GOES DCS
123rd Technical Working Group Meeting (TWG) 123
Wednesday, April 24, 2019
Denver Risk Management Center (RMC), Western Division
12596 West Bayaud Avenue, Suite 400, Lakewood, CO 80228.

Introductory Remarks; Logistics - R. Antoine

Richard Antoine opened the meeting and welcomed the participants.

GOES DCS Program Updates – Richard Antoine

Richard then went over the GOES DCS program updates. He briefed that the transition of GOES DCS on the legacy LRIT broadcast had ended and transitioned to the new HRIT/EMWIN broadcast on the GOES-R Series satellites GOES-16 and GOES-17. He also stated that the DADDS hardware refresh was being completed as he was speaking and would be completed soon. He went over the dual feed of the legacy DCS message format and the new format over HRIT that will be ending on May 20th, 2019. More critically, he reminded the attendees that the DOMSAT broadcast would be ending on May 14, 2019.

Richard then went over a project completed by the Program to get "good news" stories from DCS Users. There were stories received from US Fish and Wildlife Service, Bureau of Land Management, National Weather Service, the Chilean Center for Advanced Studies of Arid Zones, Mexico's Institute of Transportation, the National Seismology Service of Mexico, the governments of Newfoundland and Labrador and Parks Canada.

It was noted by Environment Canada that this was the only system that stays up continually.

The following is a list of Action Items from the March 2018 TWG with a status for each.

- Action 122-1: NOAA to investigate request from Bahamas Met Service to maintain 5-10 years of GOES DCS data on website. Considering but unlikely.
    - Status: Carried forward. See Appendix III.
- Action 122-2 Investigate how to make configuration files available in the USACE DCP Monitor system. See Page 07. Incomplete. Need clarification.
    - Status: Carried forward. See Appendix III.
- Action 122-3: As WCDAS puts WMO headers on 89% of messages and sends them to the NWSTG, consider putting WMO headers on all the messages; or assess whether we should be doing this at all by seeing if there are user requirements for this. Clarify a statement of need and NOAA will scope the task.
    - Status: Carried forward. See Appendix III.
- Action 122-4: Letecia to send out the link to the on-line version of the Alion Survey to all DCS users as well as the Program Manager for HRIT/EMWIN and GRB. See Page 13.
    - Status: Completed
- Action 122-5: Respond to NOAA SPRES Subcontractor, Alion Sciences, by completing the DCS User Survey for All Users. Outreach to users completed. https://docs.google.com/forms/d/e/1FAIpQLSfbcfa2APQHW6okffTJOfxFW8coIak81jk6jWxBDOm6n-8Dtg/viewform. This is very time critical to support the contractor schedule under the

NOAA Spectrum Pipeline Reallocation Engineering Study (SPRES) which will study if the 1675-1680 MHz spectrum can be shared. Please complete this survey in the next 30-60 days. See Page 13.
    - Status: Completed
- Action 122-6: Provide the location, exact latitude and longitude for all Federal and non-Federal stations (including foreign) for DRGS, LRIT, HRIT/EMWIN to the NOAA SPRES Contractor Shared Spectrum Company so that they have a correct and comprehensive list of receiving stations. Send to Dr. Todd Martin at tmartin@sharedspectrum.com and please copy beau.backus@noaa.gov. Please provide within the next 30-60 days along with a point of contact with email and phone for your organization. See Page 13. In progress.
    - Status: Carried forward. See Appendix III.
- Action 122-7: Item: Microcom Design to share DCPI test results with the user community as they become available. See Page 17. Completed.
- Action 122-8: DCS Program to prepare some vehicle for getting user input on the DCPI two-way communication project. See Page 17. Review Report before adding status.
    - Status: Carried forward. See Appendix III.
- Action122-9: DCS Program manager to prepare a briefing for OSPO and NESDIS Management on estimates on the costs to bring the DCPI two-way communication project to completion for GOES-R Series and the next generation of satellites. See Page 17. In progress of executing a project with Microcom. Presentation of recent work his afternoon.
    - Status: Carried forward. See Appendix III.
- Action 122-10: NOAA to investigate back-up (remote) pilot options including reuse of Goddard equipment or a new system for the CBU. See Page 11. Short term project complete; long term solution in progress.
    - Status: Carried forward. See Appendix III.
- Action 122-11: Investigate planning a test for a dual feed of DCS with the old and new formats. See Page 19.
    - Status: Completed.
- Action 122-12: Work with the HRIT/EMWIN Program Manager to plan for up to 10% DCS usage on HRIT/EMWIN. See Page 19. Status with HRIT Program.
    - Status: Carried forward. See Appendix III.
- Action 122-13: Investigate planning a test for a dual feed of DCS with the old and new formats on GOES-16. See Page 19.
    - Status: Completed.
- Action 122-14: Microcom to share the proposals with Aerospace (Dr. Esteban Valles) for the software defined radio prototype. See Page 19.
    - Status: Completed.

GOES DCS Program Updates – Letecia Reeves

Letecia Reeves gave a status report on the number of active, inactive, and unused DCPs in the system. She noted that she does not include the "parked" channels in her statistics. She noted that the GPS "roll over' did affect many platforms in the field.

She briefed there are only 11 active and 9 inactive 100 Baud stations left; 27,865 active, 7,775 inactive and 2,336 unused 300 baud DCPs; and 465 active, 596 inactive and 275 unused 12 baud stations. The combined total of registered DCPs is 39,332. She reminded us that an active DCP has

sent a data transmission within 2 days, an inactive DCP has not sent a data transmission in 2 days and an unused DCP has never sent a transmission in its specific channel and timeslot.

She then went over the transition from CS1 to CS2 and noted that we are almost half way to total transition. The DCS Program has been able to create 3 CS2 1200 baud channels. To make more channels, we need to have 50% of two adjacent channels free. Microcom has been tasked to come up with a channel optimization plan to create additional channels as we progress in the CS2 transition.

Letecia then went over the channel assignment policy. No CS1 transmitters should be deployed in the field. The standard rate is 300 baud and the standard window is 5 or 10 seconds while the standard transmission period is 1 hour. She noted that some organizations are using more frequent transmissions. Users must have good justification to receive more frequent transmissions. Some examples are Tsunami Monitoring and flash flood warning stations.

Letecia noted some keys to using the DCS system efficiently:

- Compression whenever possible; pseudo binary
- Not sending redundant information
- Not sending messages in ASCII

She also noted some current and future milestones:

Only CS2 transmitters should be deployed
All 100 bps transmitters should be decommissioned
All random transmissions should be reprogrammed to 300 baud ASAP
All version 1 transmitters must be upgraded by May 31, 2026

GOES DCS Program Updates – Valerie Randall

Valerie Randall presented statistics on the DCS Systems Use Agreements (SUA).

Currently there are 475 SUAs, 25 being for industry, and a total of 2039 DADDS Users.

- Canada 67
- Caribbean 20
- South America 80
- United States 283
- Other 25

Wallops Update - T. Thornton and Matt Sullivan

Travis Thornton began his presentation by reiterating that GOES-16 is now the GOES East and GOES-17 is now the GOES-West and that GOES-13, 14 and 15 are in storage orbits. He showed the footprint of the GOES and reminded all that the footprint was much larger than that of DOMSAT. Reiterated that GOES 16 and 17 are the active satellites and give the positions.

Travis showed the WCDAS backup plan at CBU Fairmont, WV, Fairbanks, Alaska and WBU in Greenbelt, MD. Fairbanks does not support GOES-R but can support a GOES NOP Series Satellite if needed. The DADDS at WCDAS has a backup DADDS at NSOF and it gets the same downlink DCS as WCDAS. Of note is that the current plan has GOES-13 moving to the Indian Ocean for the Air Force. WCDAS antennas are being shifted to accommodate this.

Travis also briefed and showed a picture of the CBU at Fairmont including the DCS Pilot Antennas that were moved there from WBU. He noted that CBU (ConsolidatedBackUp) is a replacement acronym for RBU (RemoteBackUp) and that some people still refer to that acronym. RBU was a GOES-R Backup only but after adding the NESDIS COOP backup as well the name was changed.

Travis went over the DCS Data Services or dissemination services. He noted that there are currently 4 services:

- DOMSAT,
- NWSTG,
- LRGS, and
- HRIT/EMWIN

Travis noted that the DOMSAT service would be ended on May 14, 2019.

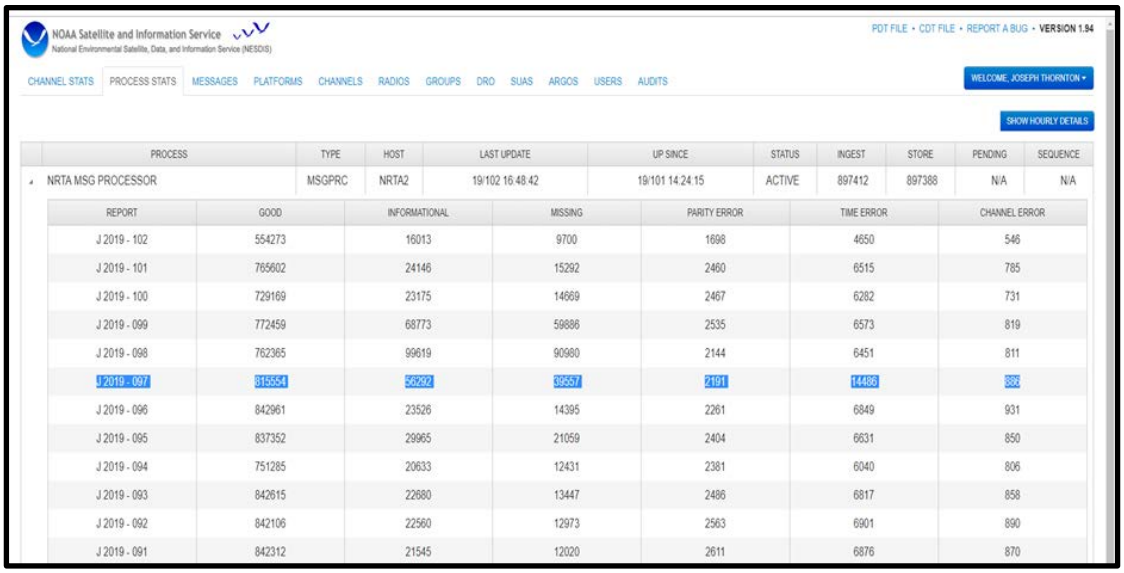
Also briefed was that the NWSTG services is a combination of two links to the NWS Telecommunications Gateway; one from WCDAS DADDS and the other from the NSOF DADDS. The NWS can select which link they wish to connect to. Another point is that the NWSTG User community is largely unknown. 86% of the NWSTG messages have a WMO header.

Matt went over the LRGS sites at WCDAS, NSOF and EDDN. He noted that the DROT server at WCDAS will be going away when the DOMSAT broadcast is terminated. Matt noted that the WCDAS monitors the LRGS network. He provided links to get the status of each machine.

- The LRGSs can be monitored through "LRGS Summary Status" web page, available through the DADDS webservers 1-4: https://dcsX.noaa.gov ►"LRGS Status" ► https://dcsX.noaa.gov/lrgs/LrgsSummaryStatus.html
- The Emergency Data Distribution Network's (EDDN) 3 LRGSs can be monitored through the LRGS Summary Status at: https://eddn.usgs.gov/lrgs/LrgsSummaryStatus.html

They reminded the attendees that the legacy LRIT broadcast is no longer operational. It was ended on February 12, 2019. The new service is the HRIT/EMWIN broadcast from GOES-R Series of satellites. Attendees were reminded that the HRIT footprint from GOES is much larger than that of DOMSAT. The ground station requires a 1 (> 10 degrees) to 1.2 (> 5 degrees) meter antenna depending on the elevation of the satellite from each individual ground station. It was also noted that there is imagery in HRIT format and the suite of EMWIN products on the broadcast as well.

WCDAS briefed their observations of the GPS Rollover that occurred Saturday, April 6th. They noted that the week counter rolled over after 1024 weeks. Some of the older transmitters required a firmware update to deal with this issue. Vendors worked with customers to mitigate the issue. There were issues but the message statistics are slowly coming back into the normal range. They showed the following graphic from the April timeframe.



PROCESS	TYPE	HOST	LAST UPDATE	UP SINCE	STATUS	INGEST	STORE	PENDING	SEQUENCE
NRTA MSG PROCESSOR	MSGPRC	NRTA2	19/102 16:48:42	19/101 14:24:15	ACTIVE	897412	897388	N/A	N/A

REPORT	GOOD	INFORMATIONAL	MISSING	PARITY ERROR	TIME ERROR	CHANNEL ERROR
J 2019 - 102	554273	16013	9700	1698	4650	546
J 2019 - 101	765602	24146	15292	2460	6515	785
J 2019 - 100	729169	23175	14669	2467	6282	731
J 2019 - 099	772459	68773	59886	2535	6573	819
J 2019 - 098	762365	99619	90980	2144	6451	811
J 2019 - 097	815554	56292	39557	2191	14486	886
J 2019 - 096	842961	23526	14395	2261	6849	931
J 2019 - 095	837352	29965	21059	2404	6631	850
J 2019 - 094	751285	20633	12431	2381	6040	806
J 2019 - 093	842615	22680	13447	2486	6817	858
J 2019 - 092	842106	22560	12973	2563	6901	890
J 2019 - 091	842312	21545	12020	2611	6876	870

They also went over the DADDS web servers; highlighting the notifications that appear on the home page; e.g. the GPS Rollover and by clicking on the Operational Notices tab in orange on the left side. They also highlighted that you can access the DCS web servers by clicking on the appropriate server name in the blue vertical banner on the left. They noted that you can access DCS documentation by going to the System Information and Program Information tabs on the blue vertical banner; e.g. TWG meeting minutes and certification standards.

WCDAS also briefed that there are DCP test channels available. They are for Users when going over the certification process and new transmitters. He noted that the permanent 1200 bps may change in the future. You can find the DCS Field Test Link on the DCS (1-4) web pages on the right side near the top of the home page.

- GOES East
  - 300bps
  - 195E for CS1 & CS2 (401.99200 MHz)
  - 1200bps
  - A99 for CS1, 497 for CS2 (401.99575 MHz)
  - Incompatible with CS2-needs to move
- GOES West
  - 300bps
  - 196W for CS1 & CS2 (401.99350 MHz)
  - 1200bps
  - A100 for CS1, 499 for CS2 (401.99875 MHz)

The also showed a slide showing the IM or Information Message codes and the message statistics. WCDAS use this for troubleshooting. They can be accessed through DADDS and the LRGS. The message codes are listed below.

- 'G' : Good Message - also transmitted with all messages except '?' and 'M'.
- '?' : Parity Error(s).
- 'A' : Correctable address
- 'N' : PDT Incomplete
- 'T' : Overlapping time error. A message was outside of, but overlapping its window.
- 'U' : Non-overlapping time error. Message completely out of its defined window.

- 'W' : Wrong channel
- 'M' : A self-timed message was not received at all, received on wrong channel, not completely inside a window or an overlapping window.
- 'B' : Non-correctable : Available on the DADDS Website message data. Messages with bad addresses are not disseminated.
- 'I' : Invalid address. Available on the DADDS Website message data. Messages invalid addresses are not disseminated.

The message statistics are listed here using an example message: 11083215414G48+2NN167EFF.

- YYDDDHHMMSS Time: YYDDDHHMMSS (Frame Sync)
- T Type: G = Good ? = Parity Errors (ARM)
- SS Signal Strength: dBm EIRP (assumes 47 dBmi Pilot)
- 25 to 56 dBm nominal demod reception thresholds
- ±X Frequency: Sign & Digit (±F times 50 Hz)
- M Modulation Index (Phase): Normal, High, Low
- D Data Quality (Phase): Normal, Fair, Poor

Does WCDAS have HRIT only? Yes, they just installed two systems.

Questions: Where is the documentation for the quality statistics and parity errors? Answer: There is a presentation and should be on the DCS web site. Missing fields in the PDT can cause these errors. Travis went over why the PDTs are important and the info should be kept up to date.

Question: Can there be a training guide on this? Answer: Yes.

WCDAS Points of Contact are as follows:

Wallops Help Desk: 757-824-7450 or 757-824-7451
24/7 Technical Support for DCS, LRGS, LRIT, HRIT

Travis Thornton: 757-824-7304
Operations Shift Supervisor and DCS Operations Team Lead
Acting Wallops CDAS Operations Branch Chief

Matt Sullivan: 757-824-7360
Calibration Laboratory, Systems Engineering Branch

Travis noted that long time WCDAS employees that have worked on GOES DCS are retiring. Philip Whaley is already retired. Al McMath retires May 30th. Travis will act in Al McMath's spot as Operations Manager for 120 days or until someone is hired.

STIWG Report - L. Broyles

LySanias began with a brief on how to jointly fund enhancements to OpenDCS for the benefit of all. He noted that he has been working on Interagency Support Agreements based on existing MOA/MOU's that would allow USACE to receive funds from STIWG agencies in support of OpenDCS development through the RMA contract. He has completed draft of agreement under

existing 7600A between USACE and NOAA. It outlines the scope of work, expectations, requirements and funding. Also noted that Interagency agreements have been delivered to STIWG agencies.

He also went over some aspects of interference analysis and mitigation. He noted that some agencies have worked on mitigation strategies.

- Some agencies have awarded separate scopes of work
    - Site analysis
    - Equipment modernization
    - Implementation of recommended mitigation measures
    - Interference monitoring: One thing to accomplish is to do a baseline of the interference in your area and then monitor what is happening in your area. There could be interference that is not killing your signal but reducing it.

LySanias also briefed DCP bi-directional, 2-way communication. He noted that this is especially useful for Users with remote systems. Some features are remote configuration changes, turn off/on message transmission, and diagnose malfunctions without having to travel to the DCP to do so. This would be especially valuable, for example, in mountainous regions requiring helicopter rental to access the DCP. He noted that this capability has been available on the GOES satellites but not used. The STIWG wants to move forward with this and is looking for demonstration and is actively pursuing the continued research and development of this capability. This capability will require development of additional software to interface with DADDS. User should anticipate a live demonstration/proof of concept in the near future

He also went over the GPS Roll Over impact. There was a logic bug that caused many DCPs to disappear. Users were not aware of a necessary patch. There were three software solutions that could be used: 1) patch could be applied remotely, 2) applied directly into the DCP or 3) send the DCP back to the manufacturer. Luckily, we did not have to recertify the DCPs. One thing noted by USACE was that the manufacturer info in the PDT was out of date. This delayed notification on the software patch that became available. On the other hand, it is noted that manufacturers could make the updates easier to find and install. LySanias also noted that this happened during a flood season where there was a lot of damage due to the flooding; especially in the Midwest.

LySanias briefed the new DCP message format for HRIT. The new format compresses the messages from 70 characters down to 41. The new quality control information will help troubleshooting. He noted that the legacy LRIT broadcast will be stopped in May 2019. The LRIT receivers need an update to use the new message format and to receive HRIT.

He also went over the effort to develop full spectrum product processing from HRIT. This would expand the products that are available to include the imagery and emergency weather data. Dealing with porting of the Rice Compression was an issue. There still needs to be a level of effort and scope of work study to address this issue.

LySanias went over past and upcoming engagement events. He noted that some interference are impacting the monitoring of certain environments data. Upcoming events with the NSF and Interstate Council on Water Policy are two where the agencies have shown concern about the frequency interference.

- 2018, 2019 ACWI-Subcommittee on Hydrology Meeting

- 2018, 2019 Committee for Operational Environmental Satellites Meeting
- 2018, 2019 Stream Information Collaborative Meetings
- 2018 USACE CWMS User Representative Group
- 2018 SatCom Forum – Amsterdam, NL
    - Presented along with international users of weather satellite systems
    - Discussed challenges and opportunities with manufacturers
- 2018 Real-Time Water Quality Monitoring Workshop – St. John's, Newfoundland, CA
    - Invited by Canadian STIWG participants to present on GOES DCS
    - Canadian users are moving towards deploying more GOES DCS platforms
    - Investigating deployment of GOES East and West DRGS receive sites
- 2019 Engagement to discuss potential impacts of radio frequency interference
    - National Science Foundation
    - Interstate Council on Water Policy

LySanias completed his presentation with a talk on STIWG Objectives.

He noted that the STIWG DCS Whitepaper synopsis of uses and importance of GOES DCS should be updated and that it is a living document. It should be updated this year. Topics for the white paper include:

- System capabilities
    - Mission topics include wildfires, floods, storms, water quality, water quantity, hydro-power, navigation, emergency response, etc.

Along with the white paper, there is a slide deck that is a condensed presentation for briefing on DCS "in a nutshell" that is based on the white paper. This should also be updated.

Other objectives include:

- OpenDCS Standardization
- Preparing for the DOMSAT discontinuation on May 14, 2019
- HRIT firmware update installed for new file format
- CS2 Migration Deadline – May 2026
- Migration of 100 baud DCP transmitters to 300 baud CS2 compliant transmitters
- Creating additional channels as bandwidth savings from CS2 transmitter conversion allows
- More frequent critical site transmissions (e.g. 15-minute interval)
- System for managing GOES DCS platforms and access to data
- Future of GOES DCS
- Spectrum Analysis/Studies
- Agency investments

GOES DCS User Reports

- **Colorado Division of Water Resources - Matt Hardesty**

The mission of the Colorado Division of Water Resources is the Administration of Colorado Water Rights. This service has a 138-year history beginning in 1881. Administrators rely on stream gauges to know how much water is present in the streams. The data is also valuable for other uses including recreational organizations, water storage and release, flood warning, dam safety and environmental monitoring. Within Colorado, there is lots of competition for water resources. There is also an interstate compact that must be considered. There are seven divisions in the state. There are over

1200 DCPs providing data for the regions; 630 GOES, 254 Cellular and 350 USGS DCPs whose data is acquired via web services.

They currently have two web sites; although they are working to combine them. One is real time data; www.dwr.state.co.us. The other is a decision support system http://cdss.state.co.us.

Matt showed the evolution of the technology over the past 10 years and some examples of some of their active stations. He noted that they are transitioning to the use of radar sensors which are easier to install.

- **National Ocean Service Center for Operational Oceanographic Products and Services (CO-OPS) – Nathan Holcomb**

Nathan briefed that the observing network is made up of approximately 460 permanent stations that are part of the National Water Level Observation Network (NWLON) and the Physical Oceanographic Real-Time System (PORTS). There are 372 water level based, 66 current meters and a few that are purely meteorological. The majority transmit through GOES, approximately 15 are Iridium and several are line of site (LOS) radios. The Iridium stations are used mainly due to power limitations.

Nathan noted that approximately 158 stations or 34% were affected by the GPS roll over event. 69 or 44% of the affected stations have had the firmware upgraded and resumed transmitting to GOES. Systems deployed from Alaska through the Gulf made it difficult to install updates. IP polling was crucial in getting a majority of the stations up. 69 or ~44% have been updated. Will not have all updated until the end of the year but will have 94 % reporting soon.

Nathan briefed and showed graphics of some impacts including some Class G ships that had to hold at anchorage due to not knowing the level of water under the keel or clearance under the bridge. During the event, HADS had to update each station manually. There was a large loss of data for the Tsunami Warning Center. They had to develop a specialized polling script to get the data. Another impact was that USACE employees were stranded in Toledo, OH due to not having tide data for flood predictions; the Coquille River flooded and the Northwest River Forecast Center was unable to track the flooding around Portland; and the international stations were not able to compare flow data between the US and Canada.

- **BC Hydro - Bruce Smiley**

BC Hydro is a provincial crown corporation servicing 95% of the population of British Colombia; approximately 1.8 million customers. It is the 3rd largest electric utility in Canada by generating capacity.

Bruce briefed that they have 229 stations in BC. The majority transmit through GOES. 120 are owned by BC Hydro and another 104 sites are funded in partnership with the Water Survey of Canada and Parks Canada. Most report hourly but some less for critical sites. The data is also provided to USACE and Bonneville Power. The main uses are for reservoir operations, water license compliance and supply forecasting.

Current issues for the system include:

- Internet only method for acquiring GOES data (They lost both their LRIT and DOMSAT)
- Data Acquisition system components reaching end of life
- No geographic redundancy for DCS toolkit portion of the data acquisition
- Users expectations are limited interruptions in data
- Difficult to incorporate new telemetry methods into the data acquisition system

The desired Future state:

- Resilient data acquisition system that can support future telemetry options
- Simpler architecture
- Satellite data acquisition as a back up for GOES data
- Geographic redundancy

Bruce emphasized that they want a satellite backup; not relying on internet.

- **USACE – LySanias Broyles**

LySanias began with a graphics showing the USACE districts and the locations of all their DCPs. He noted that many are located on reservoirs and support the water quality mission. Anglers use the information or recreation. The data is also used for flood inundation monitoring and mapping. They have a public facing river gage site; www.rivergages.com/. Data used for water supply and flood management for the goal of limiting flood damage. Corps owned reservoirs produce 25% of the hydroelectric power in the U.S. The data also supports the inland navigation system.

In summary, LySanias noted the following:

- There are ~2936 owned GOES Id's
- There are ~2527 active GOES platforms (all 300 baud)
- Channels: 17, 25, 31, 49, 58, 73, 88, 161, 162, 177
- Additional Channels:16, 20, 24, 28, 29, 30, 32, 36, 38, 54, 66, 70, 77, 80, 83, 88, 89, 90, 94, 102, 105, 109, 122, 124, 126, 128, 129, 138, 142, 144, 152, 153, 154, 156, 164, 170, 172, 202, 208
- Western districts are converting Line of Site platforms to GOES (SPL completely converted)
- Of 38 districts, over ~90% have at least one local LRIT/HRIT receive system
- There is still a desire for more frequent transmissions at critical locations
    - Some also transmit on random channel while exceeding observation threshold
- They are supplementing GOES DCP's with r/t DAMS-NT over LAN at some locks and dams, etc.
- "300 series" channels?
- They are interested in 2-Way DCP capability
- They are adding sensors sending additional observations as necessary for MMC Modeling efforts
- USACE is pursuing DRGS modernization

LySanias went over the regions. Highlights are as follows:

- Rock Island District has GOES East and West DRGS and a HRIT receiver. They are able to use LRGS as well as a backup. They are very big on redundancy.
- Northwest Division is expanding to GOES platforms. This is becoming more and more critical. They also use the DoD gateway for Iridium and can get data via HRIT as well.

- Seattle District relies on GOES very heavily and also other agency DCPs.
- The South Pacific is heavily on GOES.

- **USGS Water Mission Area - Richard Pardee**

They have 10,350 DCPs active. 30% of them have been converted to CS2. USGS is evaluating its system by looking for funding, move to another dissemination system, and looking at reliability issues. This is being done on a Case by Case basis. They are looking to have redundant communications at all sites. They want to be able to communicate with remote sites to be able to make configuration changes easier and reduce the $500 it costs per physical trip. They had 1,200 outages during the October roll over event. ~90% were fixed in a matter of a few weeks. They found that the vendors were very cooperative. They had 490 DCPs down in the April rollover event. This was less than 5% but took a lot of cooperation with vendors. They did a big outreach effort. They use 300 Iridium modems of which 150 are operational. If they cannot get to GOES, they go to Iridium. They are standing up a private network for the modems.

- **Environment Canada - Paul Campbell**

They have 1,600 DCPs for water monitoring. There are a few more for meteorology. They are moving more toward GOES as time goes on. They had 130 stations out during the roll over event. They did not mitigate immediately and kept to their normal maintenance schedule. It took 2 weeks to get 90% up. They are working on adding HRIT to decrease internet reliance and adding a DRGS.

- **Bureau of Land Management (BOM) - Phil Dayton**

They have 400 GOES sites that are used for river flow monitoring. They still have eleven 100 baud stations.

Two-Way Update - Brett Betsill

Brett initially presented a summary of the work completed over the past year since the last TWG meeting.

He noted that the Two-Way bench prototype was completed in May of last year and the report delivered to NOAA in June 2018. He noted that the bit error rate (BER) testing confirmed expected performance. He briefed that after reviewing the report in June, NOAA requested a proposal for a two-way prototype in July. After some additional work and review, NOAA authorized the project in late September and work was started in October 2018.

During this period, in April 2018, the GOES-R Program notified NOAA and Microcom that the International Telecommunications Union (ITU) is considering lowering the allowable power flux density of the two-way downlink. In order to meet a new requirement such as this, the two-way bandwidth would have to increase to 1 Mhz. As a mitigation to this possible change, Microcom was asked to revise its proposal to complete a formal study of the possibility of increasing the bandwidth to 1 Mhz.

Brett noted that the two-way downlink is not the primary signal in that band. DCS is sharing with UHF LMR and emergency services. These are voice communications. We cannot interfere or impact

them at all. We are going to hop between their channels. While not hopping, reed-solomon corrected the errors. It was noted that if the LMR signal was 1000 times stronger, it would impact us but the hopping mitigates that. But, if the ITC lowers the power 10 db, we would not be able to operate. Peter Woolner believes that if we can make a commitment to use 1 Mhz, the 100 Khz power may be grandfathered. We need a plan for the future to make that commitment. Brett briefed that the preference is to find 1 Mhz in mobile channels (not base stations).

Thus, Brett will determine what a path forward would look like. He does not see impacts to the WCDAS uplink modulator. It can easily handle the 1 MHz signal. Plus, when you expand to 1 Mhz, it is easier to hop between the LMR transmissions. The changes to the receiver are insignificant. Front end filters should be compatible as well as the downstream filters.

Microcom's conclusion to this issue is that this is relatively easy. It is possible to design for 1Mhz then deploy to 100 Khz and then change remotely later. Receivers could switch between East and West during implementation.

In conclusion to the larger issue of a two-way prototype, Microcom will be submitting a final report in May. If approved, Microcom will start testing over the air to possibly conclude in August. By Fall, Microcom should be performing over the air performance testing.

Note: *****Since this update was highly technical and gone over in a quick brief, the slide TEXT was copied to Appendix IV: Microcom Update on Two-Way DCP Communications Project.

Question: Is the downlink frequency the same on both satellites. Answer: Yes, there will be two different hops. The receiver can see both signals and be able to receive them. We will need two hopping patterns. Whatever design is approved should be made public so the manufacturers can have a starting point.

Question: What is the way to keep them in sync? Answer: They are sync'd through the GPS. We need to sync the hopping pattern and the reed-solomon error correction. The two-way transmission could be used by the receiver for time.

Question: How can you use the hopping for HRIT. Answer. The reason it works on DCS is the low data rate. There is a direct correlation between data rate and bandwidth. There is too high a data rate on HRIT.

Spectrum Update - Dave Lubar

Dave Lubar gave a presentation on spectrum sharing. There has not been any final decision making since the last meeting. A short discussion followed where it was agreed that the agencies and private industry should keep track of developments that the FCC is considering and comment through the appropriate channels.

Report and Status of the Small Satellite DCS Use Concept Validation Project - Beau Backus

Beau gave an update on the Small-Sat Project. The small-sat community is requiring a lot of spectrum. One question was can DCS support the small-sat community. They have a strong need to use the 400 MHz band. The spectrum management allows the DCS to uplink and the satellite to

downlink. However, the satellites use omni antennas. This means their downlink is in actuality, a link in all directions. This community is growing. We saw this as a risk and identified it as such. Eventually, we decided to see if we could partner with them. The net result is that there will be a satellite user that wants DCS to work right. EUMETSAT is also interested and wants to participate.

The original test of this capability was TechEdSat-8. NASA Ames put up the satellite to do this project. The doppler shift of a moving satellite will make the message change channels. Part of the project is to mitigate the doppler challenge. Unfortunately, while the TechEdSat-8 launch and antenna deployment from the ISS successfully, the battery never recharged. Thus, no testing was possible.

TechEdSat-9 will launch in late summer, if it can get on the launch manifest. They will perform some tests without Doppler correction. The plan is to do ground site collection for additional validation. There is a plan to work with EUMETSAT on ground detection.

TechEdSat-10 will build upon the validation provided by TechEdSat-9. TechEdSat-10 will be an operational case for the use of a small-sat for DCS. It will use random channels. It will be able to switch between 300 and 100 baud. Expected launch is early 2020. Small-Sat is a fast-moving industry.

Future use could be 2-way communication. Satellite operators would welcome this. The use of higher data rates is also being looked at. It is possible to use DCS to monitor the surface of Mars for environmental parameter monitoring.

This is risk reduction for DCS. Benefits include

- Increased use of the DCS channels, some of which are currently underutilized.
- Low cost enablement of scientific, educational, and development satellite low data rate communications to respective mission centers
- Ability to enable LEO&A during clustered deployments
- Projected demand for enabling two-way communications capabilities of the DCS – while in view of GOES
- Demonstrated continued efforts by meteorological community to facilitate good spectrum stewardship and efforts towards responsible sharing of spectrum resources.

There has been a delay due to the loss of TechEdSat-8 but progress is moving along with TechEdSat-9. Both TechEdSat-9 and 10 are tracking well with schedule. The intent is to expand the availability of DCS satellite use on an international basis.

HRIT New File Format - Brett Betsill

Brett went over the history of the project. Both the old format and new format are running on virtual channels 31 and 32. There is some efficiency gained by using the new format; 41 vs 70 bytes. There are sample files and the format on the DCS website.

Microcom has updated its DigiRIT receiver as there were two pieces of that did not make it into the new format. The information was an End-of-Transmission flag and a Modulation Index flag. There have been several improvements:

- 3-byte sequence number to identify message gaps.

- Abnormal Received Message (ARM) flag byte to identify message problems without having to send inefficient and multiple informational messages.
- Millisecond resolution Carrier Start and Message End Date/Time stamps.
- Improved Message Quality Statistics:
    - Signal Strength to 0.1 dB.
    - Frequency Offset from channel center to 0.1 Hz.
    - Phase Noise in degrees RMS to 0.01°.
    - Good Phase Percentage rounded to 0.5 %.
- DRGS Source Code and future Secondary Source.
- Special Missed Message Block for efficiency.
    - Eliminates header fields (e.g. message quality stats) that are not applicable to a missed DCS message.

There are several new features available with the new format:

- File type detection:
    - On segregated virtual channels during dual streams.
        - Legacy files have filename of pM-YYDDDHHMMSS-Q.dcs
        - YYDDDHHMMSS is the file date/time in UTC Julian format.
        - Q is an ASCII letter (A to Z) used in the event two files are generated at the same time.
    - New files have filename of pH-YYDDDHHMMSS-Q.dcs
        - H designates the new HRIT file format.
    - Both will use current HRIT Header DCS file type of 130 (0x82).
    - Internal Type field in legacy (DCSD) and new file formats (DCSH).

The big thing was the frequency offset. The new CS2 had a requirement for a higher resolution. Added the DRGS source code and future secondary source. Also added was a missed message block for efficiency.

The dual stream forecast to end on May 20th. If we need more time, Seth needs to know immediately.

In the future, only the new file format will be transmitted on HRIT. NOAA proposing that the new file format files will remain on Virtual Channel 32.

Question: Does anyone mind if we use 32 and disable 31? Answer: Will stay on 32, without user objection.

Action: Inform Seth that there is no DCS User Objection to canceling Virtual Channel 31 and to continue using VC 32 for the New HRIT DCS File Format

Proposed enhancement to process the better message statistics in the DAMS-NT protocol. Mike has already updated the LRGS software. Mike would vote to do it as both ends have been updated. Question is who is the arbitrator of the DAMS-NT protocol?

There needs to be concurrent changes to the DAMS-NT Protocol to make sure that this change is complete.

Question: Is the DGRS going to require a firmware update? Answer: Yes. It can be done in weeks.

Question: How do we want to move forward on this? Answer: The action to change the DAMS-NT protocol will be taken up by the STIWG.

The new format accepted by acclamation.

Xylem Data Logger Issue Report/Update - Steve Parmley

On October 18th, many Users were affected by a GPS roll over event. At first, the only clue we had was that there was a reported date of 1963.

1st root cause was the GPS roll over. The older H-2221 D2 manufactured before October 2014 had a non-typical roll over date. It had a 6 month early roll over. They took the hit early. A solution had to be rolled out before April.

2nd root cause: Firmware assumed "99" to mean 2099. This was a rollover event of the signed integer.

- '99' in ascii string perceived by firmware as 2099
- Computational standard for representing time/date as 32-bit signed integer
- Minimum = December 13, 1901, 8:45:52pm, Maximum = January 19, 2038, 3:14:08am
- Time/Date rollover: 2099 = ~61 years past 2038, actually yields a date/time in 1963
- An alarm was set for an hour. This ring would have occurred in 55 years. The GOES radio was patiently waiting.
- Thus, the transmission never went out.

There is now a formal method to undo the roll over. There is now no roll over of the signed integer. They developed a software updater. This needed full administrative rights to install. Then they adapted it to a Windows 10 and Windows 7 version without full administrative rights to push it out. This was pushed out to their web site and it is still there. We did a lot of updates in the months of November and December.

Manufacturers Reports

- Microcom Environmental – Perry West

Microcom Environmental focuses on monitoring and collection display while Microcom Design focuses on engineering. They went over their DigiRIT HRIT Receive System. He explained that at this time, it is only capable of handling the DCS part of the HRIT broadcast. It is also compatible with Open DCS. He also went over their Xpress line which is a fully integrated GOES DCS Data Collection Platform. Its main use is for long-term employment. One feature is that there is no need for gage houses. It can also serve as a seasonal deployment station or for rapid deployment.

- Sutron - Chris Buchner

Chris explained that 4 years ago Sutron was purchased by OTT Hydromet Group. The equipment still holds the Sutron brand. They are powerful, programmable data loggers. They come with Satlink3. They can be primarily GOES with an expandable Iridium modem. There are specific variants that can be designed for specific purposes.

He also went over the x-link logging transmitters. This is new and has two models; 100 and 500. They all come with the python scripting language and a GEO GPS antenna. They also offer a hydromet cloud monitoring solution.

Adjourn for the day – End of the TWG

Appendix I: Agenda
GOES DCS
Technical Working Group Meeting (TWG)
Denver Risk Management Center (RMC), Western Division
12596 West Bayaud Avenue, Suite 400, Lakewood, CO 80228.
Wednesday, April 24, 2019
Webex

Morning Session
8:00 Remote Connections/Role Call
8:30 Introductory Remarks; Logistics - R. Antoine
9:00 GOES DCS Program Updates - Antoine, Reeves, Randall
9:30 Wallops Update - T. Thornton
10:00 STIWG Report - L. Broyles
10:30 Break
11:00 User Reports
12:00-1:00 Lunch

Afternoon Session
1:00 Spectrum Update - D. Lubar
1:30 Small-Sat Concept Validation Update - B. Backus
2:00 Two-Way Update - B. Betsill
2:30 HRIT New File Format - B. Betsill
3:00 Break
3:30 Xylem Data Logger Issue Report/Update - S. Parmley
3:45 Manufacturers Reports
4:45 Review Action Items
5:00 Adjourn for the day

Appendix II: Attendees:

Last Name	First Name	Organization
Abney	Ruth	US Army Corps of Engineers
Unknown Webex	Unknown Webex	Alberta Environment
Allen	Charles	DOI/BOR
Allin	Lauren	US Bureau of Reclamation
Anderson	Quentin	Tennessee Valley Authority
Antoine	Richard	NOAA/NESDIS/OSPO/SPSD/DSB
Armour	Arthur	U.S. Army Corps of Engineers
Arrunategui	Paolo	ADR Tecnology
Ary	Edward	USBR
Backus	Beau	NOAA/NESDIS
Bell	Brian	USACE
Betsill	Brett	Microcom Environmental
Breitkreutz	Pat	Nebraska Department of Natural Resources
Broyles	LySanias	USACE
Bryant	Tammy	US Army Corps of Engineers
Buchner	Chris	Ott Hydromet Corp / Sutron
Buntain	Tyler	
Campbell	Paul	Environment and Climate Change Canada
Ceanfaglione	Matt	Microcom Environmental
Chodkiewicz	Scott	U.S. Army Corps of Engineers - Mobile District
Clayton	Richard	Bureau of Reclamation
Dayton	Phil	USBR
De Dominicis	Shayne	Manitoba Hydro
Dorsey	Warren	NOAA/NESDIS/OSGS/PETD
Embler	Scott	NOAA/NCEI/CWC/USCRN
Emry	Ross	U.S Army Corps of Engineers
Farrell	Ross	USACE St. Louis
Fraley	Tracy	USACE
Gray	Jesse	NIFC/BLM
Greenberg	Brandi	Alion Science & Technology
Hardesty	Matt	Colorado DWR
Heggli	Matt	Innovative Hydrology
Heil	Jim	NOAA NWS
Hensley	Winston	NOAA-COOPS-OSTEP
Hogue	John (Jay)	USACE Vicksburg
Holcomb	Nathan	NOAA/NOS
Hyde	Leona	Government of Newfoundland Labrador
Jackson	Brian	NOAA / National Weather Service
Kopp	Brian	The Semaphore Group, Inc.
Krug	Warren	NOAA/NOS/CO-OPS
Lubar	David	Aerospace Corp.
Maloney	Michael	Cove Software, LLC
Middlekauff	Stephen	U.S. Bureau of Reclamation
Mirza	Sheraz	System Integration Development (SID)
Neilson	Michael	USACE-Sacramento

Osenga	Elise	Aspen Global Change Institute
Pardee	Richard	USGS WMA
Parmley	Steve	Xylem
Powers	Ari	US Army Corps of Engineers, Portland District
Randall	Valerie	SSAI
Reeves	Letecia	NOAA/NESDIS/OSPO/SPSD/DSB
Rele	Bhushan	
Reynolds	Jeff	
Roberts	Gary	Campbell Scientific, Inc.
Seymour	Paul	System Integration Development (SID)
Shima	Patrick	DOI/USBR/RMP
Simms	Christopher	USACE
Sims	Jamese	Office of the Federal Coordinator for Meteorological Services (OFCM)
Smiley	Bruce	BC Hydro
Smith	Eric	USACE
Snyder	Sally	Louisville District Corps of Engineers
Stumpf	Ken	SCVWD
Sullivan	Matthew	NOAA/NESDIS/Wallops Island
Thornton	Travis	NOAA/NESDIS/Wallops Island
West	Perry	Microcom Environmental

Appendix III: Action Items:

Numbers in parentheses are TWG 122 actions carried over and, in some cases, expanded.

- 123-1 Inform Seth that there is no DCS User Objection to canceling Virtual Channel 31 and to continue using VC 32 for the New HRIT DCS File Format
- 123-2 (122-1): NOAA to investigate request from Bahamas Met Service to maintain 5-10 years of GOES DCS data on website. See Pages 01-02.
- 123-3 (122-2): Investigate how to make configuration files available in the USACE DCP Monitor system. see Page 07. This needs clarification. See Pages 01-02.
- 123-4 (122-3): As WCDAS puts WMO headers on 89% of messages and sends them to the NWSTG, consider putting WMO headers on all the messages; or assess whether we should be doing this at all by seeing if there are user requirements for this. This needs clarification or a statement of need then NOAA will scope the task. See Pages 01-02.
- 123-5 (122-6): Provide the location, exact latitude and longitude for all Federal and non-Federal stations (including foreign) for DRGS, LRIT, HRIT/EMWIN to the NOAA SPRES Contractor Shared Spectrum Company so that they have a correct and comprehensive list of receiving stations. Send to Dr. Todd Martin at tmartin@sharedspectrum.com and please copy beau.backus@noaa.gov. Please provide within the next 30-60 days along with a point of contact with email and phone for your organization. See Page 13. See Pages 01-02
- 123-6 (122-8): DCS Program to prepare some vehicle for getting user input on the DCPI two-way communication project. See Pages 01-02
- 123-7 (122-9): DCS Program manager to prepare a briefing for OSPO and NESDIS Management on estimates on the costs to bring the DCPI two-way communication project to completion for GOES-R Series and the next generation of satellites. NOAA and Microcom are in progress of executing a project plan. See Pages 01-02.
- 123-8 (122-10): NOAA to investigate back-up (remote) pilot options including reuse of Goddard equipment or a new system for the CBU. Short term project complete; long term solution in progress. See Pages 01-02.
- 123-9 (122-12): Work with the HRIT/EMWIN Program Manager to plan for up to 10% DCS usage on HRIT/EMWIN. See Pages 01-02.

Appendix IV: Microcom Update on Two-Way DCP Communications Project

- Two-Way Update – Summary since 2018 TWG
  - Bench Prototype Testing Completed in May 2018.
    - Final report submitted to NOAA in early June 2018.
    - BER testing confirmed expected performance.
  - After reviewing Bench Prototype report and other project status, NOAA requested proposal for Two-Way Over-the-Air Prototype in July 2018.
    - Initial proposal submitted in early August 2018.
    - Review of initial proposal held later in August.
    - As a result of the review, Microcom requested to make some modifications.
    - Final proposal submitted in September 2018.
    - Project authorized in late September 2018 and work on first task began in October 2018.
  - Additional initial task requested to study bandwidth expansion to 1 MHz.
  - Phase Reversal Investigation

- Two-Way Update – BER Results AWGN
  - Bench Prototype showed good correlation to theory for AWGN.
  - BPSK BER better than $4x10^{-3}$-$2x10^{-3}$ will yield overall BER below 10^{-6}

- Two-Way Update – Static BER Results LMR
  - Un-hopped Bench Prototype showed good immunity to LMR.

- Two-Way Update – Hopped BER Results
  - Hopped results with excessive (+25 dB) LMR signals present.

- Two-Way Update – BER under Extreme Case
  - Hopped results with extreme (+30 dB) LMR signals present; hopping improvement more readily apparent.

- Two-Way Update – Possible ITU Changes
  - In late April 2018, Peter Woolner notified NOAA and Microcom that the ITU is considering lowering the allowable Power Flux Density (PFD) of the Two-Way downlink.
    - Change could be as little as a few dB to as much as 10 dB.
    - To address this change, either the power has to be lowered or the signal has to be spread over a wider bandwidth.
  - Other Considerations:
    - Reducing downlink power will degrade performance so only option is to expand bandwidth up to 1 MHz.
    - Current 100 kHz bandwidth is determined by the transponder, and cannot be altered until the next generation of GOES.
    - It is believed the existing PFD would be grandfathered on current series of GOES satellites.

- Two-Way Update – 1 MHz Bandwidth Study
  - While the change is not definite, during the Two-Way Over-the-Air proposal review, NOAA and Microcom realized:

        - Any potential change would most likely further delay the realization of the Two-Way system.
        - Users would not want to purchase and deploy 100 kHz units, only to have to replace or upgrade them once a new 1 MHz system is in place.
    - As a result of the potential changes, NOAA asked Microcom to revise its Two-Way Over-the-Air Proposal to do a formal study of the possibility of increasing the Two-Way bandwidth to 1 MHz.
    - Final report submitted to NOAA in November 2018.

- Two-Way Update – LMR Spectrum Allocation
    - First step in 1 MHz BW study was to identify possible locations for wider Two-Way downlink signal.
    - Preferred spectrum is with mobile versus base stations due to:
        - Lower transmit power.
        - Lower antenna elevation.
        - Base stations often operate as repeaters ® higher use.
    - Based on number of FCC licenses, two specific areas identified.
        - A: 465.70-466.70 MHz
        - B: 468.85-469.85 MHz

- Two-Way Update – 1 MHz BW Design Impacts
    - Uplink Modulator:
        - Current implementation at NOAA is to produce Uplink Two-Way signal at a lower frequency IF (~75 MHz), which gets translated up to S-Band (2032.8 MHz).
        - Ignoring hopping, signal is very narrow-band, which results in a minimal impact, simply need to hop over wider range. Can be done with existing prototype modulator.
    - Receiver/Demodulator:
        - From a demodulator perspective change is similar to modulator – just need to de-hop over wider range.
        - From a receiver perspective, need to be certain front-end elements compatible with new frequency and wider bandwidth.
            - Initial band-pass filtering would be inherently wide enough to accommodate 1 MHz BW (i.e. a 100 kHz wide bandpass filter centered at ~468 MHz is not readily achievable or practical).
            - Downstream IF filters narrower than 1 MHz would not be of much benefit since final filter bandwidth after de-hopping is ~1 kHz.
        - Just need to ensure new center frequency is close to current frequency.

- Two-Way Update – 1 MHz BW Conclusions
    - Should be relatively easy to adapt existing hopping design to cover 1 MHz wide bandwidth – could actually provide some additional immunity to LMR since signal would spend less time near a particular channel.
    - High confidence that it is possible to design Two-Way receivers for current 100 kHz range and switch to 1 MHz with no hardware or firmware modifications if designed in at outset – units would just need to be re-configured for 1 MHz operation.
    - Units could be deployed for operation on GOES-R series satellites and switchover to future series spacecrafts with minimal user intervention – could even be commanded through Two-Way at a specified date/time.

- Recommended using 1 MHz portion of the spectrum (468.85 - 469.85 MHz) just above existing Two-Way frequency assignment (468.75 - 468.85 MHz).
    - Ensures compatibility with front-end filters.
    - No overlap to avoid 100 kHz and 1 MHz signals interfering with each other during satellite transition period.
    - Number of LMR assignments roughly equivalent.

- Two-Way Update – Phase Coherence Study
  - NOAA reviewed 1 MHz BW report and authorized Microcom to proceed to next step in Over-the-Air Project – Phase Coherence Study.
    - During final testing of Bench Prototype, Microcom observed very intermittent phase reversals during long-term testing.
    - While phase reversals did not prevent Microcom from finalizing BER testing, any operational system needs to ensure these do not happen or can be reliably mitigated.
  - First step was to re-visit original testing performed by Dr. Brian Kopp and Duane Preble to confirm that two synthesizers hopping at simultaneous rate would maintain phase coherence.
    - Both synthesizers operating on common circuit board with common oscillator and driven in sync by single microcontroller.
    - This was completed in January and early February.
    - Improved synchronization algorithm in microcontroller code.
  - Second step was to repeat synchronization testing with synthesizers on two different modulator circuit boards.
    - This is where problems were observed and needed to be addressed.

- Two-Way Update – Issue with Synthesizer
  - After identifying issue with multiple synthesizers on separate circuit boards, Microcom investigated several possible “obvious” issues that could be causing the problem.
  - Once these were eliminated, Microcom investigated the synthesizer circuit itself and found that some of the synthesizers were randomly unlocking even at a stable frequency.
  - After trying numerous fixes, Microcom ultimately replaced the problematic units and determined the problem was simply a fault in the synthesizer itself that could not be readily explained.
  - Once the faulty synthesizers were replaced with new devices, Microcom was able to successfully complete the two-circuit board synchronization test.
  - Microcom is presently applying similar fixes to the demodulator prototype to confirm that the random phase reversals seen during the bench prototype testing has been fully addressed.

- Two-Way Update – Next Steps
  - Once Microcom has successfully demonstrated phase coherence can be maintained with the bench modulator and demodulator, work will proceed to the required tasks to complete the Over-the-Air demonstration and testing:
    - Enhancing Two-Way Modulator for deployment at WCDA.
    - Developing Two-Way Receiver Front-End and Antenna system.
    - Cleaning up and finalizing Two-Way Demodulator.
    - Mating Demodulator to Receiver Front-End.
  - Hope to be sending and receiving signals through satellite by end of summer of 2019.
    - If all goes well, by fall 2019 Microcom should be performing Over-the-Air Prototype Operational and Performance Testing.