

WSR-88D Tropical Cyclone Operations Plan

05/01/2019 Build 18.X Systems

NOTE

For assistance with this Operations Plan at any time, contact the WSR-88D Field Support Hotline.

OPERATIONS PLAN GUIDANCE

- The WSR-88D Tropical Cyclone Operations Plan (TCOP) is designed to be used as an *operational reference*. Consult with the local Unit Radar Committee (URC) concerning any changes that might result in system-wide modifications. Pre-tropical cyclone event URC agreements will allow changes to be made operationally as needs arise.
- A few colors are used in this document. **Blue** indicates a hyperlink to a different location within or outside this document (i.e., an e-mail address or an internet address). **Red** is for a menu or a menu selection. **Green** is used in the **NOTE** section and serves as an informational section. **Yellow** background is a note that provides operational guidance.
- Changes will likely be made to adaptable parameters settings prior to and during a tropical cyclone. It is recommended that a backup of adaptable parameters be created prior to the event. The **RPG Adaptation Data Backup** procedure is in Table 4-34 of EHB 6-520.
- Keep in mind that the recommended adaptable parameter changes in this plan are performed by the WFO using the URC-level of change authority. There are no commands requiring Agency or ROC-level passwords in this document.
- For definitions of acronyms used in this document refer to EHB 6-521.

WSR-88D System Documentation

Below is a list of documents referenced throughout the TCOP. If any document needs to be accessed, ensure to download the version corresponding to the RPG Build currently installed on your system. The referenced documents may be accessed with a secure login through the ROC website.

EHB 6-503-2: Preventative Maintenance Inspection Work Cards:

<https://www.roc.noaa.gov/WSR88D/Program/MaintenanceManuals.aspx>

- RPG Builds 18.1 and 18.2: Revision No. 14, Change No. 1, dated 1 October 2018

EHB 6-504: WSR-88D System Security Manual:

<https://www.roc.noaa.gov/WSR88D/Program/OperationsManuals.aspx>

- RPG Builds 18.1 and 18.2: Revision No. 8, Change No. 1, dated 1 October 2018

EHB 6-520: Maintenance Instructions RPG Refresh:

<https://www.roc.noaa.gov/WSR88D/Program/MaintenanceManuals.aspx>

- RPG Build 18.1: Revision No. 8, Change No. 1, dated 1 October 2018
- RPG Build 18.2: Revision No. 8, Change No. 2, dated 29 July 2019

EHB 6-521: Operations Instructions RPG Refresh:

<https://www.roc.noaa.gov/WSR88D/Program/OperationsManuals.aspx>

- RPG Build 18.1: Revision No. 8, Change No. 1, dated 1 October 2018
- RPG Build 18.2: Revision No. 8, Change No. 2, dated 29 July 2019

WSR-88D Guidance on Adaptable Parameters Handbook, Volume 1:

<https://www.roc.noaa.gov/WSR88D/Program/OperationsManuals.aspx>

- RPG Builds 18.1 and 18.2: Revision No. 8, dated 26 March 2018

RDA Processing Algorithms

NOTE: *The following RDA algorithms are important processing techniques to be aware of during a tropical weather event. Each one serves to remind the operator of how it impacts the operational use of the radar.*

- **CMD** should be used as opposed to Clutter Regions or a static Bypass Map. CMD dynamically identifies ground clutter (i.e., automatically with each volume scan) and will almost always be superior to other suppression options.
 - In Build 18.2, an improvement to CMD mitigates the residual clutter footprint in the Dual-Pol data.
- **AVSET** will often produce faster volume scan updates, particularly when a tropical cyclone is still fairly distant from the radar.

RPG Processing Algorithms

NOTE: *The following RPG items highlight recent changes to the software the operator should be aware of as well as important actions to remember during a tropical weather event.*

- It is encouraged to **issue an FTM** to all Users from AWIPS notifying neighboring WFOs, the national centers, RFCs, the NEXRAD tri-agencies, and the weather enterprise when major operational changes are made (e.g. resetting precipitation accumulations, changing adaptable parameters, etc.).
 - An FTM can be sent via AWIPS, which sends the message to the RPG. The RPG then sends the FTM to all dedicated users except the sending AWIPS.
- In Build 18.2, additional changes were made to the 2DVDA. These changes improve dealiasing in and around tropical systems.
- Also in Build 18.2 is the ability to enable MRLE. For information on MRLE, go to: <https://www.roc.noaa.gov/WSR88D/NewRadarTechnology/NewTechDefault.aspx>.
- PRFs can be edited for VCPs in the 200 series (i.e., SZ-2), but the same PRF must be used in all 3 sectors.

- The setting of legacy PPS Max Precip Rate and the Dual-Pol QPE Max Precip Rate have been combined into one adaptable parameter setting.
- The SCL product is available via AWIPS. It lists select adaptable parameters in one location.
- After the tropical cyclone threat has passed, ensure all parameters are returned to their original values. The **RPG Adaptation Data Restoral** procedure is in Table 4-35 of EHB 6-520. Keep this information near the MSCF in case the data need to be restored.
- Refer to the current WSR-88D Guidance on Adaptable Parameters Handbook, Volume 1 for discussion on parameters listed in this document and system-wide default values.
- Additionally, operators should be familiar with all other existing algorithms (i.e., the MLDA, the HCA, and the QPE algorithm). Training materials can be found on the WDTD website at:
<https://training.weather.gov/wdtd/courses/rac/outline.php>.
- This Tropical Cyclone Operations Plan has been designed for systems that are using Build **18.X** software. If there is a question about the RPG software build being used, check with site maintenance technicians or radar focal point. Contact the **WSR-88D Field Support Hotline** for immediate issues or concerns.

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NOTE: *Table of Contents procedures 1 through 8 are performed at the RPG HCI while procedures 9 through 12 are performed at an AWIPS Workstation. Some procedures may require the URC-Level Password.*

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At the WSR-88D RPG Human Computer Interface:

1. Generator Fuel

Approximately three days prior to a tropical cyclone, ensure the RDA emergency power **generator fuel level** is adequate. The levels can be checked by opening the **RDA Performance Data** window then selecting the **Tower/Utilities** tab.

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NOTE: *With the removal of the RDA UPS in Build 15.0, it is essential Procedure 1 is performed and all components are working properly.*

2. Reinitializing Memory and Precipitation Accumulations

a. RPG Software Restart

It is recommended to **Restart** the RPG Software from the RPG Control window prior to the onset of a tropical cyclone. An **RPG Clean Startup** can be done as an alternative; however, if changes were made to the *Adaptation Data*, then an *Adaptation Data Backup* should be performed prior to the Clean Startup otherwise changes will be lost when the Clean Startup is executed.

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b. Precipitation Accumulation Reinitialize

Reset the Legacy PPS, Dual-Pol QPE, and the Difference products from the **RPG Control** window prior to the tropical event. This should be done in conjunction with your Service Hydrologist and RFC.

NOTE: *The accumulations can be reset without shutting down the RPG Software. If a Clean Startup was performed in Step 2a then this step can be skipped.*

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c. Precipitation Accumulation Initiation Parameters

The Dual-Pol QPE and Legacy PPS parameters used for initiating precipitation accumulations can be modified in the **Algorithms** window via the **Dual-Pol Precip** and **Hydromet Preprocessing** adaptation items.

The rate and reflectivity thresholds used to initiate accumulation should remain set to the *default* values while the areal thresholds should be optimized. For the Dual-Pol QPE, the **PAIF Rate Threshold** default is 0.5 mm/hr and for the Legacy PPS, the **RAINZ** default is 20.0 dBZ.

The **PAIF Area Threshold** and **RAINA** are the significant rain area thresholds for QPE and PPS, respectively, and should be determined locally during fair weather by viewing the areas of accumulation. The PPS and QPE accumulation areas are listed in the SCL product on AWIPS and may differ due to algorithm differences. Refer to Procedure 9 below for instructions to access the SCL then locate the entries for **PPS/QPE Precip Status (Area KM²)**. The ROC recommends setting these parameters to values representative of the residual clutter area during fair weather or to the default value of 80 km², whichever is greater.

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3. **Clutter Suppression**

Use CMD whenever possible. CMD helps improve overall algorithm performance, including rainfall estimates. **Enabling CMD** is generally better than using either operator-defined Clutter Suppression Regions or a static Bypass Map because ground clutter locations change with beam propagation. Additionally, switching to an SZ-2 VCP automatically enables CMD and downloads the default clutter map. The status of CMD is displayed at the lower right of the RPG HCI.

For additional information on Clutter Suppression, refer to Section 3.8.9 in EHB 6-521.

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4. **Mode and VCP Selection**

a. **Mode Selection Function**

In order to ensure the automatic MSF does not override the selected VCP, set the Clear Air and Precipitation Switching selections both to **Manual**.

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b. **VCP Selection and Velocity Dealiasing**

The *four* main considerations in VCP selection are (i) the **range** from the radar to the center of the tropical cyclone, (ii) the **location** (with respect to the radar) of structural regions of the tropical cyclone, (iii) the **frequency** of volume updates, and (iv) velocity **dealiasing errors** (i.e., apparent inbound velocities are where outbound velocities should be or vice versa or discontinuities that do not make sense meteorologically).

VCPs 121, 212, and 215 are designed to mitigate range folded data (i.e., purple haze), which can be a problem during tropical cyclones. A reduction in range folding results in better velocity coverage. Likewise, the aforementioned VCPs allow for better visual pattern recognition and performance of the algorithms. Refer to Procedure 4c for more information on mitigating range folding.

NOTE: The 2DVDA is enabled by default and should remain enabled during tropical cyclone events. For VCP 121, the Multiple PRF Dealiasing Algorithm (MPDA) is used.

The following table summarizes the recommended VCPs for tropical cyclone events with their optimal usage and limitations:

VCP	Tilts	Time*	Usage	Limitations
**121	9	6 min.	VCP of choice for hurricanes or widespread stratiform precipitation events. Significantly reduces range-obscured V/SW data within 124 nm compared to other VCPs.	PRFs are not editable for any tilt. Gaps in coverage above 5° and low elevation circulations may be missed. SAILS and MRLE are not allowed.
**212	14	4.6 min.	Rapidly evolving, severe convective events (e.g., supercells, squall line, MCS). Uses SZ-2 to significantly reduce range-obscured V/SW data compared to VCP 12.	All Bins clutter suppression is not recommended. High antenna rotation rate decreases the effectiveness of clutter filtering and decreases the accuracy of the base data estimates. PRF sectors not allowed.
**215	15	6 min.	VCP for general surveillance of precipitation. Best vertical coverage. Lower SNR than VCPs 12/212. Uses SZ-2 to reduce range-obscured V/SW data. Low-level antenna rotation rates increase the accuracy of base data estimates. Shares common lower elevations with VCPs 12 and 212.	All Bins clutter suppression is not recommended. Slower low-level updates than VCP 12/212. Limited to a single SAILS scan. PRF sectors not allowed.
**12	14	4.3 min.	Fastest VCP. Rapidly evolving, severe convective events (e.g., squall line, MCS).	High antenna rotation rate decreases the effectiveness of clutter filtering and decreases the accuracy of the base data estimates.

* VCP update times are approximate.

** The VCP time changes if AVSET and/or SAILS or MRLE are enabled.

For a more comprehensive overview of *all* VCPs, refer to Figure 3-1, the VCP Comparison Table in EHB 6-521.

Below is a simplified list of VCP choice, prioritized by the primary concerns:

Choice	Velocity Dealiasing	Tornado Detection
#1	121	212
#2	215	12
#3	212	215

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c. Mitigation of Range Folding

By opening the **PRF Control** window then selecting **Manual PRF**, operators have the ability to move the maximum unambiguous range (R_{max}) out to 94 nm by adjusting the PRF when allowed by the VCPs described in the table under Section 4b. The minimum distance of R_{max} is 63 nm. Manually-selected PRFs can be defined for up to three sectors. Remember, for SZ-2 VCPs (e.g., 212 and 215) the PRF chosen must be the same for each sector.

Auto PRF-Storm is useful when embedded severe convection is present with a tropical cyclone. This is the default setting.

For additional information on range folding, refer to the WSR-88D Guidance on Adaptable Parameters Handbook, Volume 1.

NOTE: *The NHC prefers an R_{max} with sufficient range to provide velocity data near the eye or center of a tropical system; however, local needs may dictate otherwise and will take precedence. Therefore, a VCP with an operator-specified PRF may be needed to mitigate range folding in the region of concern. VCP 121 does not use Auto PRF.*

For further information about the improved Auto PRF function, go to: <https://www.roc.noaa.gov/WSR88D/NewRadarTechnology/NewTechDefault.aspx>.

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d. AVSET

Using **AVSET** potentially produces faster volume scan updates. When AVSET is enabled, the volume scan terminates when no echoes of at least 18 dBZ (covering at least 80 km²) above 5 degrees elevation are detected.

For additional information about AVSET, refer to Section 2.4.16.5.2 in EHB 6-521.

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e. SAILS

SAILS inserts up to three supplemental scans of the lowest elevation cut into each volume when enabled. This processing option can be applied to VCPs 212, 215, and 12. Note, however, that only one SAILS cut can be added to VCP 215. The additional supplemental lowest elevation cut(s) is/are evenly spaced, in time, throughout the volume scan.

For additional information about SAILS, refer to Section 2.4.16.5.3 in EHB 6-521.

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5. Velocity Measurement Increment for Extreme Wind Speeds

Velocity measurements are limited to approximately +/- 122 kts when the VMI is set to 0.97 kts, which is the default value. When hurricane speeds are expected to exceed 122 kts, NHC recommends operators change the VMI to 1.94 kts, preferably prior to the hurricane becoming a Category 3 storm.

NOTE: *The 2DVDA will remain active when the VMI is changed to 1.94 kts.*

The velocity color scale displayed with all 8-bit (i.e., 256-data level) velocity products on AWIPS is the same. This could create confusion on which VMI is being used. Fortunately, the AWIPS CAVE cursor sampling of the velocity products indicates speeds *in tenths of a knot* for velocity increments of 0.97 kts and *in whole knots* for velocity increments of 1.94 kts. The velocity increment setting is located in the **VCP and Mode Control** window. It is found by clicking the **VCP** button on the RPG HCI window. In addition, the new SCL product displays the current velocity increment being used.

NOTE

Ensure the VMI is the last change you make when modifying a VCP. Otherwise, changes will be lost when a VCP change is made or the system is rebooted.

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6. Algorithm Adaptable Parameters

NOTE: *Procedures 6a and 6b will independently increase the radar's detection efficiency for small, shallow circulations typically found in tropical cyclones. Precipitation algorithm changes will result in more realistic rainfall estimates during tropical weather situations.*

a. Mesocyclone Detection Algorithm Optimization

The Minimum Display Filter Rank should be lowered in order to enable detection of weaker circulations within the tropical cyclone; however, doing this particular procedure may result in a greater number of false alarms being generated. To help reduce the false alarm rates, detections must be within 20 km of a SCIT-identified cell.

Under **Algorithms** → **Adaptation Item** → **MDA**, change the **Minimum Display Filter Rank** to 4 (or even 3).

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b. Tornado Detection Algorithm Optimization

Similar to the MDA, the TDA parameters should be changed in order to better detect weak or distant tornadoes. Under **Algorithms** → **Adaptation Item** → **Tornado Detection** change (i) **Min 3D Feature Depth** to 1.6; (ii) **Min 3D Feat Low-Lvl Delta Vel** to 27; and (iii) **Min TVS Delta Velocity** to 27.

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c. Precipitation Estimation Optimization

NOTE: *Subsections i, ii, and iii refer to Dual-Pol QPE parameters, while subsection iii and iv refer to Legacy PPS parameters. Recall that changes to these parameters should be coordinated with your RFC(s).*

i. QPE R(Z, Zdr) Equation

Under **Algorithms** → **Adaptation Item** → **Dual-Pol Precip**, change the **Precipitation type used for R(Z, Zdr)** for the Dual-Pol QPE algorithm to TROPICAL, if desired, during tropical cyclone events.

The MRMS website has a tool that shows where tropical rainfall will likely occur. Alpha estimates higher than 0.0225 (pink and red shades) are indicative of tropical rainfall microphysics. Follow the link below to access the tropical trigger tool. If you cannot view the website below, contact Dr. Stephen Cocks at Stephen.Cocks@noaa.gov to request access.

https://mrms-dev.nssl.noaa.gov/roc/tropical_trigger/tropical_trigger.php

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ii. QPE Maximum Reflectivity

The **Maximum Reflectivity** default value is 53 dBZ. The operator may want to increase this value in order to accommodate higher reflectivity values due to heavy rainfall in tropical cyclone events. It can be changed in the **Dual-Pol Precip** adaptation item menu.

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iii. Maximum Precipitation Rate Threshold

Also under the **Dual-Pol Precip** adaptation item menu, the **Max Precip Rate** parameter can be edited. This single entry applies to both the Dual-Pol QPE and Legacy PPS algorithms. For tropical cyclone events, the ROC recommends setting this value between 150 to 200 mm/hr.

For additional information, review Section 7.5.9 of the WSR-88D Guidance on Adaptable Parameters Handbook, Volume 1.

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iv. PPS R(Z) Relationship

Under **Algorithms** → **Adaptation Item** → **Hydromet Rate**, change the **Relationship used for R(Z)** to TROPICAL, if desired, during tropical cyclone events.

As stated above, the MRMS developmental website can be useful in determining where tropical rainfall will likely occur.

NOTE: While monitoring precipitation accumulations compared to rain gauges, it is important to not change R(Z, Zdr) or R(Z) relationship too soon as doing so may result in overestimation. Contact your RFC for guidance.

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d. Melting Layer Detection Algorithm Heights

The MLDA attempts to determine the height of the ML using elevations from 4.0 through 10.0 degrees. The ML is generally higher in tropical cyclones as compared to that of extratropical cyclones. The determined ML is used in the HCA. The output of the HCA is ingested into the Dual-Pol QPE algorithm.

i. Settings for Sites With Model Data

The WFOs across the contiguous U.S. and Puerto Rico have access to the RAP model data via AWIPS. The operator wishes for the MLDA to use model data, ensure **Model Update** is On via the RPG HCI and verify, under the **Algorithms** → **Adaptation Item** → **MLDA**, that the **Melting Layer Source** is set to Model_Enhanced.

In order to verify that new model data are actually being received from a host AWIPS, look for the **MODEL DATA** entry shortly after the top of each hour in the RPG Status window.

The Model Data Viewer in the RPG HCI can be utilized to ensure the model data are correct and representative of the environmental conditions. Refer to Section 2.4.17.9.5 of EHB 6-52 for more information about the Model Data Viewer.

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ii. Settings for Sites Without Model Data

The WFOs outside of the contiguous U.S. do not receive model data. These offices should verify, under the **Algorithms** → **Adaptation Item** → **MLDA**, that the **Melting Layer Source** is set to Radar_Based.

If a WFO is unable to use RAP model data then the operator will need to update temperature heights by manually entering data from the sounding closest to the WSR-88D. Manual entry of these data can be done via the **Environmental Data** Editor. Refer to Section 3.10.4 of EHB 6-521 for more information on **Data Entry**.

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7. **Precipitation Product Data Levels**

Adjustment to the precipitation data levels will be needed if the potential for heavy rainfall is expected as the tropical cyclone approaches the WSR-88D. The maximum displayable value for OHP, THP, and the Dual-Pol OHA is 12.7 inches. Likewise, the maximum displayable value for STP and the 4-bit Dual-Pol STA is 25.4 inches. USP uses the **OHP/THP, OHA Data Levels** unless the maximum value exceeds the value set for Code 16. Otherwise, USP uses the **STP, STA Data Levels** values.

In the **Selectable Parameters** window, select **OHP/THP, OHA Data Levels** and **STP, STA Data Levels** to set the desired Precipitation Product Data Levels.

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8. **Level II and Level III Radar Receive Status**

WFOs can check the status of Level II and Level III data dissemination by following the links below. As a reminder, WFOs are responsible for monitoring their assigned DoD and FAA WSR-88D(s).

Level II: <https://radar2pub.ncep.noaa.gov/>

Level III: <https://radar3pub.ncep.noaa.gov/>

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AWIPS Workstation Preparation:

9. Shift Change Checklist

The SCL Product, which is generated every volume scan, can be viewed through AWIPS. AWIPS requests it once per hour, and it can be viewed using the Text Window by typing **SCLxxx** in the **AWIPS ID** box (where **xxx** is the 3-letter radar identifier). Current volume scan values of the SCL Product can be retrieved by doing an OTR or routinely via an RMR.

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10. Data Archiving

Prior to a tropical cyclone, the WFO should confirm their Data Archiver is running. On AWIPS, archiving of the data is a permission-based application, and it can only be activated by the System Manager or User Administrator.

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11. Data Requests from Adjacent Radars

As a tropical cyclone approaches your WSR-88D, an RMR can be initiated to surrounding WSR-88Ds for products not available via the Satellite Broadcast Network (SBN). To view a list of the products available via the SBN, go to:

https://www.weather.gov/media/tg/noaaport_radar_products.pdf.

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12. Communications Backup

Ensure you have printed out a copy of your latest AWIPS Radar File Help Sheet and the WSR-88D Communications Documentation.

The AWIPS Radar File Help Sheets provide site-specific radar access information that could prove pivotal in the event default telecommunication (telecom) systems become inoperative during a tropical cyclone event. Similarly, each office's WSR-88D Communications Documentation provides site-specific telecoms information for the NWS and NEXRAD tri-agency partners. Both sets of documentation are maintained on a secure server at the ROC. ESAs at each office have been provided with the necessary information to access those servers. Contact the WSR-88D Field Support Hotline for assistance if your ESA or technicians are not available to provide you with these documents or if they have trouble accessing either server.

AWIPS to WSR-88D WAN Dedicated operations could prove pivotal in the event one

WFO needs to perform WSR-88D backup transmission for another WFO. AWIPS RC 16035 was worked jointly by the AWIPS NCF and the WSR-88D Field Support Hotline this past year to ensure WAN Dedicated permissions are working at all coastal WFOs. Despite that, it is strongly recommended this functionality be re-tested during benign weather and well in advance of any landfalling tropical system.

All Gulf of Mexico and Atlantic coastal WFOs from Brownsville, TX to Portland, ME, with the exception of Taunton, MA have an AWIPS WAN dynamic fail-over capability via built-in OPSnet VSAT in the event the terrestrial OPSnet WAN fails.

All WSR-88Ds in CONUS, Puerto Rico, and the Hawaiian Islands who rely on commercial telecoms for either the wideband circuit or the primary DoD or FAA to NWS private-IP connection now have either 4G wireless or permanent (built-in) VSAT auto-fail-over backup installed. The WSR-88D Communications Documentation for those locations includes the 4G or VSAT backup communications data.

If your office relies on backup communications for either the wideband or private-IP to a DoD or FAA WSR-88D, check with the applicable WSR-88D maintenance staff and determine when EHB 6-503-2 Preventive Maintenance Inspection Work Card Sets 2-009A (28-Day System Status Check) and 2-019A (84-Day Backup Comms Fail-Over Test) were last accomplished in advance of any landfalling tropical system. Ideally, backup communications fail-over will be confirmed in advance of any landfalling tropical systems.

In advance of significant landfalling tropical systems NEXRAD enterprise telecoms providers are asked to place a heightened watch on the telecoms they provide to the NWS and WSR-88D systems in the forecast path of any major landfalling tropical system.

The ROC, Regional Focal Points, Office of Dissemination, and AWIPS NCF will partner to evaluate and initiate restorative telecoms solutions, backup scenarios, and tertiary or emergency restorations, as required.

For additional information on contingency and operations plans, refer to the latest version of EHB 6-504.

Likewise, radar service backup is addressed in **National Weather Service Instruction 10-2201**, Appendix I: Communications Backup. It can be accessed at:

<https://www.nws.noaa.gov/directives/010/010.php>.

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Closing Comments

A copy of the National Hurricane Operations Plan can be found on the Office of the Federal Coordinator for Meteorology's website at:

<https://www.ofcm.gov/publications/nhop/nhop2.htm>.

After the tropical cyclone threat has passed, all parameters will be returned to their original values. The **RPG Adaptation Data Restoral** procedure is in Table 4-35 of EHB 6-520. If the data needs to be manually entered then refer to the current WSR-88D Guidance on Adaptable Parameters Handbook, Volume 1 for system-wide defaults.

For all other inquiries or concerns about the information contained in this document, contact the WSR-88D Field Support Hotline.

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