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June 13, 2019

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

Re: Written ex parte presentation, WT Docket No. 19-116

Dear Ms. Dortch:

In the Notice of Proposed Rulemaking ("NPRM") in the above-captioned docket, the Commission seeks comment on an alternate means of delivering the NOAA data currently broadcast in the 1675-1680 MHz band to the non-Government users who listen in on the band.[1] These non-Government users currently obtain the data via their own Earth stations. As illustrated below, this is an expensive, complicated, and exclusionary means of obtaining the data, one that takes at least 11 months and costs over one hundred thousand dollars to set up. This process stands in stark contrast to the ease and efficiency of the alternate means the Commission suggests—a content delivery system ("CDS"). A CDS is not just a theoretical possibility. As explained below, Ligado Networks LLC ("Ligado") has already established a CDS and that system is currently providing the NOAA data to George Mason University ("GMU") and the University of Oklahoma ("OU"). The public interest benefits of a CDS are clear: it could increase by orders of magnitude the number of users that have access to the NOAA data without any sacrifice in reliability or latency. In fact, as discussed further below, NOAA itself has developed similar CDSs as part of its Big Data Project.

Using Earth Stations to Listen-in on NOAA Data Is Expensive and Time-Consuming

The approximately 100 non-Government entities listening in on the 1675-1680 MHz band do so using an Earth station. The process of procuring and installing the Earth station is time-consuming and costly, and its use requires ongoing maintenance and additional costs. This drastically limits the number and type of parties that can gain access to the NOAA data. As documented in the attached declaration by Ligado consultant Geoff Stearn, it took Ligado, *which already was a satellite operator*, nearly a year to procure and install such an Earth

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[1] Allocation and Service Rules for the 1675-1680 MHz Band, NPRM and Order, WT Docket No. 119-116, at ¶ 20 (rel. May 13, 2019) ("1675-1680 NPRM")

station.[2] Ligado had every head start in the process. The satellite dish is 14.8 feet in diameter and requires a footprint of 256 square feet, which can present siting challenges given that the dish requires both sufficient space and a clear line of sight free of obstructions so it can be oriented toward the NOAA satellite. Ligado had an existing, secure satellite antenna compound with adequate space to accommodate the dish, but if it had been Ligado's first Earth station the company would not only have had to identify a suitable location, but also would have needed to obtain the consent of its landlord (perhaps requiring lease amendments) as well as zoning approval (likely requiring the advice of a land use attorney). The dish also required suitable power, grounding systems, and data connection into Ligado's data center. Again, Ligado's antenna compound already had these critical systems and connections in place as well as emergency backup power in case of a commercial power failure.[3] Despite all of these advantages, it took eleven months—from February - December 2016—from when Ligado had its first meeting with Earth station equipment provider Morcom to when the satellite was installed and operational.[4] In Mr. Stearn's opinion, any party without these advantages would need even longer to deal with these complexities and obtain access to the NOAA data via its own dedicated Earth station.[5]

In addition to being time consuming, installation and operation of a dedicated Earth station is costly. Equipment and installation of Ligado's satellite dish totaled $123,661.90, not including costs to connect the dish to Ligado's existing power, grounding system, and data network.[6] Yearly maintenance contracts are approximately $10,000.[7] Again, were the company not an existing satellite operator these costs may have been higher: Ligado's power and connectivity costs were relatively low given its other satellite dishes, and the company has a staff of engineers expert in satellite communications who played a central role in the procurement and installation process and continue to assist today.[8] These costs are likely prohibitive for many potential users. For example, according to GMU they are "beyond the means of most individual academic institutions."[9]

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[2] *See* Declaration of Geoffrey Stearn at ¶¶ 2-3, attached hereto as Exhibit A ("Stearn Declaration").

[3] *Id.* at ¶ 3.

[4] *Id.* at ¶ 2.

[5] *Id.* at ¶ 3.

[6] *Id.* at ¶ 4.

[7] *Id.* at ¶ 6.

[8] *Id.*

[9] Letter from James L. Kinter III, Chair, Department of Atmospheric, Oceanic and Earth Sciences, George Mason University, to Maqbool Aliani, Senior Vice President, Spectrum

For New Parties Wanting Access to NOAA Data, CDS Is Fast, Easy, and Low Cost

In contrast, the time it took the two users of Ligado's CDS to begin receiving the NOAA data is measured in minutes, not months. Their costs are negligible, not hundreds of thousands of dollars.

In parallel to the satellite dish procurement and installation process, Ligado worked to build a CDS on which the NOAA data would be stored and accessible to end users. Two major public research universities with significant weather research programs, GMU and OU, currently receive the NOAA data via Ligado's CDS. In order to begin receiving the NOAA data, each had to do two things: First, they had to allocate server space to store the NOAA data as a repository for their students and scientists—a "tiny" cost, according to GMU, compared to acquiring an Earth station, which would have required servers as well.[10] Second, they had to provide the range of the school's IP addresses (as part of the CDS security and access protocol) and contact information via a short email form.[11] That's it.

The attached statement from GMU documents this point: "[W]e were up and running within minutes of our data servers being placed into operation. This contrasts with a satellite GRB receive station which would have taken many months to procure and install (if such funding had been available)."[12] GMU and OU are using the NOAA data in numerous ways—to develop new products and displays of products for the weather community, to stimulate student interest in the atmospheric sciences, and to collaborate with other organizations, such as the National Science Foundation.[13] GMU presented its analysis on the efficiency of the CDS at the American Geophysical Union conference in December 2018 and the American Meteorological Society meeting in January 2019.[14]

It is critical to note that use of the CDS offers all of these benefits *without sacrificing reliability or latency*. NOAA represents that the GRB service availability is 99.988 percent.[15]

Standards & Technology, Ligado Networks LLC, at 2 (June 4, 2019), attached hereto as Exhibit B ("GMU Letter").

[10] *Id.*

[11] Stearn Declaration at ¶ 8.

[12] GMU Letter at 2.

[13] *See, e.g., id.* at 3.

[14] *Id.* at 2.

[15] Department of Commerce, GOES-R Series Ground Segment (GS) Project Functional and Performance Specification (F&PS) at 22 (Aug. 15, 2017), https://www.goes-r.gov/resources/docs/GOES-R_GS_FPS.pdf ("GOES-R GS F&PS"). We note that this

The reliability of a CDS with a typical parallel redundant structure is superior to that. In the NPRM, the FCC asks whether there is a particular network configuration that minimizes the risk of server overloads or other interruption to data feeds.[16] The obvious answer is: Yes. Introducing parallel redundancies into the network configuration does so. Hosting the data across a cloud provider's multiple regions, for example, or using multiple cloud providers to guard against the possibility of a provider outage results in a service availability of 99.999874. Employing both a multi-region and multi-cloud strategy results in an availability of 99.999875 percent.[17] With regard to latency, it takes an average of 15 seconds for a file to be transferred from Ligado's Earth station to its CDS. This number could be reduced by approximately one second if the CDS received its data feed directly from NOAA, rather than through a third party Earth station.[18] Users would access the CDS via broadband connection. As previously discussed, many highly reliable, dedicated Internet products are available on the market, and given the position of the non-Government users as major companies and research universities, they likely already have service-level agreements with their broadband provider that themselves use parallel processes to guarantee extremely high levels of uptime.[19] Therefore, last mile delivery should not negatively impact delivery of the NOAA data via CDS.

In the more than two years that Ligado's CDS has been operational, it has *delivered over 292 million files with zero delivery errors*.[20] No major weather events have affected the Ligado CDS' latency or reliability. To the extent that the 1675-1680 MHz band proceeds to auction and Ligado makes a winning bid, Ligado commits to support the development, funding, and

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percentage is a theoretical value and does not include reliability of last mile delivery to end users.

[16] 1675-1680 NPRM at ¶ 20.

[17] Calculated using data provided by Amazon Web Services regarding its Elastic Compute Cloud and S3 Cloud Storage products. *See* Prior Version(s) of Amazon EC2 Service Level Agreement, https://aws.amazon.com/ec2/sla/historical/; Amazon S3 Storage Classes, https://aws.amazon.com/s3/storage-classes/. (Note that these figures were calculated using an earlier monthly uptime percentage guarantee by Elastic Compute Cloud of 99.95 percent. The service currently guarantees a monthly uptime percentage of 99.99 percent, *see* Amazon Compute Service Level Agreement, https://aws.amazon.com/compute/sla/(last updated Mar. 19, 2019).)

[18] GOES-R GS F&PS at 249.

[19] *See* Letter from Gerard J. Waldron, counsel, Ligado Networks, to Marlene H. Dortch, Secretary, Federal Communications Commission, WT Docket No. 19-116 (June 5, 2019); Letter from Gerard J. Waldron, counsel, Ligado Networks, to Marlene S. Dortch, Secretary, Federal Communications Commission, RM-11681; IB Docket No. 11-109; IBFS File Nos. SESMOD-20151231-00981, SAT-MOD-20151231-00090, SAT-MOD-20151231-00091 (Mar. 1, 2017).

[20] As of May 2019.

operation of a broader scale CDS with the features discussed above to serve all of the users who currently receive the NOAA data in this band via dedicated Earth station.

NOAA Itself Has Developed CDSs to Share Its Data with the Public

Given the tremendous benefits of a CDS, it is no surprise that NOAA has sought to develop them as part of its Big Data Project. NOAA worked with Amazon Web Services ("AWS") (the host of Ligado's CDS), Google Cloud Platform, IBM, Microsoft, and the Open Commons Consortium ("OCC") to develop a way to store and process NOAA data and to make it available to more users.[21] It worked. For example, in October 2015, NOAA transferred its 300 terabyte NEXRAD 88D Weather Radar Archive to AWS, Google, and OCC. Following the release of the AWS service, usage more than doubled, and new uses were developed.[22] NOAA's provision of GOES-16 data to the Open Commons Consortium enabled the *Tampa Bay Times* to create a stirring visual article on Hurricane Irma.[23] Referring to these cloud platforms, NOAA stated that "industry builds what is needed to support its users."[24] NOAA's mission is: "1. To understand and predict changes in climate, weather, oceans and costs; 2. *To share that knowledge and information with others*; and 3. To conserve and manage coastal and marine ecosystems and resources."[25] NOAA has "a proud history of government open data leadership and partnerships with industry and academia," and through the Big Data Project is seeking to "make NOAA's open data accessible and widely usable at no cost to the US taxpayer."[26] Developing a CDS to share the NOAA data currently broadcast in the 1675-1680 MHz band directly serves NOAA's mission and follows the great steps it has already taken to advance open data.

* * *

In sum, a CDS can be used to deliver the NOAA data non-federal users currently access via dedicated Earth stations in a faster and more reliable way than they currently receive it. The current system of receiving the data is prohibitively time consuming and expensive for many entities, such as universities, that could make good use of the NOAA data. In contrast, any user with an Internet connection could immediately access the CDS, for the mere cost of maintaining

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[21] Edward J. Kearns (NOAA Chief Data Officer), NOAA's Big Data Project at 17-20 (Apr. 20, 2018), https://www.cmts.gov/downloads/CMTS_Webinar_Speaker_Kearns_20Apr2018.pdf ("Big Data Project Presentation").

[22] *Id.* at 21.

[23] *Id.* at 30-31; Nathaniel Lash and Neil Bedi, "A matter of miles: How the slightest shift kept Hurricane Irma from turning into an even worse disaster," TAMPA BAY TIMES (Sept. 20, 2017), http://www.tampabay.com/projects/2017/hurricane-irma/matter-of-miles/.

[24] *Id.* at 17.

[25] NOAA, Our Mission and Vision, https://www.noaa.gov/our-mission-and-vision (last visited June 13, 2019) (emphasis added).

[26] Big Data Project Presentation at 38.

such connection and server space. This means that a CDS will increase the total number of users with access to this data, providing students and more scientists with access to this important weather data. The Commission should proceed with the auction of 1675-1680 MHz, confident in the knowledge that those non-federal users currently listening in on the band will be able to continue receiving the NOAA data after the band is allocated for shared Federal and commercial use.

Please direct any questions to the undersigned.

Respectfully submitted,

__/s/_____
Gerard J. Waldron
Hannah Lepow

Counsel for Ligado Networks LLC

Attachments

EXHIBIT A

DECLARATION OF GEOFFREY STEARN

1. My name is Geoffrey Stearn. I am an independent telecommunications consultant and advisor. From July 2010 to February 2019, I worked for Ligado Networks LLC ("Ligado"), most recently as Senior Vice President - Strategic Initiatives, and I still work closely with the company in a consulting role. During my tenure at Ligado, I was centrally involved in the more than one year long process of sourcing and installing an Earth station to receive the data broadcast by NOAA in the 1675-1680 MHz band, in order to develop the content delivery system ("CDS") that currently shares weather data broadcast by NOAA in the 1675-1680 MHz band with George Mason University and the University of Oklahoma. I have over 30 years of experience in the wireless communications industry. I hold a B.A. from the University of Maryland and an M.B.A. from The George Washington University.

2. In late 2015, Ligado began the process of conceptualizing and creating the CDS. First, we had to evaluate available technologies that would be suitable for the distribution of the NOAA data in a highly reliable, scalable and cost-effective manner. An essential element common to all potential CDS designs was to purchase and install an Earth station so that we could receive the NOAA data that would then be stored on the CDS and accessible to CDS end users. The procurement and installation of the Earth station took a full year. After performing our due diligence on potential vendors, we had our first contact with our ultimate Earth station equipment provider, Morcom International Inc. ("Morcom"), in February 2016. We continued to learn more about the availability, options and requirements of Earth stations capable of receiving NOAA data while working with Morcom, and received our first quote from them in the Spring of 2016. After further discussion, evaluation and refinement of the proposal, we placed our order

with Morcom for the Earth station in July 2016. The satellite dish and associated equipment were installed and placed into operation in December 2016.

3. It is important to understand that this year-long process could have taken much longer. As a satellite operator itself, Ligado was in an ideal position to purchase and install the satellite dish as quickly as possible. The satellite dish is 14.8 feet in diameter and requires a footprint of 256 square feet. This can present siting challenges, as you need not only sufficient space, but a clear line of sight-free of obstructions so the dish can be oriented toward the NOAA satellite located at 75.2°W. Ligado has an existing, secure, satellite antenna compound that had adequate space to accommodate the satellite dish. If this had been Ligado's first Earth station , it would have not only had to identify a suitable location, but would have needed to obtain the consent of its landlord (perhaps requiring lease amendments) as well as zoning approval (likely requiring the services of a land use attorney). The company already had obtained these necessary permissions for its existing antenna compound. Even so, installing this new dish did require, among other things, a civil engineering analysis. Ligado already had experience obtaining such analyses for installations it had performed previously related to its own satellite systems which kept this element from affecting the overall installation timeline. Additionally, the dish required suitable power, grounding systems and data connections into Ligado's data center. Ligado's antenna compound already had these critical systems and connections in place as well as emergency backup power in case of a commercial power failure. In my opinion, any party without these advantages would need even longer than a year to deal with these complexities in order to obtain access to the NOAA data via its own dedicated Earth station.

4. Cost would also be a substantial factor for any entity seeking to install its own dedicated Earth station. The satellite dish itself is costly, with equipment and installation costing

$123,661.90. This does not include other costs to connect the Earth station to the existing power, grounding system and data network at the site. These power and connectivity costs were relatively low for Ligado given the other satellite dishes it already had, but would be substantial for a party without existing infrastructure who would have to run power, install new grounding systems and install new fiber connectivity to this site. The cost could have been higher still if the satellite dish had been located at a more northern latitude than that Ligado's Virginia location. Northern sites have greater difficulty connecting to geostationary satellites and require larger, more expensive, satellite dishes to do so in order to compensate for the more challenging signal path, as well as needing more clearance to be free from obstructions.

5. An additional complexity Ligado had to contend with at the time was the transition by NOAA to its next-generation satellite constellation known as GOES-R. The previous system (which was still in operation in 2016) used a satellite link called GVAR. This was upgraded in GOES-R to a higher bandwidth service called GRB. Ligado needed to purchase a system that could accommodate both GVAR and GRB and this dual functionality accounted for approximately $23,000 of the total price tag. Despite this additional cost, Ligado was in a better position than those entities with satellite dishes that were GVAR-only and could not easily upgrade to GRB. Those entities, in addition to having previously purchased their GVAR-only system, would have to purchase a complete new GRB-capable system at a cost of approximately $100,000 plus any third-party installation fees.

6. There are significant ongoing costs beyond installing the satellite dish itself. Maintenance contracts for the Earth station are nearly $10,000 per year, though Ligado has been able to scale back those costs as it has been able to transition most maintenance services over to its own internal operations team. Finally, Ligado has a staff of engineers who are experts in

satellite communications and who played a central role in this process. A party without these resources would need to spend both money and time contracting with sufficiently qualified engineers.

7. Once the Earth station was operational in December 2016, Ligado began the testing and acceptance process to ensure the integrity of the data being received which was validated by George Mason University ("GMU"), the first end user of the CDS. Later on, GMU informed Ligado that they wished to receive the data in NetCDF format—the format widely used by the weather community (Ligado's satellite dish vendor's receive equipment employed proprietary software that converted the NOAA data to a format that was different from NetCDF). In parallel to the satellite dish procurement and installation process, Ligado had been working with Teleworld Solutions ("Teleworld") to build the CDS on which the NOAA data would be stored and accessible to end users. Teleworld was able to develop a solution by integrating the Community Satellite Processing Package (CSPP) software that provides the GRB data feed in real-time NetCDF format—a process that took approximately six weeks to complete.

8. Two major research universities currently receive the NOAA data via Ligado's CDS: GMU and the University of Oklahoma ("OU"). The time it took them to begin receiving the data is measured in minutes, not years. GMU only needed to allocate server space to store the NOAA data as a repository for its students and scientists—a cost of doing business for a major research university—and to provide its range of IP addresses (as part of the CDS security protocol) and authorized points of contact via a short email form. It then immediately began receiving the NOAA data while Ligado was still in the testing and acceptance process. As discussed above, the data GMU first received was not in its desired format, but Teleworld addressed this issue GMU began receiving the same high-quality data in NetCDF format.

9. The process for the University of Oklahoma ("OU") was even simpler. After meeting with members of their school of meteorology and their IT department, Ligado quickly connected OU to the CDS in early Fall 2018. By that point, the CDS had been operational for well over a year and working with an end-user for the vast majority of that time. The CDS data was already in the NetCDF format used by the weather industry. Again after designating server space and responding to the brief email form, OU also began receiving the NOAA data immediately.

Signed: */s/*
Geoffrey Stearn

Date: June 13, 2019

EXHIBIT B

Department of Atmospheric, Oceanic and Earth Sciences
284 Research Hall, Mail Stop 6C5
4400 University Drive, Fairfax, Virginia 22030
James L. Kinter, Professor and Chair
Telephone: 703-993-5700; Email: ikinter@gmu.edu

4 June 2019

Mr. Maqbool Aliani
Senior Vice President, Spectrum Standards & Technology
Ligado Networks LLC
10802 Parkridge Blvd.
Reston, VA 20191

Dear Maqbool:

I am writing to give you a progress report on our innovative collaboration with Ligado to demonstrate the feasibility and value of receiving real-time satellite-based weather data over a cloud-based content delivery network ("CDN") to advance both research and higher education in the study of the Earth's atmosphere and climate. Since we began receiving the National Oceanic and Atmospheric Administration ("NOAA") Geostationary Orbiting Earth Satellite ("GOES") data stream via the cloud in December 2016 (GOES Variable data at that time, and GOES Re-Broadcast or GRB currently), we came to fully appreciate how valuable the CDN would be on a wider scale.

As you know, George Mason University is Virginia's largest public research university and a member of the elite group of 115 tier-one research institutions as ranked by the Carnegie Classification of Institutions of Higher Education. Mason's climate and weather science department is are among the best in the country. The cumulative number of citations for the 19 tenure-line Department of Atmospheric, Oceanic, and Earth Sciences ("AOES") faculty members is over 70,000, and they currently conduct research grant projects with awards totaling over $20 million. Mason's Center for Ocean-Land-Atmosphere Studies ("COLA") is the largest single academic group of climate dynamics and climate modeling experts in the U.S., and contributes substantially to the Mason Climate Dynamics Ph.D. program, which is unique in its focus on training the next generation of climate modelers and analysts, including 44 alumni who are active in the field and 21 current Ph.D. students.

Mason's research and educational programs in Climate Dynamics rely on public data sources that are produced by NOAA and other entities. Real-time data has great potential as a resource for evaluating the quality of weather forecasts and climate predictions, event monitoring, and for educating undergraduates in atmospheric science. However, the acquisition and processing of real-time data from NOAA's satellite systems is an expensive undertaking that has previously required the purchase, installation, operation and maintenance of dedicated

satellite receive equipment, which is beyond the means of most individual academic departments.

On the other hand, the CDN has proven to be an important advancement, reliably bringing us real-time data without the enormous expense of installing our own satellite equipment. The only costs that Mason incurred in connecting to the CDN were for new servers to process and store this new NOAA data. The cost of the servers is tiny compared to the costs that would have been associated with acquiring our own GRB satellite dish – and these servers would have still been necessary in that scenario as well. Additionally, there have been no incremental costs associated with the connectivity to the CDN as we've been able to utilize our existing internet bandwidth to receive this data.

Another benefit of the CDN is the speed at which we were able to connect and receive this data when we first partnered with Ligado. We were up and running within minutes of our data servers being placed into operation. This contrasts with a satellite GRB receive station which would have taken many months to procure and install (if such funding had been available). Furthermore, the CDN frees Mason from the responsibility of maintaining and upgrading the hardware and software associated with a GRB receive station.

As you know, a major benefit of our work together is bringing this data to the public, as the CDN can be accessible to all users with an Internet connection. Our two servers have different specifications that receive data from the CDN and both are currently receiving GRB data. As of April 15, 2019, we had received 175 terabytes of data from nearly 270 million files, and no data packets have been lost.

We developed software applications to automatically track the timestamps of all data files and generate daily and overall statistics of the data latency to evaluate efficiency of the CDN delivery. The Ligado-GMU system performance is judged to be very good, with L1b data latency between 17 and 63 seconds (depending on file size), compared to receiving files directly over a satellite GRB link. By establishing a method to receive the CDN data, we not only benefit our students and researchers but also create a foundation that other schools can build upon to access this data. Mason was pleased to present the results of our analysis-to-date at both the American Geophysical Union conference in December 2018 and the American Meteorological Society meeting in January 2019. A team member also presented our website at the COLA Current Climate Conversation. All presentations were well-received with positive feedback.

Mason is developing additional features that will enhance the existing software packages used by the scientific community to display GRB data products. These include product generation and displays of new products that the GOES-R series of satellites produce including the Global Lightning Mapper ("GLM"), as well as additional tools for already-existing displays such as:

- Image loops,
- Event detection,
- Event frequency accumulation, and
- Mapping satellite data onto Earth grids using Geographical Information System (GIS) or other software packages.

We have also developed and integrated tools to analyze and visualize the low latency data for various applications, such as hurricane monitoring, wildland fire monitoring, tornado post

analysis, dust storm monitoring etc. The images and videos are automatically generated and disseminated through the project website http://aoes-ligado.gmu.edu. The data associated with these events are stored for further research and analysis. We will focus on event detection in particular, as further developing this ability will both serve the research community and provide important tools for decision-making in emergency management and other fields.

Leveraging the high frequency and high spatial resolution of real-time GOES data, we collaborate with other GMU units, such as the project sponsored by the National Science Foundation ("NSF") on spatiotemporal computing infrastructure to work on artificially intelligent downscaling of rainfall from general circulation models, development of automatic tracking of hurricanes using machine learning methods, tracking of GLM performance with lightning data from National Lightning Data Network ("NLDN") and re-analysis and assimilation of vertical profile data at high resolution to examine fine detail Convective Available Potential Energy ("CAPE") and atmospheric duct structure.

We also plan to use our influence as a major research university to further stimulate student interest in the atmospheric sciences. In addition to using the CDN data in the classroom, we have created displays that can be posted on the AOES website, shared via social media, and used in meetings of meteorological organizations. These prototype displays, which include standardized plots and animations that are automatically updated in real time as well as case study graphics of interesting events, are currently being refined and will be linked to the AOES website soon.

We look forward to continuing our collaboration with Ligado and seeing how much we can achieve to excite students with this new, zero-cost source of high quality, real-time NOAA data.

Sincerely,

James L. Kinter III
Chair