As is described in further detail in the attached white paper from TeleWorld Solutions, CDNs are a common mechanism for delivering content (such as financial information or video stream) over the Internet to end users quickly and reliably by making content available on many widely distributed servers, rather than requiring all users to request the content from a single location. Typically, the “original” version of a file is stored on a central server or server farm, and copies of the file are periodically distributed to different servers across a regional or global network. When an end user requests a copy of the file, the CDN fulfills the request using the servers that are located physically closest to the end user or that are otherwise in the best position to quickly provide the file to the user, which minimizes latency.

There are different varieties of CDNs. Some CDNs wait until a user requests a particular file; the CDN then pulls the requested file from the central server, provides the file to the requesting user, and caches a copy of the file. The next time a user requests the same file,

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<sup>49</sup> Letter from Susan Benton, President and CEO of Urban Libraries Council, to Marlene S. Dortch, Secretary, Federal Communications Commission, RM-11681; IB Docket No. 12-340 (Aug. 11, 2016).

instead of delivering the file from the central server, the file will be delivered from the nearest CDN server's cached copy, until that copy expires. Other CDNs proactively send files to the CDN servers from a central location, even before the file has been requested by any end users. For instance, a large commercial bank and credit card company could establish a CDN to push the latest financial products, account information, and other vital financial information to its customers as soon as the new data is available, on the expectation that users will want this content. Such CDNs thus can be very effective at making large files of high-value data available for end users to download with low latency and high reliability, even for the first user requesting a particular file. Ligado's proposed CDN falls into the latter category, as it is designed to deliver *real-time* data feeds with very low latency.

In order to meet the needs for distribution of real-time data feeds, Ligado has proposed that the 1675-1680 MHz band auction winner be required—unless NOAA undertakes this activity itself—to establish a robust CDN for distributing the NOAA data. As explained in the TeleWorld Solutions white paper, the data would enter the CDN through a primary server located at a designated receive point (optimally at NOAA's satellite operations facility in Suitland, Md., which packages 2,700 weather products for the National Weather Service and other users).<sup>50</sup> The CDN would then archive the data and immediately push it to a widely distributed set of servers. Non-NOAA users now have to wait for the NOAA data to be uplinked to GOES-R and then receive it via downlink. As the CDN would transmit data directly from the receive facility, CDN users would access the data *even more quickly than they do now*, saving up to 500 milliseconds of latency. CDN users would also be able to receive more weather products

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<sup>50</sup> See TeleWorld Solutions, Overview of Proposed Content Delivery Network for Non-NOAA Users, submitted as Attachment E hereto.

than they do currently. NOAA produces more weather products than its uplink can transmit. By connecting directly to the receive facility, the CDN would be able to provide all of these products should NOAA chose to include them. End users could access the CDN over the public Internet or via a direct fiber connection, depending on each user's needs. The end result of the CDN would be the provision of NOAA data to existing non-NOAA users via a fast, reliable terrestrial network, that shaves off valuable milliseconds of latency from how non-NOAA users currently receive the data. The CDN also would provide access to more weather products, all while lowering the practical and cost barriers that have prevented other parties from accessing this data.

This proposal has obvious appeal and is consistent with how leading financial institutions, high-tech companies, high-value content companies, and virtually every other sector of the modern economy deliver high-value content today.<sup>51</sup> Given the inherent logic of using the vast fiber optic and cloud resources in the country to deliver this vital information, it is not surprising that others have thought of this same idea. As discussed above, NOAA itself is exploring non-satellite delivery of weather information. Ligado agrees with NOAA that making

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<sup>51</sup> See *id.*; see also "FINRA Case Study," AWS.Amazon.com, <https://aws.amazon.com/solutions/case-studies/finra/> (last visited Aug. 11, 2016) (noting that the Financial Industry Regulatory Authority, one of the largest independent securities regulators in the U.S., relies on Amazon Web Services' CDN platform "to capture, analyze, and store a daily influx of 75 billion records"; "Met Office," Akamai.com, <https://www.akamai.com/us/en/our-customers/customer-stories-the-met-office.jsp> (last visited Aug. 9, 2016) (noting that the website of the UK Met Office, which relies on its website as "a key delivery channel" for its weather services and interactive content, relies on Akamai's CDN platform and other cloud services); "AWS Case Study: Earth Networks," AWS.Amazon.com, <https://aws.amazon.com/solutions/case-studies/earth-networks-cloudfront/> (last visited Aug. 11, 2016) (explaining how Earth Networks uses a CDN to distribute the data from its various weather sensors, which collect real-time weather and lightning information, to their large number of users); "AWS Case Study: Capital One," AWS.Amazon.com, <https://aws.amazon.com/solutions/case-studies/capital-one/> (last visited Aug. 11, 2016) (demonstrating how Capital One uses a CDN to push the latest financial products and information to its customers).

this data more broadly accessible over the cloud, direct fiber connections, and the Internet is a worthy goal deserving of research and energy.

Many commenters expressed concerns that a CDN may not be as reliable as satellite distribution.<sup>52</sup> These concerns are belied by the trillions of dollars in the modern economy that depend on internet connectivity.<sup>53</sup> The proposed CDN will utilize a secure and private Internet network that non-NOAA users will be able to rely on, and will feature the option of a direct connection to the CDN.<sup>54</sup>

**D. Non-NOAA Users Are Gaining More Protection Than Provided During Recent Proceedings.**

Spectrum is a limited resource, and this is not the first time that the Commission has had to address interference concerns. In fact, it is not even the first time the Commission has had to address interference concerns raised by non-NOAA users concerning their access to NOAA in adjacent bands. As part of the recent AWS-3 proceeding, the Commission auctioned the 1695-1710 MHz band, which is near NOAA operations from the right-hand side, as opposed to the 1675-1680 MHz band, which is near NOAA's operations from the left-hand side. It bears emphasis that almost identical concerns, using some of the same rhetoric, were brought to the

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<sup>52</sup> See, e.g., Comments of American Meteorological Society, RM-11681 (June 20, 2016), at 2 (stating that latency of more than 30 seconds could negatively impact the services members provide); Comments of International Association of Emergency Managers, RM-11681 (June 20, 2016), at 3 (stating that Internet is often the first utility lost during severe weather, when this data is needed most).

<sup>53</sup> See, e.g., eMarketer, *Global B2C Ecommerce Sales to Hit \$1.5 Trillion This Year Driven by Growth in Emerging Markets* (Feb. 3, 2014), <http://www.emarketer.com/Article/Global-B2C-Ecommerce-Sales-Hit-15-Trillion-This-Year-Driven-by-Growth-Emerging-Markets/1010575> (explaining that global B2C e-commerce sales alone in 2014 were valued at \$1.5 trillion).

<sup>54</sup> See generally Attachment E.

Commission’s attention in that proceeding.<sup>55</sup> However, the Commission did not alter its rules or impose any special conditions in that proceeding.<sup>56</sup>

As a result of the AWS-3 proceedings, the same non-NOAA users who are concerned about interference to GVAR/GRB and DCS/DCPR from operations in the left-hand side at 1675-1680 MHz are likely to have similar concerns regarding interference from AWS-3 operations in the right-hand side when they commence. This point—that non-NOAA users already have a problem that needs their attention—is established by the attached presentation by Microcom Design, Inc. (“Microcom”) from April 2016. In the presentation, Microcom explains the results of its analysis that the LTE signal being generated by the 1695-1710 MHz AWS-3 band will cause harmful interference to various NOAA products including DCS DRGS.<sup>57</sup>

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<sup>55</sup> Aerospace Industries Association stated that “[i]nformation carried by federal systems in some of these bands is utilized by . . . industries[] and citizens for the protection of life and property (e.g. severe storm warnings, wildfires, flood water levels). Additionally, industries which require accurate and timely information derived from environmental satellite downlinks can be adversely impacted if the sharing, coordination and enforcement rules do not protect the products which they use in their operations and planning. Those end users may not be aware that federal spectrum repurposing activities have the potential to disrupt availability of products whose input data traverse the bands of interest.” Comments of Aerospace Industries Association, GN Docket 13-185 (Sept. 18, 2013), at 2.

<sup>56</sup> The Commission did not deem the concerns referenced in footnote 55, *supra*, significant enough to address in the *AWS-3 Order*. While the Commission noted one commenter’s concern about interference in the Order, it found the argument lacking, stating : “One commenter expressed concern that the standard OOBE limit may not provide adequate protection for adjacent-band Meteorological Satellite operations. Raytheon argued that, ‘[b]efore the Commission adopts an OOBE limit applicable at the 1695 MHz band edge for AWS-3 systems, sufficient testing and/or analysis should be completed to support the Commission’s determination in light of the [Emergency Managers Weather Information Network] and other operations below 1695 MHz.’ Raytheon errs in focusing on just one part of the regime we are establishing to protect the 1675-1695 MHz band. The OOBE attenuation factor functions together with the interference resolution provisions of section 27.1134(c). This combination has worked satisfactorily for the AWS-1 service, and we believe it will serve equally well for AWS-3.” *Amendment to the Commission’s Rules with Regard to Commercial Operations in the 1695-1710 MHz, 1755-1780 MHz, and 2155-2180 MHz Bands*, Report & Order, 29 FCC Rcd. 4610, 4621 (2014) (“*AWS-3 Order*”).

<sup>57</sup> See Microcom Design, Inc., DCS & LRIT LTE Adjacent Band Interference Study (Apr. 2016) 2, 16–18 submitted as Attachment F hereto. Microcom studied interference to the Data Collection Platform Report (DCPR) and Low Rate Information Transmission (LRIT) links. NOAA uses its LRIT broadcast system to disseminate GOES data, DCS, the National Weather System’s Emergency Managers Weather Information Network (EMWIN) and other (continued...)

In the AWS-3 example, the Commission left those concerns unaddressed, and presumably the non-NOAA users will have to find ways to adjust to potential interference from AWS. Here, a far different approach is being suggested. For the 1675-1680 MHz band, the proposal is that the commercial use of the 1675-1680 MHz band be expressly conditioned to address any potential impact to non-NOAA users.

**E. Issuance of an NPRM to Share 1675-1680 MHz Will Promote a Workable Solution.**

Ligado requests the Commission issue a Notice of Proposed Rulemaking to allow for shared commercial use of the 1675-1680 MHz band. Issuance of an NPRM would be just the first step down the long road to eventually opening this band to shared use. The process has many gates along the way: the comments and reply comments filed in response to the April 22, 2016 Public Notice will inform the Commission's drafting of the NPRM; if an NPRM is issued, then parties could file comments and reply comments on the proposed rules and license conditions; and the Commission presumably then would hold meetings with affected parties to understand their concerns and also would consult with the Department of Commerce and with the National Telecommunications and Information Administration ("NTIA"). Then, if the Commission were to find it in the public interest, the Commission would issue a Report and Order ("R&O") allocating the spectrum to shared use and presumably defining service rules for the band. Sometime after that point, the Commission would issue a public notice establishing a date for the auction of 1675-1680 MHz and related procedures. The auction itself would still be months away and eventual deployment in the band would be years away.

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meteorological products to users. This study applies to the current DCPR on GOES-NOP, but the analysis will also apply to the future GOES-R DCPR downlink at 1679.9 MHz.

To cite one example, the Commission issued an NPRM in the AWS-3 proceeding on July 23, 2013.<sup>58</sup> The Commission did not issue an R&O until March 31, 2014.<sup>59</sup> The Commission issued three public notices between the NPRM and the R&O, and five public notices after issuing the R&O and before the spectrum auction started on November 13, 2014.<sup>60</sup> The auction ended on January 29, 2015.<sup>61</sup> Only at that point could the licensees even begin the process of building the technology to utilize their spectrum licenses. AT&T has stated that it will deploy its new spectrum beginning in 2017-2018—four to five years after the issuance of the NPRM.<sup>62</sup> Ligado expects the process for the sharing of the 1675-1680 MHz to follow a similar track, and the Commission has yet to reach the NPRM stage. This deliberate, lengthy process is designed to provide ample time to resolve any concerns that may arise about shared use.

But just because the road is long does not mean we should not start down it. In fact, it makes it even more important to begin moving forward. As CTIA explained in its comments, “[g]iven the long timeframes associated with freeing spectrum for mobile services, action is required now to ensure the pipeline does not become depleted.”<sup>63</sup> And as Public Knowledge and the Open Technology Institute at New America (“OTI”) observed, “with 5G technologies on the

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<sup>58</sup> See *Amendment of the Commission’s Rules with Regard to Commercial Operations in the 1695-1710 MHz, 1755-1780 MHz, and 2155-2180 MHz Bands*, Notice of Proposed Rulemaking and Order on Reconsideration, GN Docket No. 13-185.

<sup>59</sup> See *AWS-3 Order*, *supra* note 57.

<sup>60</sup> Summary for Auction 97, FCC.gov, [http://wireless.fcc.gov/auctions/default.htm?job=auction\\_summary&id=97](http://wireless.fcc.gov/auctions/default.htm?job=auction_summary&id=97) (last visited Aug. 11, 2016).

<sup>61</sup> *Id.*

<sup>62</sup> Press Release, AT&T, AT&T Adds High-Quality Spectrum to Support Customers’ Growing Demand for Mobile Video and High-Speed Internet, (Jan. 30, 2015), [http://about.att.com/story/att\\_adds\\_high\\_quality\\_spectrum\\_to\\_support\\_growing\\_demand\\_for\\_mobile\\_video\\_and\\_high\\_speed\\_internet.html](http://about.att.com/story/att_adds_high_quality_spectrum_to_support_growing_demand_for_mobile_video_and_high_speed_internet.html).

<sup>63</sup> Comments of CTIA, RM-11681 (June 21, 2016), at 3.

horizon and the Internet of Things growing at a tremendous pace, the need for additional spectrum for mobile broadband, to support new and innovative products and services, is even more acute.”<sup>64</sup> Recognizing this need, Public Knowledge and OTI support Ligado’s proposal, “because the successful deployment of mobile broadband services using this band serves the public interest.”<sup>65</sup> As discussed below, shared use of this band will accelerate the transition to 5G broadband technology and IoT.

### **III. ALLOCATING 1675-1680 MHz TO SHARED COMMERCIAL USE WILL ACCELERATE TRANSITION TO 5G AND IoT.**

The demands and opportunities for broadband service are continuing to evolve. 5G broadband technology and IoT promise to usher in revolutionary services, and Ligado is uniquely positioned to apply the 1675-1680 MHz band in service of the new technologies.

#### **A. This Band Can Be Used by the Commercial Sector to Accelerate 5G Transition.**

Just this summer, Chairman Wheeler discussed the critical nature of 5G and the importance of U.S. efforts to expedite its deployment. Calling 5G a “national priority,” Chairman Wheeler explained that “[t]o seize the opportunities before us, we need the next generation of wireless connectivity—a fifth generation, or 5G. And if the United States is going to continue to be a world leader in wireless, we need to speed the deployment of 5G, here, on our shores.”<sup>66</sup> Advancing broadband has been a priority not just for the Commission but also for the

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<sup>64</sup> Comments of Public Knowledge and Open Technology Institute at New America, RM-11681 (June 21, 2016), at 1-2.

<sup>65</sup> *Id.*

<sup>66</sup> Prepared Remarks of FCC Chairman Tom Wheeler, “The Future of Wireless: A Vision for U.S. Leadership in a 5G World”, National Press Club, Washington, D.C., June 20, 2016, [http://transition.fcc.gov/Daily\\_Releases/Daily\\_Business/2016/db0620/DOC-339920A1.pdf](http://transition.fcc.gov/Daily_Releases/Daily_Business/2016/db0620/DOC-339920A1.pdf) (“Chairman Wheeler Remarks”).

Administration. Six years ago, the White House issued a Presidential Memorandum requiring NTIA to work with the Commission to make available 500 megahertz of federal and nonfederal spectrum suitable for mobile and fixed wireless broadband use.<sup>67</sup>

Mid-band spectrum is an essential element of the solution. In its Ten-Year Plan and Timetable, developed to implement the presidential directive, the National Telecommunications and Information Administration (“NTIA”) identified the 1675-1680 MHz band as one of the bands to be included in the 500 megahertz initiative.<sup>68</sup> And Chairman Wheeler has explained that the characteristics of mid-band spectrum “enable an order of magnitude increase in spectrum efficiency.”<sup>69</sup>

**B. Ligado Has a Strong Interest in Obtaining Bandwidth to Bring 40 MHz of Greenfield Mid-Band Spectrum to Promote 5G and the Internet of Things.**

If the Commission decides to auction the 1675-1680 MHz band for shared use and Ligado wins the auction, the company will be poised to bring 40 MHz of mid-band spectrum to market. Ligado’s pending license modification applications can enable the use of 35 MHz, and if successful at auction, the company would use the 1675-1680 MHz band to create a 10 MHz downlink in combination with its 1670-1675 MHz band. This 10 MHz block is vital to Ligado now that it has requested that the Commission remove its authority to use its upper downlink to ensure coexistence with GPS companies. Access to more mid-band spectrum will enable the delivery of advanced connectivity services and accelerate the transition to 5G—a clear goal of

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<sup>67</sup> See Memorandum from The White House, Office of the Press Secretary, *Unleashing the Wireless Broadband Revolution* (June 28, 2010), at Section 1(a), available at <https://www.whitehouse.gov/the-press-office/presidential-memorandum-unleashing-wireless-broadband-revolution> (“Presidential Memorandum”).

<sup>68</sup> See NTIA, Plan and Timetable to Make Available 500 Megahertz of Spectrum for Wireless Broadband 7 (Oct. 2010), available at [https://www.ntia.doc.gov/files/ntia/publications/tenyearplan\\_11152010.pdf](https://www.ntia.doc.gov/files/ntia/publications/tenyearplan_11152010.pdf).

<sup>69</sup> Chairman Wheeler Remarks, *supra* note 66.

the Obama Administration and the Commission.<sup>70</sup> Relatedly, this spectrum can enable a network optimized for IoT use cases to allow new connected devices to grow and develop. In sum, the 1675-1680 MHz band has the potential to serve as a critical element in unlocking the next wave of communications technology.

While moving this spectrum forward toward the future, Ligado will also ensure that its current users, both licensed and those “listening in,” are not harmed. If Ligado prevails at auction, it will meet all FCC requirements imposed on the licensee in connection with the band, will ensure that NOAA’s operations are protected, and will make sure that non-NOAA users continue to enjoy access to the NOAA data they currently use.

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<sup>70</sup> The White House, *Administration Announces an Advanced Wireless Research Initiative, Building on President’s Legacy of Forward-Leaning Broadband Policy* (July 15, 2016), <https://www.whitehouse.gov/the-press-office/2016/07/15/fact-sheet-administration-announces-advanced-wireless-research>; Chairman Wheeler Remarks, *supra* note 66.

#### IV. CONCLUSION

By adopting an NPRM to allow for shared commercial use of the 1675-1680 MHz band, the Commission can take a step that is consistent with its own goals of making mid-band spectrum available for 5G, consistent with the President's Budget and the bipartisan views of Congress, and consistent with the public interest. Specifically, the Commission can ensure that incumbent users will be protected, non-NOAA users will be held harmless, and the public will benefit by obtaining broader and cheaper access to NOAA's important weather information. With this refreshing of the record, the Commission has ample factual and legal support to initiate a rulemaking to allocate the 1675-1680 MHz band for shared terrestrial mobile use. We urge the Commission to move expeditiously to issue an NPRM seeking comments on such an allocation.

Respectfully submitted,

/s/ Gerard J. Waldron  
Gerard J. Waldron  
Michael Beder  
Ani Gevorkian  
Hannah Lepow  
COVINGTON & BURLING LLP  
One CityCenter  
850 Tenth Street, NW  
Washington, DC 20001  
(202) 662-6000

*Counsel for Ligado Networks LLC*

August 11, 2016

Attachments:

Attachment A	Ligado-NOAA Correspondence
Attachment B	Goldstein/NOAA Slides to Senate Commerce Committee
Attachment C	Noblis Spectrum Chart
Attachment D	Aliani Declaration
Attachment E	TeleWorld Solutions' CDN White Paper
Attachment F	Microcom Presentation

# **Attachment A**

April 20, 2016

Vice Admiral Manson Brown  
National Oceanic and Atmospheric Administration  
1325 East West Highway  
Silver Spring, MD 20910

Dear Manson:

Thank you for the meeting with you and your staff on Monday, April 18. We appreciate your statement at the start of the meeting that NOAA is in fact committed to the Administration's goal of implementing a plan to share the 1675-80 MHz band of spectrum, and we look forward to your open and transparent approach to the issues related to the sharing of the spectrum between NOAA and commercial use. We wish to reiterate both our recognition of the importance of your mission to the country and to public safety, and our firm commitment to ensure our operations do not adversely affect your mission. Indeed, we hope that the shared use of that spectrum can enhance the capability of your agency to deliver weather data. We believe there are solutions that will protect your systems and may even improve them by making weather information available in the cloud and accessible from multiple locations.

We appreciate your statement that NOAA is committed to working cooperatively with the FCC and the federal spectrum agencies on sharing, and we understand the desire expressed by Zach Goldstein to conduct due diligence and analysis concerning possible interference issues for NOAA's earth stations dedicated to receiving signals from your GOES-R satellites given the use of 1675-80 MHz for terrestrial use. However, we believe the key questions raised by the Administration's policy goal of sharing the spectrum relates to *how* to do it rather than whether it should be shared. We look forward to exploring with your staff the "how" question in the weeks ahead.

I hope that you found our discussion of the FCC's public notice process to be helpful. As Reed Hundt explained, we expect that the FCC will issue shortly a public notice that will invite NOAA, Ligado and any other interested party to discuss how the 1675-80 MHz spectrum allocation should be modified, and what requirements and/or conditions should be imposed on the holder of the license for terrestrial use. Examples of such conditions could include requiring the licensee to provide to non-NOAA users of the band the same weather data using an alternative content delivery network that maintains and enhances

the data, as well as assurances that there will be no interruption of their access to such weather data.

In that vein, I was pleased to report that we intend to meet with the American Meteorological Society and with other interested parties, such as those current users of your GVAR data. We also expect that the FCC's issuance of a public notice will bring attention to the issue as well. Based on our outreach and feedback obtained by us and through the FCC process, we will refine our proposal to seek ways to improve the delivery of the data available to these users, including for example through high speed access to cloud-store data such as the FCC now guarantees to every school and library in the country. As we discussed, we welcome the opportunity to preview developments to the proposal prior to submitting it to the FCC, and will follow up with Mr. Goldstein in the next few weeks on that matter as well as on the transition plan for the spectrum. We hope that you will view the public notice process as an opportunity to express support for the proposed license requirements that we will be submitting to the FCC during the upcoming public notice.

Finally, we discussed the process the FCC is likely to follow after the public notice is issued. Based on past auction procedures similar to this one, the FCC is likely to consider the record made in response to the public notice and then decide, at some point later this year, whether to issue a Notice of Proposed Rulemaking to modify the 1675-80 MHz allocation for shared use. That NPRM likely will contain conditions it proposes to impose on any entity that wins the license—such as conditions to protect NOAA's operations and to assure data availability for non-NOAA users. That NPRM will trigger another round of comments and reply comments, and thus afford yet another opportunity for NOAA to ensure that its interests are protected. We hope the NPRM process will be similar to the public notice process and will involve a transparent and public dialogue between NOAA and Ligado and any other interested party on the issues relevant to the sharing of 1675-1680 MHz spectrum. Only after those two opportunities for public dialogue (and likely in late 2016 at the earliest) would the Commission be in a position to decide the reallocation question and to begin to think about scheduling an auction for the band sometime in 2017. Of course, our views on this timeline are just that: our views. While they are based on the facts we know, the FCC's past auction activity, and the decision in favor of shared use that is reflected in the President's FY 2017 budget proposal, it is, of course, the FCC that will establish the actual timeline.

We are encouraged by the constructive and open engagement between NOAA and the FCC and private parties to accomplish a sharing agreement relating to the AWS-3 auction. If that process were followed here, after an award of the license by auction the winner—who might or might not be Ligado—we emphasized that there would be a few years before any auction winner would actually use the spectrum on a shared basis. That

“transition” time would be devoted to implementing the license conditions imposed to address the concerns of NOAA and non-NOAA users alike.

In sum, we truly appreciate your time and your commitment to fostering a genuine public dialogue on the issues relating to the sharing of this critical spectrum, and we look forward to additional conversations with your staff soon.

In the meantime, please do not hesitate to contact me if you have any questions about the points contained in this letter.

Very truly yours,



Doug Smith  
President and CEO





**U.S. DEPARTMENT OF COMMERCE**  
**National Oceanic and Atmospheric Administration**  
Office of the Chief Information Officer  
High Performance Computing and Communications  
**CHIEF INFORMATION OFFICER**

May 12, 2016

Mr. Doug Smith  
President and CEO  
Ligado Networks  
10802 Parkridge Boulevard  
Reston, VA 20191

Dear Mr. Smith,

Thank you very much for the correspondence on April 20, 2016 subsequent to our meeting on April 18, 2016. As Admiral Brown mentioned in the meeting, I am the contact person for this matter. I would like to thank you for recognizing the importance of NOAA's mission to the country and to public safety, and your commitment to ensure your operations do not adversely affect NOAA's mission. I also want to clarify that NOAA's commitment is to the Administration's goal of making available a total of 500 MHz of Federal and nonfederal spectrum over the next 10 years, suitable for both mobile and fixed wireless broadband use. As part of that commitment, NOAA is continuing to explore whether sharing of 1675-80 MHz band of spectrum is possible, without interfering with NOAA's mission; and if determined to be possible, what methods of sharing might be feasible.

Regarding the invitation to discuss the Public Notice issued by the FCC on April 22, and Ligado's response to the Notice, the offer is appreciated but I decline. As an Executive Branch agency, NOAA's comment on any FCC action must be worked through our regulator, the NTIA, the only agency authorized to provide official public comment on FCC actions. Our response to Public Notice DA 16-443, along with those of other Federal agencies, will be submitted to the NTIA's Interdepartment Radio Advisory Committee (IRAC) and cannot be developed or released outside the IRAC process.

Thank you for this opportunity for dialogue. As always, NOAA is fully committed to advancing the President's broadband initiative and working with the NTIA through the Policy and Planning Steering Group to make more spectrum available for broadband use.

Best regards,

A handwritten signature in black ink, appearing to read "Zachary Goldstein".

Zachary Goldstein  
Chief Information Officer and Director, High Performance Computing and Communications  
National Oceanic and Atmospheric Administration

Cc: Admiral Manson Brown  
Mr. Reed Hundt



# **Attachment B**



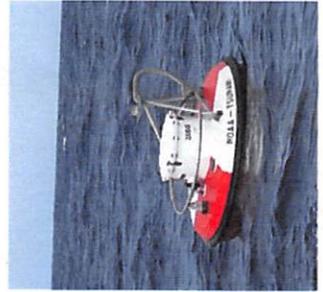
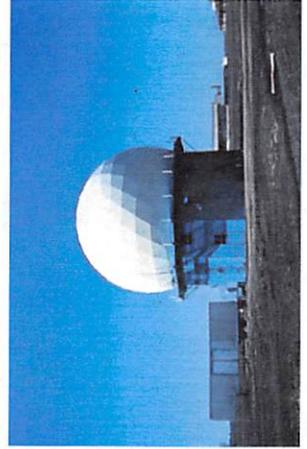
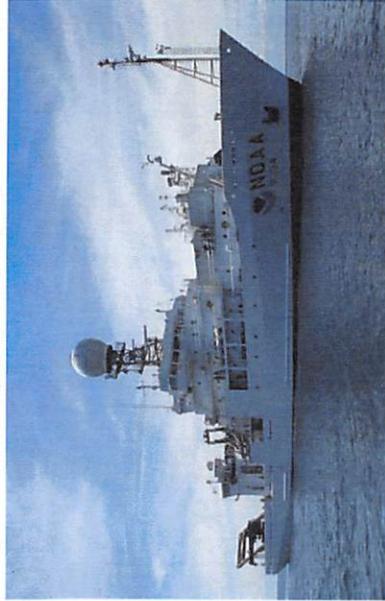
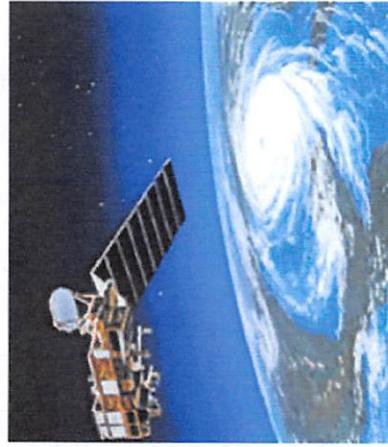
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# NOAA Satellite Spectrum

Zachary G. Goldstein  
NOAA Chief Information Officer  
Director, High Performance Computing and Communications  
20 January 2016



# NOAA Spectrum Use





# GOES-R Broadcast Architecture

**GOES-West**  
137° West

**GOES-East**  
75° West

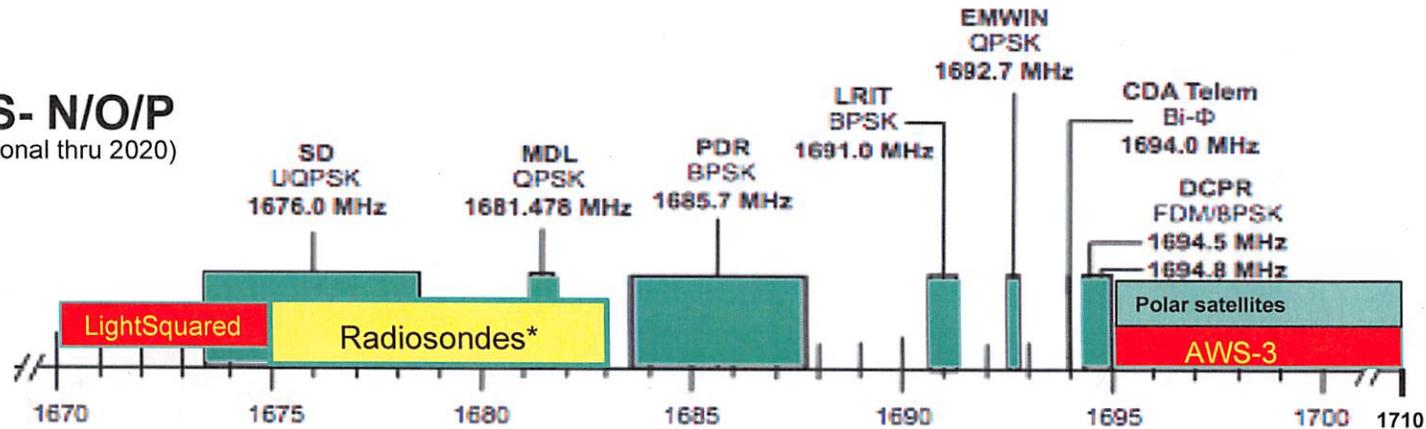




# NOAA's Use of Satellite Spectrum

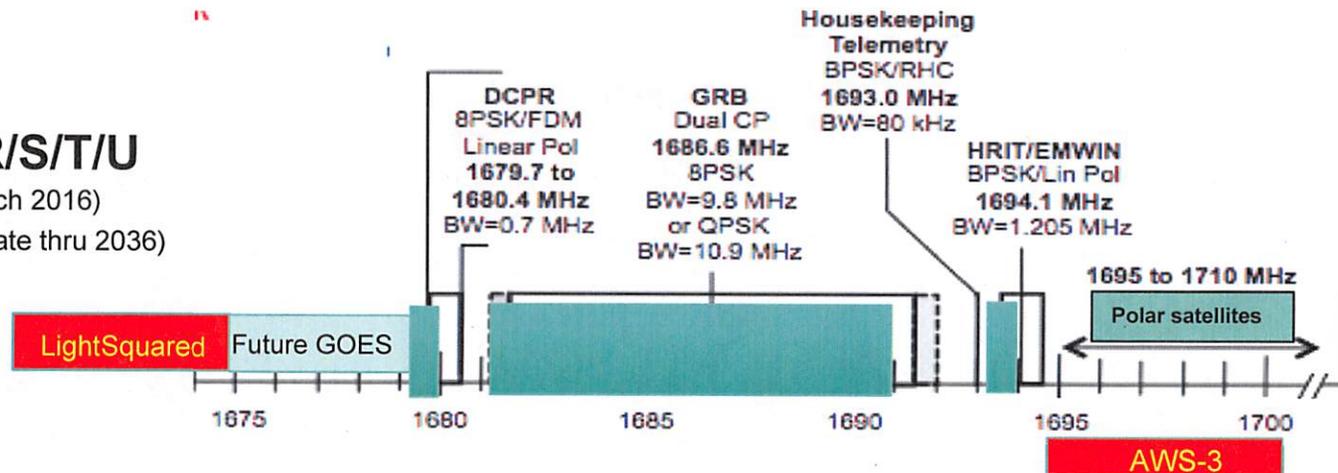


## GOES- N/O/P (operational thru 2020)



\*Radiosondes moving to 403 MHz through 2021

## GOES- R/S/T/U (GOES-R launch 2016) (Series will operate thru 2036)





# 1675-1680 MHz & LightSquared



- Current Situation:
  - Give up 1545-1555 MHz operating authority in exchange for access to 1675-1680MHz
  - Move planned 1545-1555 MHz operations (towers to mobiles) to 1670-1675 MHz band
  - NOAA satellite operations at Wallops Island, VA is experiencing interference from Light Squared operations in the 1670-1675 MHz for the past several years
- October 2013 to February 2014 – LightSquared & NOAA joint study on radiosonde relocation and LightSquared band sharing with NOAA satellites
  - Study concluded NOAA radiosonde operations could move to 401 MHz
  - Study did not fully address how to protect satellite ground stations
  - Study did not address protection of direct broadcast users
- Planned sharing of 1675-1680MHz band will impact
  - Reception of sensor data from current GOES
  - Reception of DCPR data from GOES-R



# Potential Impact of 1675-1680 MHz Sharing with Mobile Broadband



- Current GOES-N,O,P satellites operate Sensor Data in 1675-1680 MHz
  - GOES-N, O, P Sensor Data downlink contains the raw Imager and Sounder data collected by sensors onboard the spacecraft and transmitted to NOAA data acquisition stations
  - Loss of these data will result in the loss of images required to track hurricanes and monitor the rapid development of severe storms that may develop into destructive tornados
  - This data is the basis for many of the satellite products that NOAA provides the public and private companies
- Federal and non-federal users of Data Collection Platform rebroadcast (DCPR), 1694.5 MHz (GOES N-P), 1679.7 MHz (GOES-R) outside protection zones will be subject to interference.
  - Impact reception of hydrological data from sensors deployed nationwide which provide data needed for flood prediction and warnings
  - Impact reception of sensor data required for wildfire management



# Summary of Key Concerns



- NOAA satellite operations at Wallops Island, VA is experiencing interference from Light Squared operations in the 1670-1675 MHz for the past several years
- Additional concern over sharing of 1675-1680 MHz between NOAA and commercial broadband operations:
  - Current interference from LightSquared transmitters originating from distances over one hundred kilometers away
    - Interference has resulted in loss and corruption of mission critical satellite data
  - Federal users who receive direct broadcast as primary source to create products that serve the public
  - Non-Federal users who receive direct broadcasts to obtain products in a timely manner and also create products within the private/commercial sectors
- Federal and non-federal Data Collection Platform outside protection zones cannot be protected and will be subject to interference
  - Will impact emergency management, weather warnings, and wildfire management capability
- Number of ground stations requiring protection and protection zone sizes could make band not economically viable for broadband service providers

# **Attachment C**



# **Attachment D**

**Before the  
FEDERAL COMMUNICATIONS COMMISSION  
Washington, DC 20554**

In the Matter of )  
 )  
Comment Sought to Update the )  
Record on Ligado’s Request That the )  
Commission Initiate A Rulemaking to ) RM-11681  
Allocate the 1675-1680 MHz Band For )  
Terrestrial Mobile Use Shared With Federal )  
Use )

**DECLARATION OF MAQBOOL ALIANI**

1. My name is Maqbool Aliani. I am currently the Vice President of Spectrum Strategy & Technology Development at Ligado Networks, LLC (“Ligado”). I joined the company (then called Mobile Satellite Ventures) in 2007, and have 18 years of engineering experience. I received a M.S. in Electrical Engineering from George Mason University and a B.S. in Electrical Engineering from NED University of Engineering & Technology, Karachi, Pakistan.

2. In my position at Ligado, I play a lead role in the company’s effort to install a GOES Variable (GVAR)/GOES Rebroadcast (GRB) receiving system to capture the weather-related data associated with NOAA’s current broadcast of GVAR and future broadcast of GRB data.

3. Currently NOAA transmits its environmental data in GVAR format. The data is broadcast from current generation GOES satellites, measured by the independent GOES Imager and Sounder instruments. To the best of my knowledge, this data can only be received in real time by users who have installed a GVAR antenna and receiver system. The data arrives in

a format that needs to be interpreted by additional software and technicians with knowledge of its content. Once NOAA's GOES-R satellite is operational—the launch is currently scheduled for November 4, 2016—GRB will replace the GVAR service. GRB will provide new data products and provide them more reliably, using two digital streams, each at 15.5 Mbps, as opposed to GVAR's single 2.11 Mbps stream. The non-NOAA users currently “listen in” on the 1685.7 MHz downlink center frequency, adjacent to the 1675-1680 MHz band, using a GVAR receiver system, and when GRB launches they will utilize a GRB receiver system to “listen in” on the 1686.6 MHz downlink center frequency, again adjacent to the 1675-1680 MHz band.

4. In order to understand how the non-NOAA users listen in on this band, Ligado is currently installing a combined GVAR/GRB receiving system in the parking lot of our corporate headquarters in Reston, Va. Fewer than ten companies manufacture this dish, and Ligado's total cost for equipment and installation is \$123,661.90. While a smaller version of the dish exists, it can only receive the GVAR service. The cost for that dish begins at about \$52,330.

5. The dish Ligado is installing is 14.8 feet in diameter, and requires 250 square feet of open space. It will be mounted on a steel sled that has to be specifically designed to meet the wind load requirements for successful operation. The received signal from the dish will run by coax cable into a shelter that already exists in the antenna compound of our parking lot, where the receiver, server, and software will be installed in a pre-existing 19-inch server rack. The system will be powered with a 120VAC 10 Amp protected service with generator backup. This system will feed our test Content Delivery Network (“CDN”) by routing the data from the server via a private IP connection to a local data center.

6. Ligado has retained MORCOM International to provide and install the necessary equipment. As previously stated, the total cost for the equipment and installation is

\$123,661.90. This does not include civil works, which are still in the process of being estimated, or the cost of access to the space, antenna compound, and server rack needed to maintain the dish which Ligado already has as a satellite company. Thus, other entities seeking to “listen in” on the current GVAR 1685.7 MHz downlink and future GOES 1686.6 MHz downlink may have to invest even more than Ligado did to obtain access to this NOAA data.

Signed:           /s/ Maqbool Aliani          

Date: August 11, 2016

# **Attachment E**

## Overview of Proposed Content Delivery Network for Non-NOAA Users

### ***Introduction***

TeleWorld Solutions is a strategic engineering and consulting firm offering network operators, OEMs and tower companies turnkey design, optimization, network dimensioning, deployment, and IT services. With the experience of hundreds of thousands of successful program and projects with the world's leading network operators and OEMs trust our knowledge and experience to develop, plan, perform, troubleshoot and implement an array of technologies and solutions. TeleWorld Solutions helps customers plan, design, manage, measure and monetize opportunities throughout the network lifecycle and across every element of their network.

This white paper first describes content delivery networks and then details the content delivery network that TeleWorld Solutions is constructing for Ligado Networks to distribute various NOAA weather data products.

### ***Background: What Is a CDN and How Are They Used to Distribute Valuable, Time-Sensitive Data***

A content delivery network, or "CDN," is a common mechanism for delivering valuable content over the Internet to end users faster and more reliably than traditional single server systems by making content available on many widely distributed servers, rather than requiring all users to request content from a single location. Typically, the "original" version of a file is stored on a central server or server farm, and copies of the file are distributed to different CDN servers across a regional or global network. When an end user requests a file, the CDN fulfills the request and delivers the file from the CDN servers that are located physically closest to the end user or that are otherwise in the best position to quickly provide the file to the user, thus minimizing latency.

In general, the primary advantages of CDNs are providing higher availability, lower network latency, lower packet loss, better protection from denial-of-service attacks. A CDN also can help a service scale up to handle increased numbers of concurrent users. There are several types of CDN architectures. A "pull" CDN (also known as a "relayed" CDN) waits until a user requests a particular file; the CDN then pulls the requested file from the central server, provides the file to the requesting user, and caches a copy of the file. The next time a user requests the same file, instead of delivering the file from the central server, the file will be delivered from the nearest CDN server's cached copy, until

that copy expires. Thus, the determination of which files are most easily accessed (because they are available through the CDN) is made according to which files users request. This means that popular files are most likely to be easily and quickly accessible to end users. One disadvantage of a pull CDN, however, is that the first user who requests a file will not receive optimal performance because the file will not yet be available through the CDN, but must be accessed from the central server.

An alternative CDN architecture is the “push” CDN (also known as a “hosted” CDN). Unlike a pull CDN, a push CDN proactively sends files to the CDN servers from a central location, even before the file has been requested by any end user. For instance, a large commercial bank and credit card company could set up a CDN to push the latest financial products and information to its customers as soon as the new data is available, on the expectation that users will want this content. Here is one example: <https://aws.amazon.com/solutions/case-studies/capital-one/>. Push CDNs can be very effective at making large files of highly-valued content available for end users to download with low latency and high reliability, even for the first user accessing a particular file.

From the end user’s point of view a CDN system may look like a simple solution of distributed servers, but effectively managing a CDN requires advanced networking technologies and components to effectively deliver content to users. For instance:

- A CDN requires a content distribution and management system to automatically import, maintain copies of, and configure content at the edge of the network, as well as to make content routing decisions based on user requests and other factors (such as the relative load on different servers). CDN management is critical to distributed network architectures.
- Content routing provides the end user with the best site response possible by routing user requests between multiple data centers to ensure the user is matched with the closest or best content, regardless of location. This reduces latency and dramatically increases content availability.
- Content switching is a new generation of networking algorithms specifically designed to address the unique requirements of CDN systems. Content switching intelligently load-balances traffic across servers in a data center, based on the availability of the content and the load on the server. This provides both higher performance and increased reliability.

An illustration of how a CDN is used across various industries is Amazon Web Services, which provides a CDN service, referred as CloudFront. CloudFront has been used by various companies to alter their previous architecture to distribute various sets of media and data. A case study is the example of Earth Networks<sup>1</sup>, and its story can be seen in this 4-minute video. <https://www.youtube.com/watch?v=gcq5kE496NA>. This video explains how Earth Networks uses a CDN to distribute the data from its various weather sensors, which collect real-time weather and lightning information, to their large number of users that use Weather Bug.

### ***Ligado's Prototype CDN***

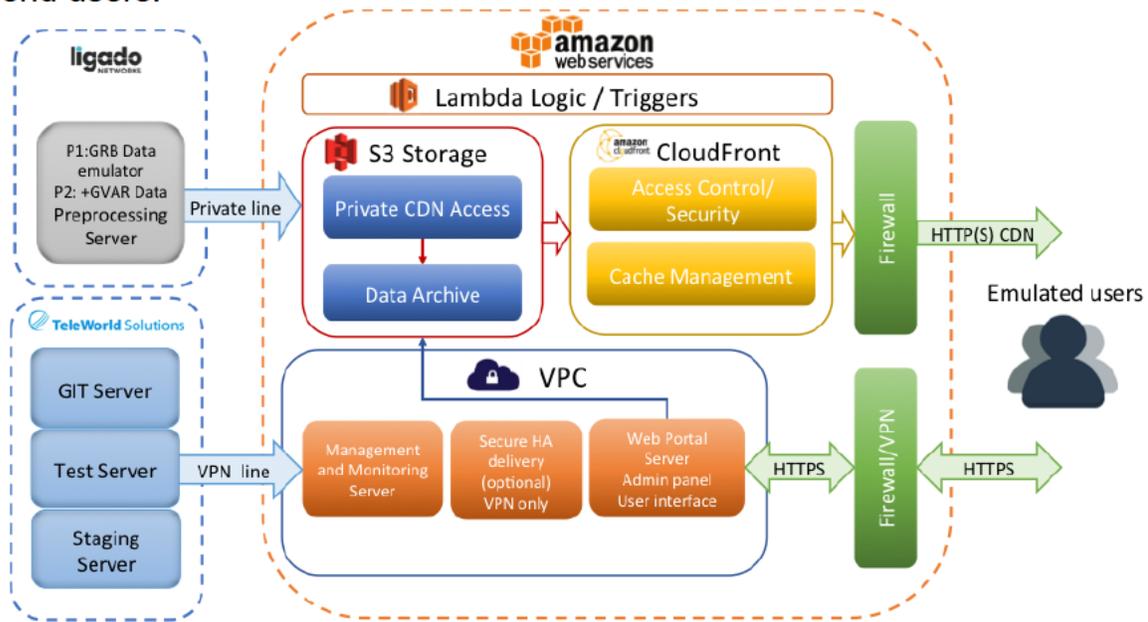
NOAA is planning on replacing its current Geostationary Operational Environmental Satellite ("GOES") Variable service, known as the GVAR service with a GOES Rebroadcast service ("GRB") that will provide the primary relay of full-resolution calibrated, near-real-time direct broadcast of Level 1b and Level 2 data. Under current plans, the only way for end users to access this data would be to set up a satellite receiver dish tuned to the GRB downlink frequency, 1686.6 MHz. Although only NOAA holds satellite earth station receiver licenses for sites receiving data on this frequency, other parties can and do "listen in" on these data transmissions. It has been suggested by some parties that this downlink frequency could be affected by shared commercial use of the 1675-1680 MHz band, which is the subject of a pending FCC proceeding, such that various non-NOAA parties may not be able to access the NOAA data. To address these concerns, Ligado has decided to build a cloud based Content Delivery Network prototype leveraging the available NOAA data to provide an open and secure distribution network in preparation for future cloud based GRB programs. Distributing the NOAA data to non-NOAA users via a fast, reliable terrestrial network would eliminate the need for these users to rely on satellite downlinks, while lowering the practical and cost barriers that have no doubt prevented other parties from accessing this data. An added benefit of the CDN is that it will assure non-NOAA users access to critical NOAA data that might otherwise be affected by AWS-3 uplinks (1695-1710 MHz) already authorized by the Federal Communications Commission.

The purpose of Ligado's project is to create a cloud based conceptual prototype network to validate the distribution system for the bandwidth, security, and cost scaling. Ligado's prototype will use the Amazon Web Services CloudFront CDN, one of the most mature and popular commercial CDN services. As described in Illustration 1, the

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<sup>1</sup> Earth Networks is a company that owns Weather Bug, a service that provides live weather data and maintains a network of over 8,000 weather stations.

prototype will use both emulated and real NOAA data to simulate the distribution of this data to end users.



*Illustration 1: Prototype CDN architecture*

The prototype will be composed of the following components. Each component will provide a set of functions to ensure performance, reliability, and security meet or exceed the expectations of current legacy satellite broadcast systems.

- 1) Amazon Web Services will be used to create the prototype. Amazon Web Services CloudFront provides a CDN service, with 20 edge locations nationally in the United States and 33 globally. A list of the edge locations are listed on their website (<https://aws.amazon.com/cloudfront/details/>). The prototype will utilize various Amazon Web Services functions to provide connectivity, security, load and traffic balance, and storage.
- 2) TeleWorld Solutions will oversee various Servers internally, separate from CDN network. These servers will handle the maintaining and managing of code, testing of new code, and staging before implementing to full production.
- 3) The point to receive the NOAA data will be the GVAR Data Preprocessing Server. In the prototype, Ligado will install a GVAR dish at its headquarters in Reston, VA, and the data will be aggregated and pushed to the prototype CDN network. During initial implementation, a GRB data emulator will also be implemented to illustrate

the future state function of GRB data and how it would perform with the prototype CDN network.

- 4) The end user will have access to the data through a simple web portal. An authentication function to access the GVAR and GRB data will be optional. A user will be able connect to the CDN either over the user's existing Internet connection or by integrating a private line between the user's facility and the CDN infrastructure.

The end state of the CDN, in full production, will have additional capabilities that will allow performance to be enhanced for users.

- 1) Optimally, the GVAR/GRB data would be distributed directly from the NOAA Suitland, MD facility. This step will minimize the latency from raw data and processed data to the end user.
- 2) The operational CDN will have flexibility to deploy additional edge locations in addition to or distinct from the AWS network. This will increase reliability and further reduce the latency of the data to the end user.
- 3) In addition, TeleWorld will engage in increased monitoring and load and traffic management software to ensure consistent performance among all end users. The CDN will allow the distribution of existing weather products as they currently exist and also allow future products to be added without the constraint of satellite bandwidth.

The goal of the project is to demonstrate that the proposed CDN would provide existing non-NOAA users with the same data they receive now in an equally effective way, while also allowing new users to access the data for the first time. TeleWorld Solutions is working to deploy the prototype in the 4<sup>th</sup> quarter of 2016.

# **Attachment F**

# DCS & LRIT LTE Adjacent Band Interference Study

**Microcom Design, Inc.**

April 2016



## **Task Description**

---

- **Determine the susceptibility of NOAA LRIT and DCS DRGS links to newly authorized frequencies sold at auction by the FCC**
  - 1695 MHz to 1710 MHz
  - Currently limited to handsets
  
- **This presentation is limited to Adjacent band LTE interference**
  
- **Currently there are 16 NOAA ground stations surrounded by protection zones, e.g. Wallops, Greenbelt, Suitland ...**

# Setup

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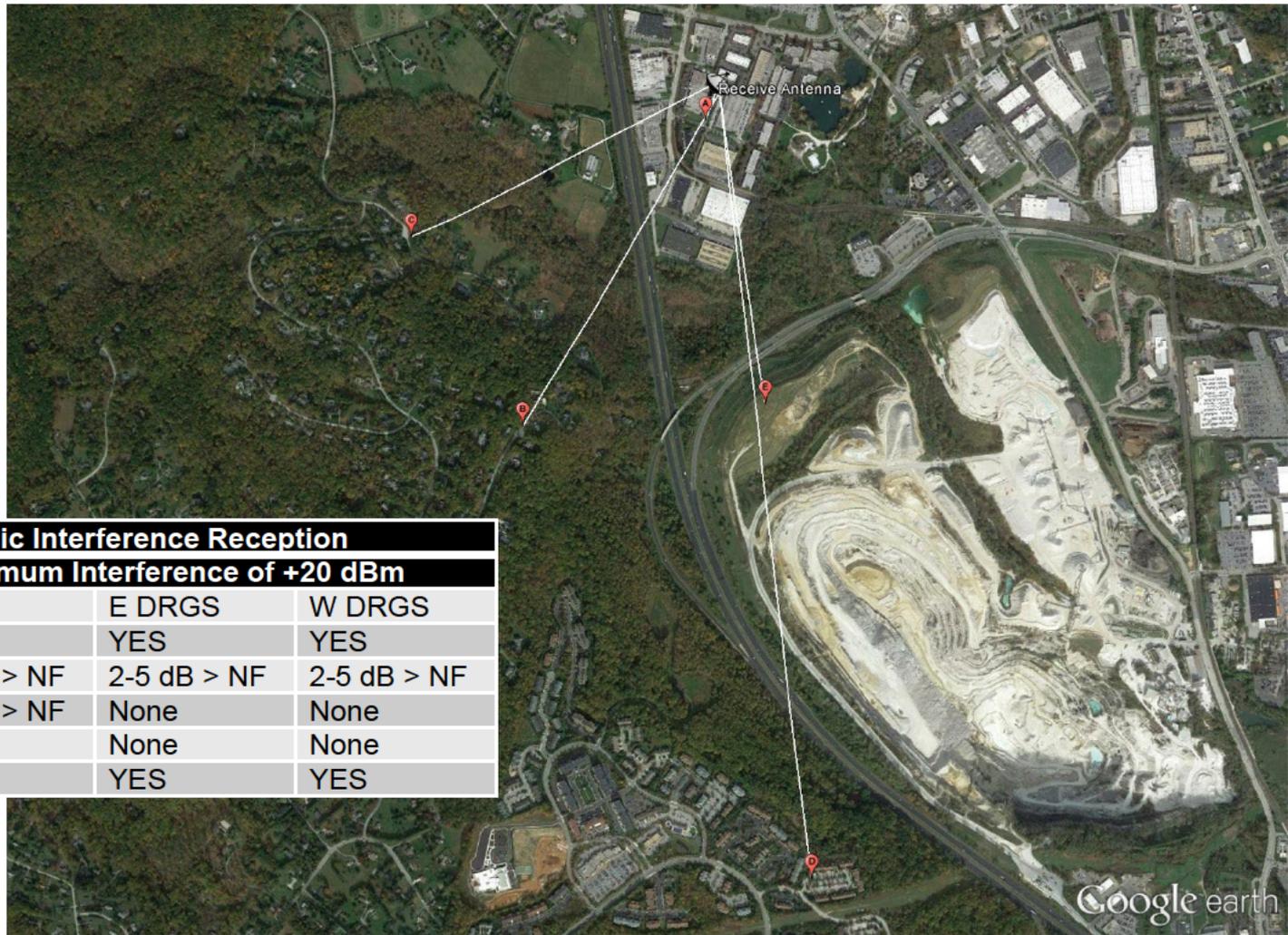
## ➤ Transmit

- Agilent N5182B signal generator
- $\frac{1}{4}$  wavelength dipole antenna
- 5 MHz wide band with 100% utilization
- Center frequency of interference band was adjusted from 1697.5 MHz to 1705 MHz in 0.5 MHz steps
- Power set to +10 dBm

## ➤ Location

- Five sites (A – E) were used to investigate the effects of distance on interference
- Transmission location (A) was focused on for the majority of the measurements
- Site was chosen because it provided a consistent line of site to the front of the antenna while being 250 feet away

# Locations



Basic Interference Reception			
At Maximum Interference of +20 dBm			
Site	LRIT	E DRGS	W DRGS
A	YES	YES	YES
B	2-5 dB > NF	2-5 dB > NF	2-5 dB > NF
C	2-5 dB > NF	None	None
D	None	None	None
E	YES	YES	YES

# Setup

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## ➤ Receive

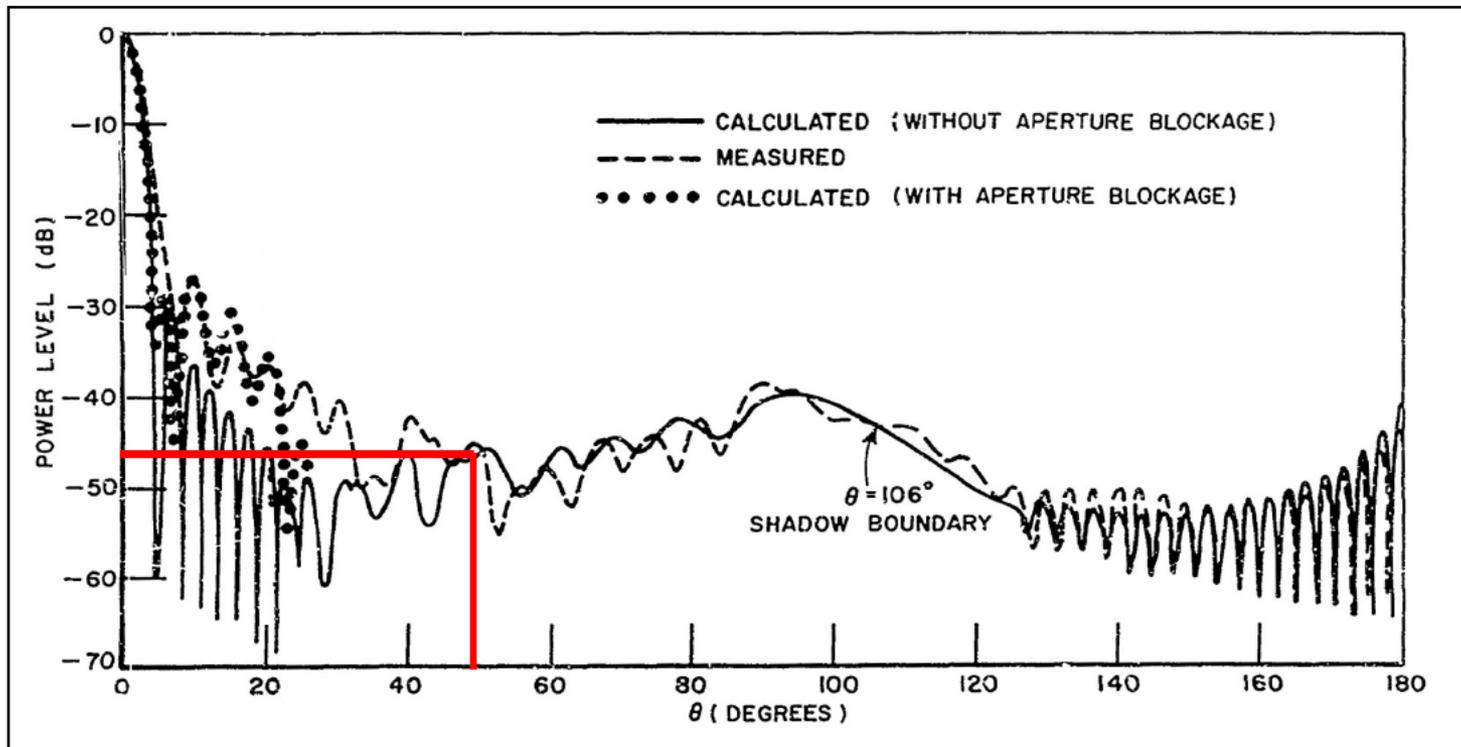
- DCS 3.6 meter dish
- LRIT 1.2 meter dish
- Limited study to GOES East reception / Interference

## ➤ Link

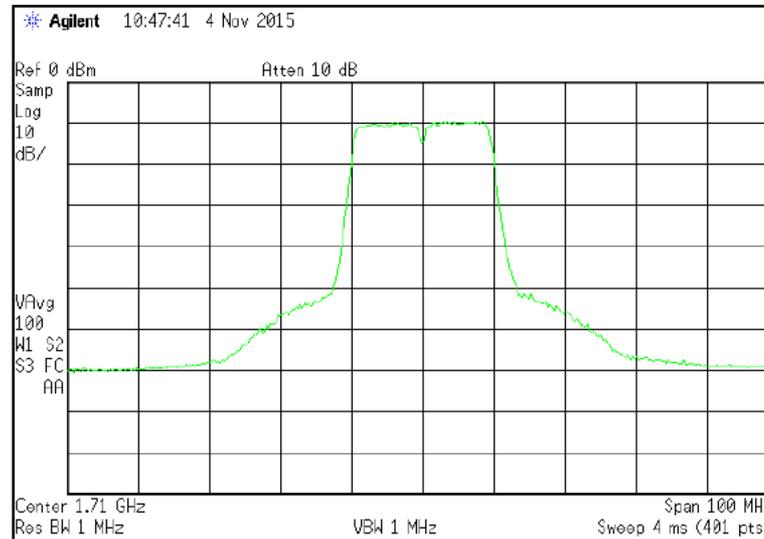
- 250 foot separation between transmitter and receive dishes
- DCS and LRIT dishes pointed 49° off axis from LTE transmitter

# Antenna

- Estimated Location within example parabolic dish gain pattern
  - Transmitter located  $49^\circ$  off center, about  $-47$  dB down



# Example Interference Waveform



- **Example LTE signal from signal generator demonstrating ability meet the LTE requirement of -25 dB down within 10 MHz and -47 dB down outside 10 MHz**
- **LTE bandwidth is adjustable between 6 options (1.4MHz, 3MHz, 5MHz, 10MHz, 15MHz, 20MHz). The above picture shows the 10MHz option**

## **Data Source**

---

- **DPCM phase noise measurements were recorded from the Microcom Design DAMS-NT Client software DPCM Pilot Level / Noise Floor Graph**
- **LRIT Reed-Solomon success percentages were recorded from the Microcom Design DAMS-NT DigiRIT DIGITAL LRIT/HRIT RECEIVER front panel display**
- **70 MHz tap from the DCS antenna front end was fed into an Agilent E4402B spectrum analyzer**
- **Screen shots were taken from the spectrum analyzer**

# Site Aerial View



**Microcom Design, Inc.**

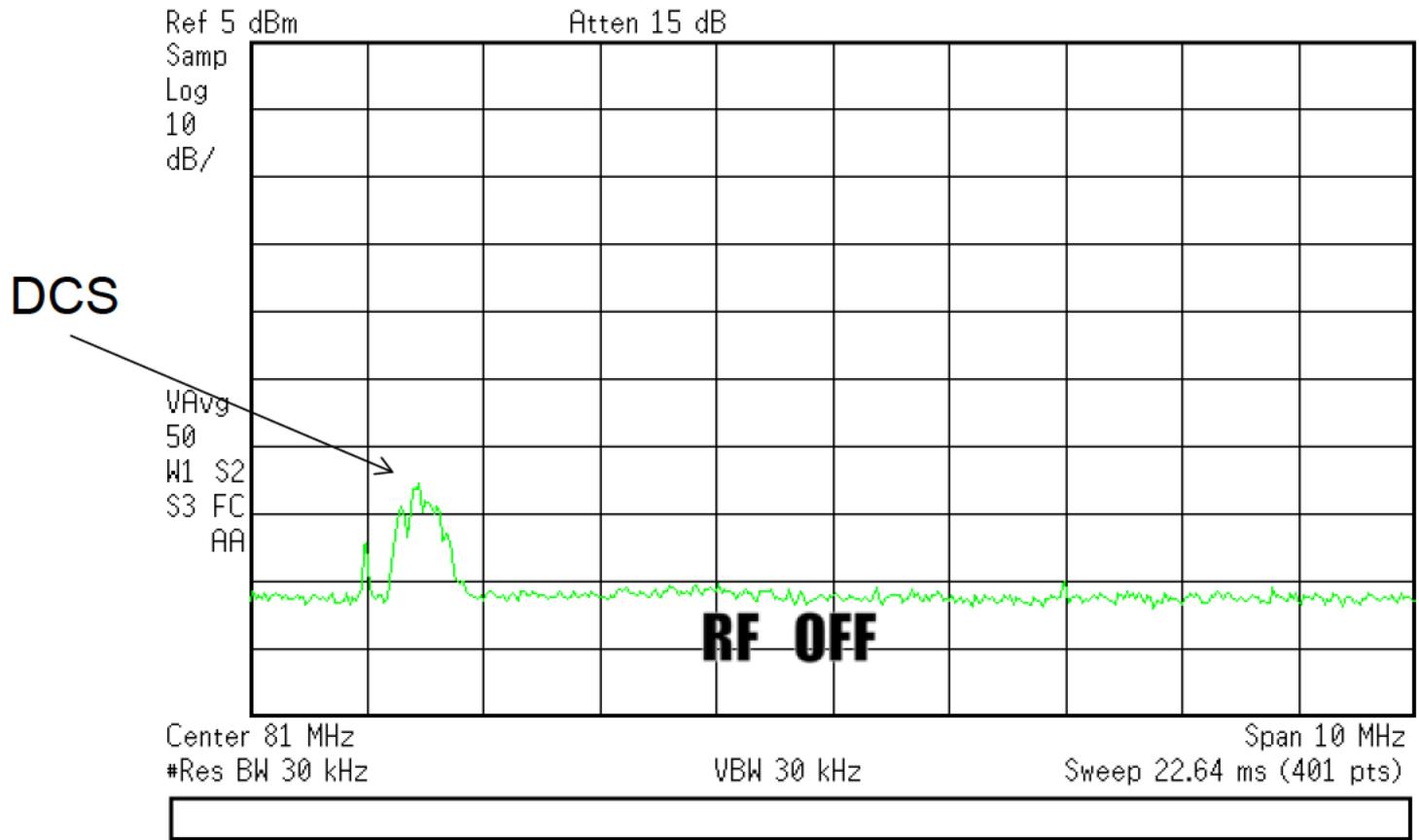
## Testing Results

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- **Transmitting at 1703 MHz and at +10 dBm**
  - DRGS phase noise increased from 2.0° to 2.5°
  - Phase noise increased as the LTE signal came closer
- **Transmit power at : +20 dBm**
  - LRIT and DRGS lost signal due to front end overloading

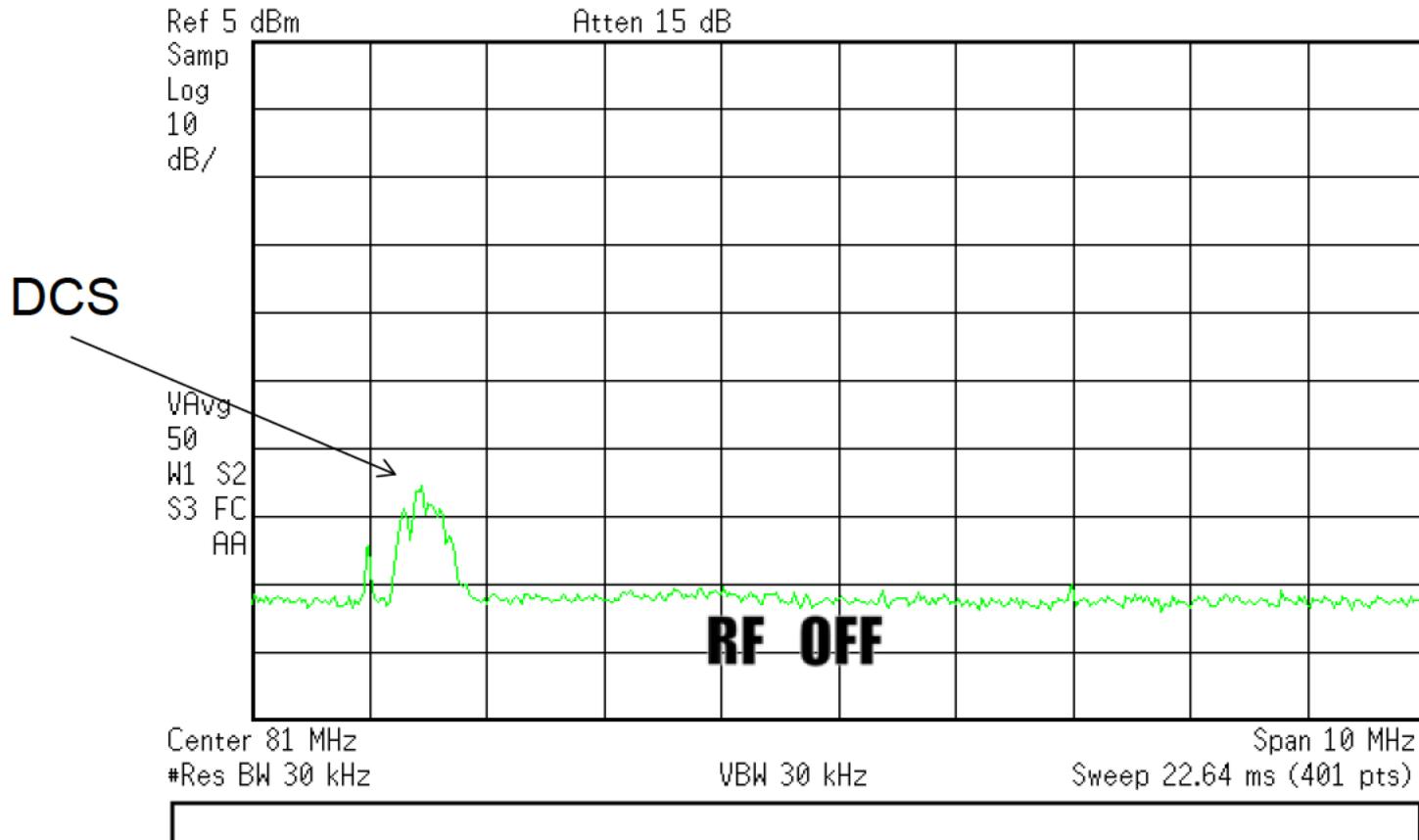
# LTE Out-Of-Band Interference Animation

Agilent 15:46:55 18 Feb 2016



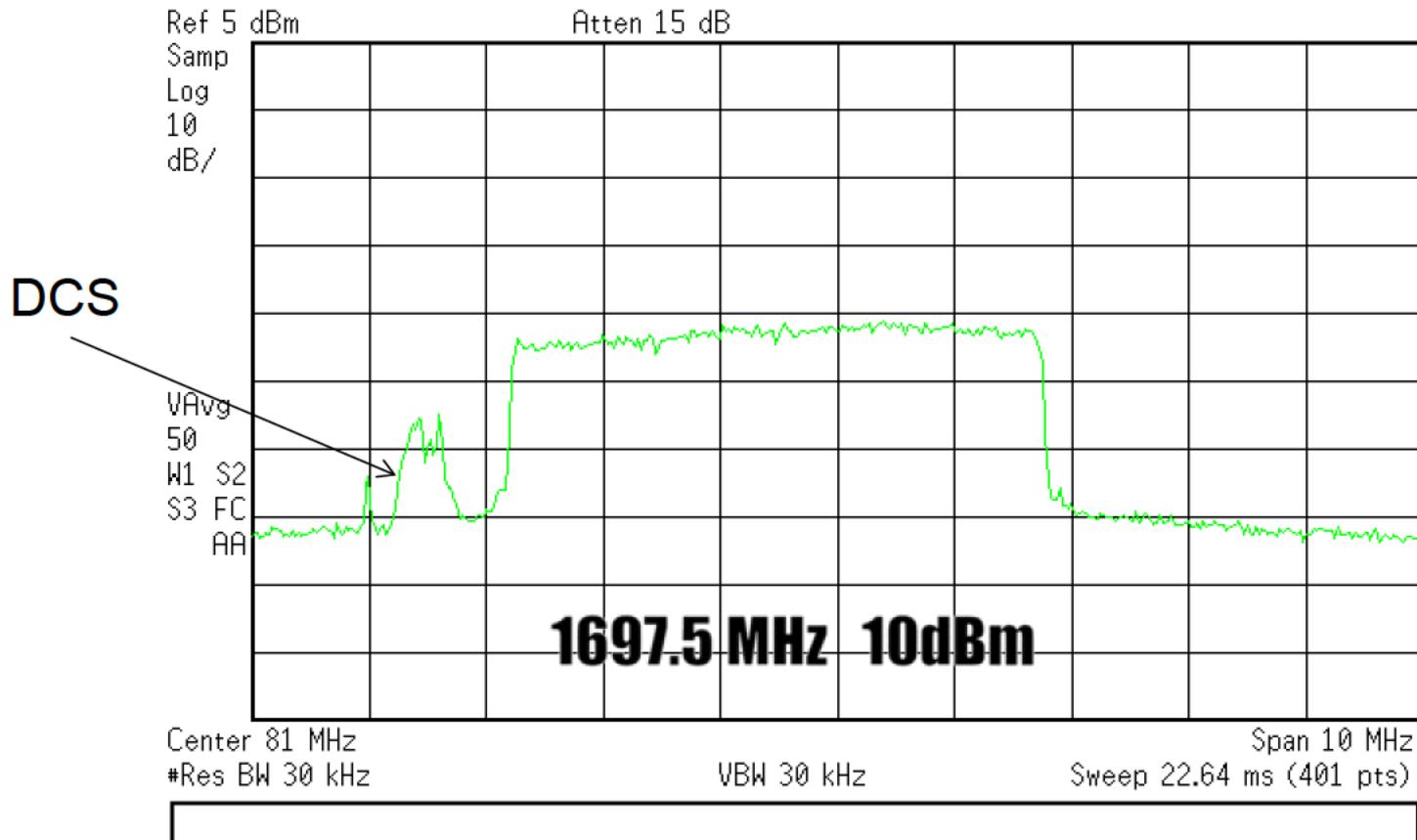
# LTE Out-Of-Band Interference Animation

Agilent 15:46:55 18 Feb 2016



# LTE Out-Of-Band Interference Animation

Agilent 16:36:37 18 Feb 2016





## Cause of interference

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- **Front end overloading due to powerful LTE signals being amplified by the front end**
- **Despite the interfering signal being attenuated by -47 dB it was still strong enough to overload the front end**

## Summary

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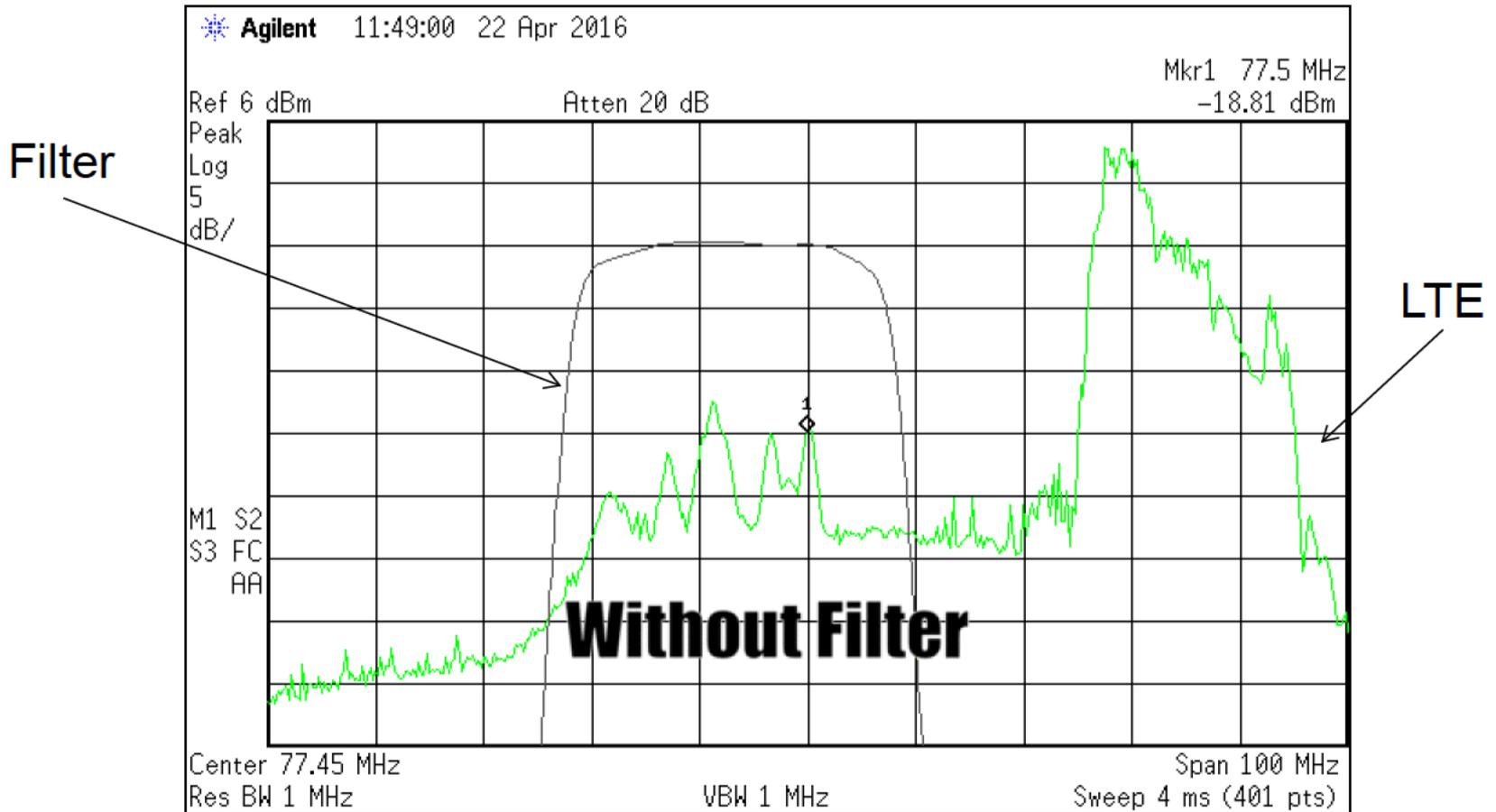
- **Receive sites are susceptible to out-of-band interference**
  - **Testing showed that data loss can be caused by an LTE handset transmitting near a receive site antenna**
- **Handset transmitting 250 feet away from and 49° off axis from receive dish can cause interference when transmitting with more than +10 dBm of power**

## **Recommendation**

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- **Protection zones around receive antenna**
- **Narrow band filters could be retrofitted onto existing dishes**
  - **A filter (K&L 5C45-168/T28-0/0) was installed onto the 3.6 meter dish to show the filters' effectiveness**
- **Multiple receive paths (DRGS & LRIT & Internet) can be used to protect against data loss**
- **RF fences could be constructed around dishes**

# Filter Animation



# Filter Animation

