Evaluation Report
National Traffic System Performance
Cascadia Rising Exercise

June 8 & 9, 2016

Evaluation report submitted July 11, 2016

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PART ONE
BACKGROUND AND EXERCISE DESIGN

I Purpose of Exercise Evaluation

This independent exercise evaluation report was commissioned by the three National Traffic System (NTS) Area Staff Chairmen and the Federal Emergency Management Agency in order to obtain an objective and professional analysis of the performance of NTS communications networks during a proof of concept exercise conducted in association with the larger Cascadia Rising exercise event.

The evaluation report is broken into three sections, these being:

1. Background and Exercise Design
2. Exercise Results
3. Recommendations

Part one, entitled "Background and Exercise Design" provides essential background explaining the structure of the National Traffic System and the theoretical and practical concepts on which network topography and operating standards are based. This section explains the exercise methods utilized to test and analyze the network within these design parameters.

Part two, entitled "Exercise Results," utilizes the data collected during the exercise to objectively analyze the performance of the various networks within the NTS. The metrics developed from the exercise data provide important insights into the current capabilities of the NTS and provide the objectivity needed to create a foundation for corrective actions or enhancements to network capabilities.

Part three, entitled "Recommendations," outlines opportunities for enhancing the performance of both the network infrastructure and the operating guidelines, which regulate their operation. Ideally, the use of objective data will result in targeted and specific recommendations designed to enhance emergency response capabilities.

All essential data and reference material is included in the appendices associated with this report.

II The National Traffic System:

The National Traffic System, commonly referred to as NTS, is a system of interoperable, layered radio networks designed to provide survivable messaging in time of emergency. NTS networks are staffed by FCC licensed radio amateurs who are specially trained to provide accurate and reliable messaging service on behalf of emergency management, relief agencies or the public.

NTS networks employ a universal, standard messaging format referred to as the radiogram format. This message format both meets and exceeds the requirements of ICS213 and similar general message formats. It combines enhanced accountability data with network management data to ensure that message integrity remains intact within a complex disaster telecommunications environment. This accountability and network management data also facilitates message tracking and defines network topography to facilitate the routing of reply or service messages.

The NTS utilizes multiple communications technologies within its operation. Primary modes utilized by NTS include radiotelephone, radiotelegraph and an automated *PACTOR* digital network. These networks are arranged to allow radiograms to pass between network layers using a variety of modes. For example, a message can originate utilizing an automated digital mode and be transferred to a destination recipient (addressee) utilizing an available amateur radio voice circuit or public safety communications network without loss of essential accountability or network management data.

As an essential Amateur Radio Service program, NTS offers the classical advantages of decentralization and dispersal. Volunteer radio operators are often located close to a disaster area. They can quickly deploy to provide basic communications or otherwise provide essential situational awareness reports to served agencies. The use of the High Frequency radio spectrum, which serves as the primary medium for NTS networks, ensures survivability under worst-case conditions.

While NTS is not designed to be a high-capacity data carrier, it offers, in exchange for limited data capacity, a high degree of survivability. The messages conveyed via NTS might be likened to brief telegram messages or press agency "flash reports." Most routine messages run in the range of 25 words or less. While there is no limit on the length of priority or emergency radiograms transmitted on behalf of served agencies, brevity is encouraged and most agencies try to target message length to 50 words or less. However, messages of significantly greater length can be conveyed if absolutely necessary.

When not active in emergency response, NTS operates 365 days per year, 24-hours per day on a limited cycle. During routine operations, general administrative traffic or casual "telegram" style messages can be originated to addresses throughout the United States, Canada, and selected foreign countries. These routine operations exercise the system and ensure operational readiness.

III Scope of Exercise:

At the request of the Federal Emergency Management Agency, the NTS conducted a proof-of-concept exercise on June 8 and 9, 2016, in parallel with the larger Cascadia Rising exercise. This exercise was designed to test the ability of the NTS to provide connectivity between a widespread disaster area and the FEMA National Response Coordinating

Center (NRCC). NTS and ARES (Amateur Radio Emergency Service) operators within the following states participated:

- Alaska
- Idaho
- Northern California
- Oregon
- Washington

Two types of message traffic designed to provide a thorough test of NTS accuracy and reliability were originated. These two message types can be described as follows:

1. <u>NRCC Messages</u>: Radiograms, consisting of simulated five letter cipher groups were used to test both connectivity and accuracy between the disaster field locations and the NRCC.

2. <u>Network Management Messages</u>: These radiograms were utilized as an internal mechanism within the NTS to allow network management staff to track the status and local connectivity of personnel in the field.

IV Radio Frequency requirement:

As designed, the exercise simulation required the use of "all-RF" resources. In other words; message traffic could not be transferred to the Internet or a similar commercial telecommunications common carrier for any part of its journey. For example, a message could not originate within the simulated disaster area using radio, be routed into the Internet and emerge elsewhere for subsequent routing or delivery. This requirement demonstrated the capacity of NTS to convey operational message traffic under worst-case conditions.

Within this all-RF environment, messages were allowed to flow freely between radio modes. For example, a message might originate on a radiotelephone network at the local level and be transferred to a high-speed radiotelegraph circuit or an automated digital network within the NTS system for subsequent routing to its destination.

Modes Utilized:

Four different radio communications modes were used during this exercise:

- Radiotelephone networks (high frequency SSB)
- Radiotelegraph networks (high frequency CW)
- NTS *PACTOR* digital network (high frequency *PACTOR* network)
- Alaska ARES *PACTOR* digital network (high frequency *PACTOR* network)

V Role of WebEOC:

WebEOC was utilized to effect final delivery of radiograms to the NRCC. However, certain rules were applied to the exercise in order to ensure that the use of the Internet during this final delivery phase did not alter the basic exercise requirement calling for long-haul, radio-frequency only, communications: Exercise guidelines required that radiograms be delivered only upon reaching the destination NTS Eastern Area. In this respect, WebEOC essentially served as a simulation of an on-site radio operator at or adjacent to the NRCC.

VI Controlled inject messages:

In advance of the exercise, a series of 181 messages were prepared by the NTS exercise design team, 66-percent of which consisted of simulated five-letter cipher groups, which were addressed to the NRCC. The remainder of the message traffic consisted of internal network management messages, the general structure of which was defined by the NTS exercise design team, but which were drafted by the individual radio operators participating in the exercise. These latter messages, while not controlled with a reference copy retained by the exercise design team, served to simulate the administrative overhead associated with a properly coordinated deployment of NTS resources.

The controlled inject messages were provided to exercise participants in sealed envelopes, which were stamped with the date and time at which the envelope was to be opened and the messages originated via a NTS network. This simulated a more natural flow of message traffic, such as that which might occur in time of emergency.

VII Data collection:

For a disaster exercise to be effective, it must meet certain criteria:

- It must be realistic
- It must be attainable
- It must be objective
- It must be measurable

In keeping with these requirements, exercise guidelines called for each radio operator to record essential network data against time. In this way, it became possible to eliminate bias and create a basic data set, which can serve as a baseline against which future exercises can be measured. This data also serves as the basis for implementing future network modifications or changes to standard operating guidlines.

Upon conclusion of the exercise, all evaluation data was entered into a master spreadsheet, the data from which was then be broken out to measure the performance of individual networks or communications modes. This facilitates a comparison of the relative efficiency of various communications modes and networks and is therefore instructive in the sense that one can identify best practices for applying a specific communications mode or network to a specific emergency management function. Likewise, this data can be used to compare the performance of various communications networks or modes under various radio frequency conditions.

The following metrics were of primary interest to the exercise evaluation team:

1. *Message accuracy*: Message accuracy across the overall operation, as well as a relative comparison of message accuracy between manual mode networks (radiotelephone/radiotelegraph) and automated digital resources can reveal commonalities, which identify problematic procedures or training deficiencies. This allows for subsequent corrective actions.

2. *Message propagation time*: The length of time measured from message inject to message delivery provides critical insights into the ability of a disaster telecommunications resource to provide timely communications. Likewise, the relative comparison of message propagation time between several modes/networks provides additional insights into operator training, network topology, the effects of radio frequency conditions and other efficiency factors.

3. *Statistical Outliers*: Delayed messages or connectivity failures in which messages did not arrive or were significantly delayed are also of significant interest. This data can reveal to choke-points, fragile segments of network infrastructure or other details requiring correction.

VIII Message integrity scoring:

As stated above; accuracy scoring is an integral component in the evaluation of a disaster telecommunications exercise. Two types of failures may be found in message traffic:

- *Non-fatal errors*: These errors do not alter the meaning of the message. Examples include minor misspellings of a word, the accidental elimination of a conjunctive, punctuation errors or minor errors in network management data.

- *Fatal errors*: Fatal errors include factors, which either alter the meaning of a message or misplace the message against a time-line. For example:

    - If more than one message is originated in reference to a particular subject, functional representatives within an EOC or the NRCC must be able to place each message in its proper temporal context. If an error is present in a date-time group, a message that should modify a response may be overlooked or it may trigger an inappropriate decision.

- Some messages are critical to a proper decision making process. Examples include etiological information identifying a pathogen during a bio-terrorism event, complex chemical names, quantities associated with supply or personnel requests, and so forth. Errors in spelling, quantities or missing information can result in mission failure.

In order to simplify the evaluation process, accuracy and message propagation time scoring was limited to those messages transmitted to the NRCC. Because these messages were transmitted in simulated five-letter cipher groups, an analytical method had to be developed to determine the difference between fatal and non-fatal errors. These criteria can be summarized as follows:

1. Each letter or figure within the radiogram was treated as a unique data point.

2. Each distinct error, such as an improperly transcribed letter or figure was grade as a single error.

3. Up to three errors associated with *different* cipher groups were treated as individual errors. Four or more errors within an entire message were treated as a fatal error and the message was discarded.

4. Two errors within a single group (five letter cipher group or word) were counted as five errors.

5. Three errors within a single group were counted as a fatal error and the message was discarded.

IX Accuracy chain:

As alluded to earlier, the accuracy check was designed to inclusively identify all errors from point of origination to the final product delivered to the NRCC. In the case of the NRCC messages, the inject messages were already formatted in order to provide a reference point against which the delivered product could be compared. Typical errors in message traffic include:

- *Data entry errors*: NTS digital networks incorporate automatic error checking. However, data entry errors are still possible. Therefore, operators must still exercise care when entering message traffic into a data terminal.

- *Transcription errors*: Manual mode networks, such as high-speed radiotelegraph networks, require an operator to not only decode Morse, but also transcribe the message at intermediate relay points, such as within a message center. An error during the transcription (receiving) process is possible.

- *Message Transfer*: Messages originated by both digital and manual modes required transfer to WebEOC, during which transcription errors might occur. Likewise, during disaster operations, a message may be transferred from one radio network to another for final routing to its destination. Errors can occur during this process as well.

X Network topography:

NTS networks are designed to balance a variety of factors to achieve reliability in time of emergency. These factors include:

- Interoperability
- Decentralization
- Universality
- Survivability.

Moving a message across country seems like an easy task in the era of the Internet and cellular mobile data networks. However, the picture is more complex and nuanced when the Internet is not available in a disaster area or when other circumstances dictate the use of more survivable options.

In addition to the use of a universal radiogram format, which includes essential network management data and accountability information, NTS networks are designed to accommodate message flow between any number or type of communications circuits. This interoperability allows messages to be routed through any available NTS network regardless of mode, coverage or other variables. This goal of full interoperability also enhances decentralization.

In exchange for these interoperable characteristics, some variations are to be expected in message propagation times through the system. Manual mode networks, in particular, see variations in propagation time as individual radio operators exchange files of messages between NTS layers. Larger files result in longer transfer times between net layers, thereby lengthening the propagation time of “first-in” messages while having less effect on “last-in” messages.

Injection points within the network layers also affect overall propagation times. For example, if an inject point is associated with a higher level network, such as those networks functioning at the region or area level, transcontinental propagation times will be less, whereas those messages injected at a lower network level, such as within a local NTS or ARES network may need to be transferred through several net layers, thereby lengthening message propagation time.

The prototype NTS National Response Plan implemented for "Cascadia Rising" utilized a modified network topology designed to limit the number of net layers and therefore limit the number of file transfers required to support the simulated disaster operation. This prototype national response plan will be adjusted based on exercise outcome, but the general plan is to utilize a standard network structure for routine, daily communications while implementing a specialized, streamlined structure for disaster operations.

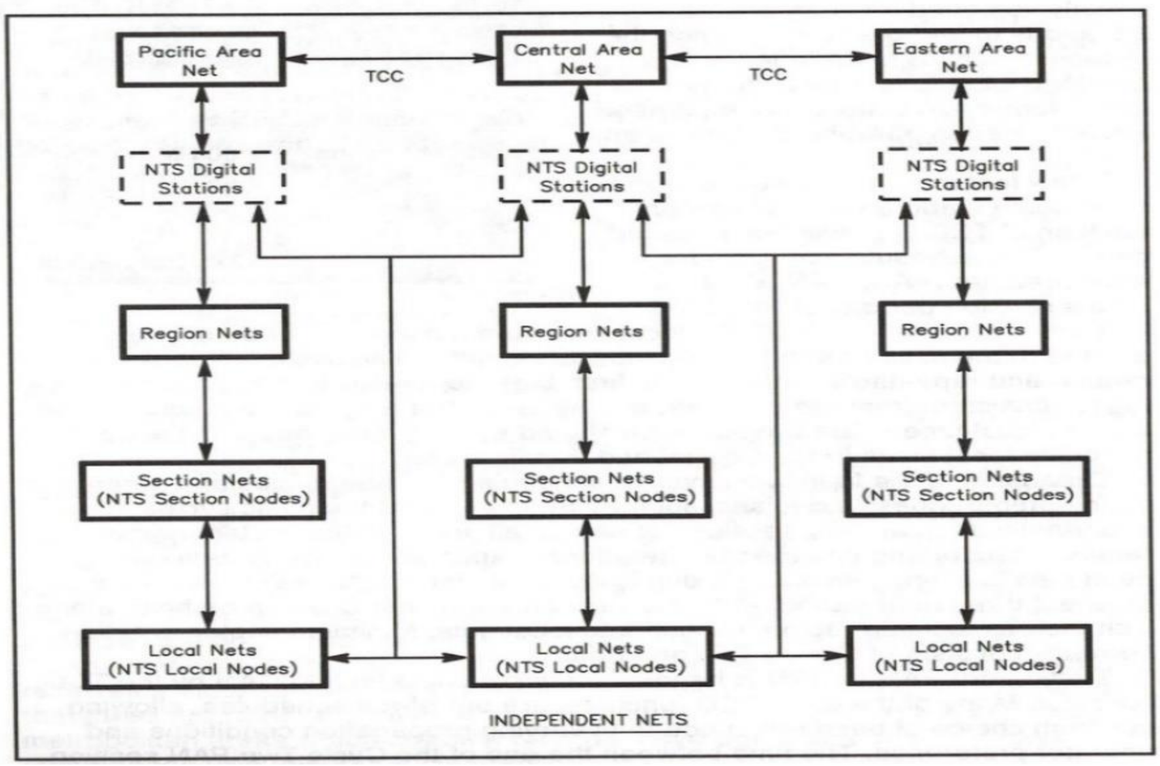

Fig. 1: Overview of NTS Network Topography

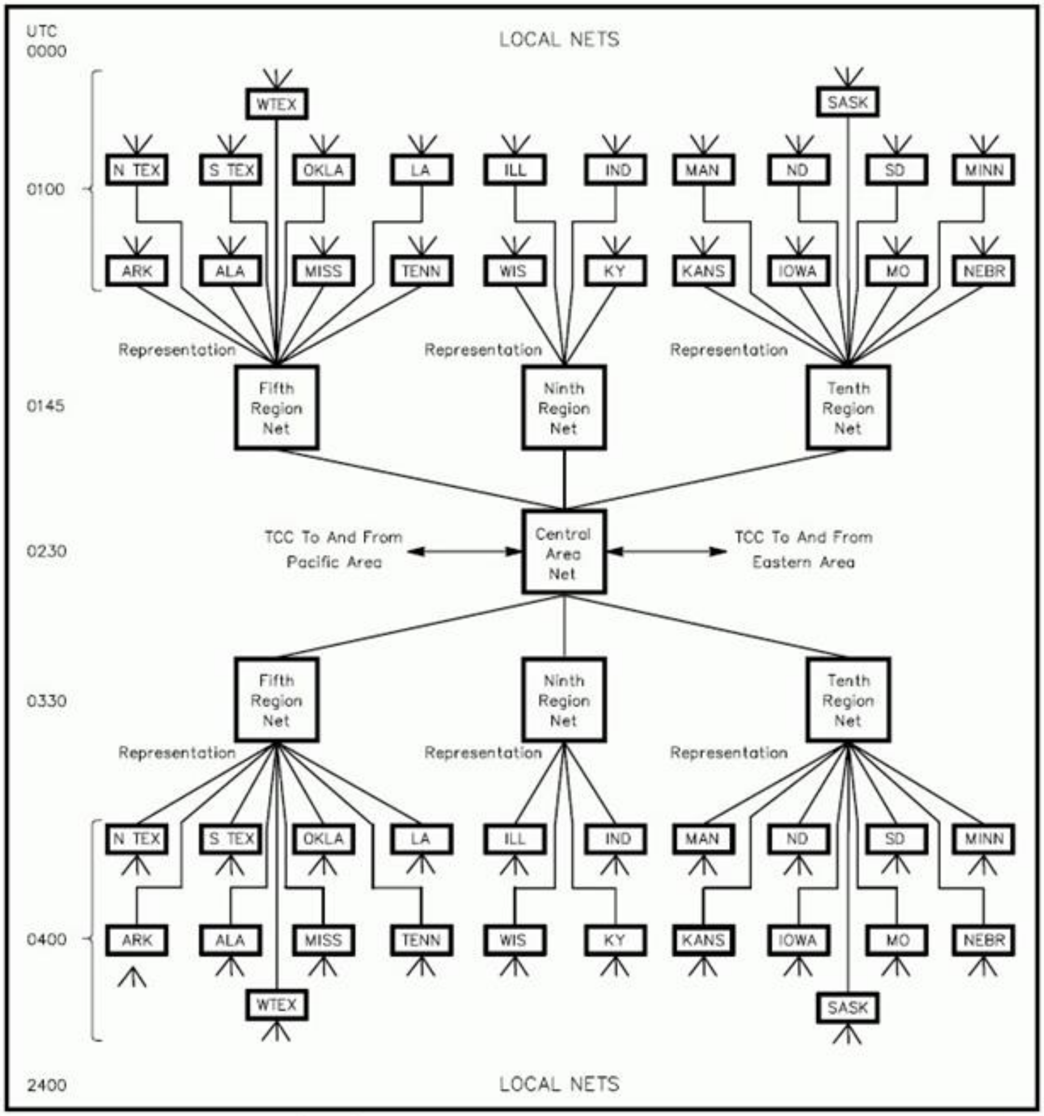

Fig. 2: Example of NTS Topography for Central Area

Digital Network:

The NTS digital network has never been tested in a simulated disaster situation.

In an effort to determine the required changes to network topology and routing tables, the decision was made to leave NTSD in its “routine” configuration. When operating in routine mode, the digital network is designed to convey daily, routine “radiogram” communications. The operational demands within this operational context are therefore minimal. Radiogram propagation times of 12 to 16 hours are considered acceptable.

Digital network nodes had recently been upgraded to a new software platform (BPQ-32), which was designed forward message traffic in a more responsive fashion. However, the upgrade was quite recent and operational experience, including any useful metrics defining baseline performance under routine or operational conditions were unavailable in advance of “Cascadia Rising.”

The goals of this unmodified test of the digital network were:

- Confirm the ability of BPQ-32 nodes to automatically route message traffic in a timely fashion.
- Ensure that message traffic was not held or duplicated.
- Examine performance under the varying propagation conditions present during the three exercise phases.

The digital network may be viewed as a “star and hub” arrangement in which section (state) level digital relay stations transfer radiogram messages to a region hub. The region hub then forwards the message traffic to its destination region, where it is distributed to the appropriate state or municipality for distribution. This relies on a fairly structured message flow pattern throughout the network. Therefore, the lessons learned during the exercise could prove essential to revising network topology.

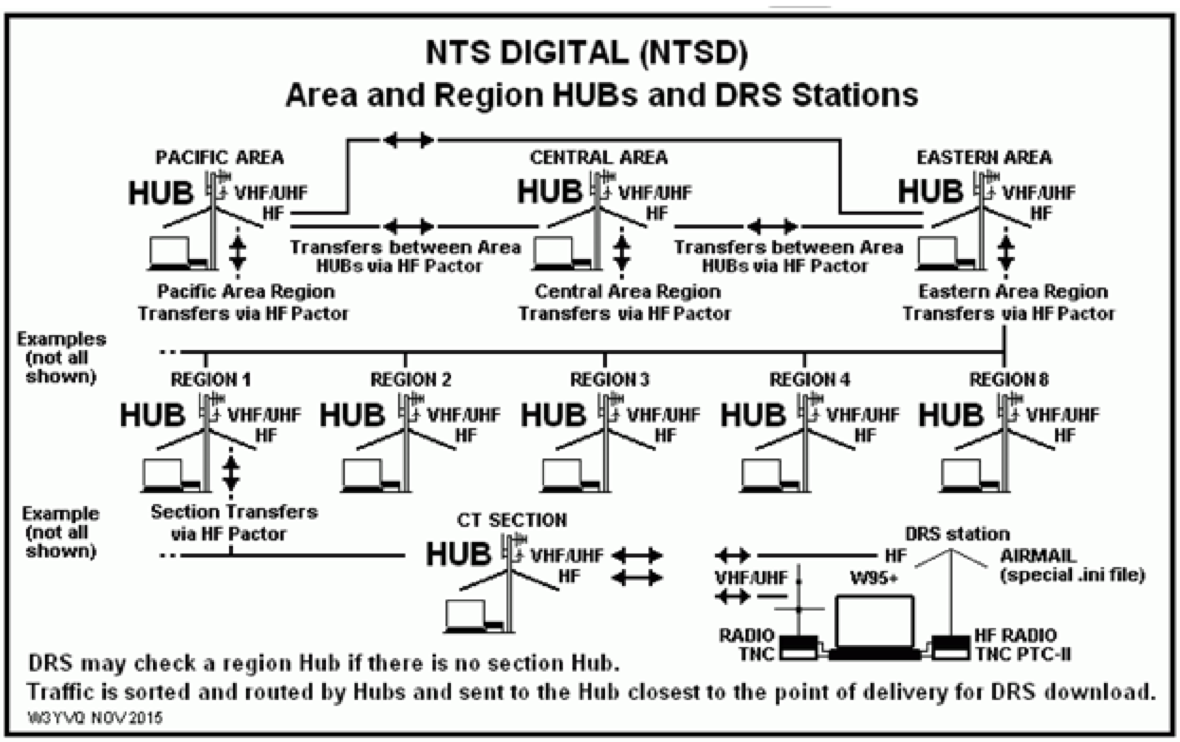

Fig. 3: Digital network structure

PART TWO
EXERCISE RESULTS

Appendices A through C contains all metrics associated with the NRCC messages based on network and mode. Please utilize these spreadsheets for reference if necessary.

XI Accuracy assessment:

Overall, NTS exhibited an excellent accuracy record against the simulated 5-letter cipher groups utilized for the exercise. Overall accuracy exceeded 99-percent, with only occasional minor errors in a few messages. *No fatal errors occurred in any of the message traffic conveyed.*

Radiotelegraph:	**99.998 percent**	**15 non-fatal errors in 10220 data points**
NTSD:	**99.997 percent**	**16 non-fatal errors in 7008 data points**
Alaska Intrastate:	**100.00 percent**	**no errors**

A review of the actual copies of message traffic submitted to the evaluation team does much to explain the nature of errors.

Radiotelegraph Networks:

Errors within the radiotelegraph networks were rarely associated with improper decoding of International Morse. For example, the investigation of a sample of errors pointed to transcription errors, particularly when a radio message was transcribed by hand; for example, the letter "P" carelessly written to resemble a "D" or the like. Decades of military and commercial experience were essentially confirmed by these findings:

- Expert radiotelegraph operators rarely make errors copying International Morse.
- Most errors are related to transcription.
- The word processor or typewriter ("all-capital mill") prove advantageous for transcribing operational message traffic.

Digital networks:

It is interesting to note that a similar number of errors was associated with the digital network across fewer data points. This points to most errors being related to transcription or data entry during the overall messaging process. However, it is again important to understand the interoperable construct of the National Traffic System. A small percentage of these messages may have occurred when messages were originated using radiotelephone methods and then transferred to the digital system. Further investigation of the source of errors was deemed unnecessary because the overall error rate was felt to be de minimis. Continued training in the area of net operations combined with subsequent exercising should further eliminate most errors.

XII Message propagation time:

Radiotelegraph network*:*

As alluded to earlier, the radiotelegraph networks turned-in an excellent record of performance during "Cascadia Rising." Message propagation times for the exercise can be summarized as follows:

Average radiotelegraph message propagation time:	**30.5 minutes**
Minimum propagation time:	**1 minute**
Maximum propagation time:	**110 minutes**

A review of the data does indicate that, overall, the average propagation time is less if one removes several outliers. The average message propagation time drops into the 10 to 15-minute range depending upon the standards implemented to manage statistical outliers. A review of Appendix A is recommended. In particular, an examination of the data contained in the "propagation time" column will provide some intuitive insights into the overall efficiency of the radiotelegraph networks.

Factors affecting radiotelegraph network propagation times:

Network Topology: Systematic message flow requires a layered net approach. Messages may be collected on a state-level (section) network as a "file" of multiple messages before being forwarded across country via the Transcontinental circuits. This introduces an administrative delay of some minutes.

Operator Staffing Levels: Radio operators working individually must balance message file size against factors such as network sequencing and administrative overhead. For example, smaller files require more frequent traffic exchange between network layers. However, if this is done too often, inefficiency is increased due to the need to regularly re-establish communications. If it is done too infrequently, file sizes build up and messages, which fall early in the file sequence are naturally delayed longer.

Message Center Configurations: The delay problems indicated above are minimized when a shared communications facility is utilized and configured as a 'message center" or "relay office" arrangement in which incoming messages from lower network layers are not held within a file, but rather quickly transferred to the outgoing message layer by a clerk or other transfer arrangement immediately upon receipt.

Digital networks*:*

Message propagation times for the digital network can be summarized as follows:

Average message propagation time: 82.14 minutes
Minimum message propagation time: 26 minutes
Maximum message propagation time: 147 minutes

As with the radiotelegraph component of the exercise, it is important to examine outliers. However, in this case, the outliers tend to push any qualitative conclusions regarding network performance to an unfavorable conclusion. For example, messages delayed longer than 2.5 hours were not included in the analytical statistics.

An intuitive review of Appendix B propagation times will show that the digital network was significantly impacted by poor radio frequency conditions. Within this environment, certain factors likely caused delays and slowed message propagation:

Co-channel or adjacent channel interference: Heavy use of the excessively narrow automated digital sub-bands undoubtedly impacted message propagation times. NTSD nodes utilize an automatic detection scheme in which transmission is suppressed if a channel is determined to be busy. Heavy use of a shared channel may result in a file of messages awaiting transfer until which time the target node (receiving node) can respond.

Noise floor: Noise floor, particularly during unsettled geomagnetic conditions can seriously impact a node's ability to hear a connect attempt. If the signal-to-noise ratio falls below a certain threshold, acknowledgement may be impossible and the traffic may be held for a later retry.

Node profiles: NTS digital nodes were designed to use the minimum amount of power necessary to facilitate routine communications. 100-watts RF power output is common. Also non-directional antennas are often used to facilitate connection with numerous digital relay stations in various locations. The combination of poor radio frequency conditions and these design parameters likely resulted in nodes periodically failing to link.

It is anticipated that some minor changes to digital node configurations will significantly increase reliability. These changes, which are itemized in latter portions of this report, will need to be verified through internal tests in advance of further exercises.

Alaska Intrastate Exercise:

The Alaska Intrastate component exceeded expectations. Message propagation times can be summarized as follows:

Average message propagation time:	**5 minutes**
Minimum propagation time:	**1 minute**
Maximum propagation time:	**11 minutes**

While there are many similarities between the Alaska Intrastate component of the exercise and other exercise components, there is also a significant difference. In particular, the Intrastate coverage area was more geographically limited. Furthermore, few relay points were required to access the CW gateway. This tends to decrease the message propagation times and minimize connectivity failures.

Important points to take away from this exercise component include:

1. The Alaska ARES organization had placed considerable emphasis on training and exercising. All participants were well equipped with the necessary digital equipment and were well versed in its use.

2. Alaska ARES regularly conducts exercises requiring the formatting and processing of record message traffic. This clearly paid big dividends in the exercise.

The CW gateway also performed well. However, radio frequency conditions at these latitudes can often prove problematic. As alluded to earlier, high frequency circuits between CONUS and Alaska are often degraded by aurora and other solar effects. The inconsistencies in high frequency radio conditions was well understood by the U.S. Army Signal Corps, Canada’s Northwest Territories and Yukon Radio Service, Canada’s Royal Corps of Signals and similar organizations operating radio networks at these latitudes.

Recommendations for upgrading the resilience of the CW gateway are contained in latter sections of this report.

XIII FEMA broadcast message

A NTS generated, simulated FEMA broadcast message was originated to all stations during the exercise (message serial number 311), The purpose of this message was to demonstrate the capacity of NTS to inject a broadcast or informational message into a disaster area. These messages were tracked to the state level. Those states acknowledging receipt of the broadcast message are listed in Appendix F.

It should be noted that additional stations may have received the broadcast message, but did not record it in their records.

XIV Radio Frequency Conditions.

Radio frequency conditions play a significant role in high frequency radio network efficiency. All networks operating in the high frequency environment are subject to variable radio conditions due to the solar cycle, solar flares, geomagnetic conditions and related factors. In the worst case scenario, unstable conditions can completely disrupt communications.

Under marginal conditions, such as those present during the three phases of “Cascadia Rising,” the result is typically increased message propagation times. These increases can often be traced to factors such as:

- Situations in which digital circuits fails to initially establish an automatic link due to a high noise floor or weak signal conditions (poor signal-to-noise ratio)
- Situations in which a digital network must “retry” packets when check-sums do not confirm.
- Situations in which radiotelegraph or radiotelephone operators slow the transmission of message traffic to improve readability.
- Situations in which “fills” or confirmations must be utilized to ensure message integrity on radiotelephone or radiotelegraph networks.

There are, of course, other factors, which affect message propagation time through a high frequency radio network. These include:

- Adjacent channel or co-channel interference.
- Large “batch files” or message files being exchanged between layered networks.
- The use of handling instructions, which increase demand on circuit capacity.
- Improper network procedures, which increase demand on circuit capacity and therefore limit the amount of message traffic, which can be conveyed.

XV Detailed discussion of radio frequency conditions during the exercise:

Because NTS assets utilize the high frequency radio frequency spectrum to facilitate connectivity, one cannot entirely divorce the exercise results from the context of radio frequency conditions. Variations in sunspot cycle, geomagnetic conditions and other planetary influences affect the ionosphere in often unpredictable ways, thereby enhancing or degrading high frequency radio communications in the 3 to 30-mHz range.

The science of selecting a suitable operating frequencies to facilitate connectivity over a given distance and within a specific time frame is essential to proper the proper functioning of NTS networks. Network Managers must exercise careful planning to ensure that connectivity can be established. This includes developing a frequency management plan, which offers alternatives in response to variations in ionospheric conditions.

The "Cascadia Rising" event took place during a period of unsettled propagation conditions. This had a significant impact on the operation.

Two propagation paths were of particular interest during the exercise, these being the Alaska to CONUS circuit and the Region 7 (Pacific Northwest) to Region 3 (Philadelphia Area) circuit, which served as the terminus for message processing and delivery to the NRCC.

Alaska – CONUS circuit:

The Alaska to CONUS circuit consisted of a single, high-speed radiotelegraph circuit between Fairbanks, Alaska and Clastskanie, Oregon. NRCC message traffic within Alaska was originated and conveyed utilizing a digital *PACTOR* network. This message traffic was then routed to the Fairbanks, Alaska radiotelegraph gateway, which transferred the message traffic to Oregon. Once in Oregon, the file of message traffic was moved across country via a NTS Transcontinental Corps (TCC) circuit to Region 3 for delivery.

Radiotelegraphy was selected for use over these long HF circuits due to its narrow bandwidth, universality and resistance to propagation anomalies. Because Alaska is situated at high latitudes, HF radio circuits between Alaska and CONUS are more sensitive to ionospheric disturbances, such as aurora and other factors. The use of a narrow-bandwidth mode, such as radiotelegraphy, therefore offers great benefits.

The use of radiotelegraphy during Cascadia Rising proved to be an excellent choice. With unsettled radio frequency conditions and other negative factors degrading propagation, it is unlikely that other modes could have provided both the necessary resistance to propagation anomalies and the overall efficiency needed to process the exercise message traffic.

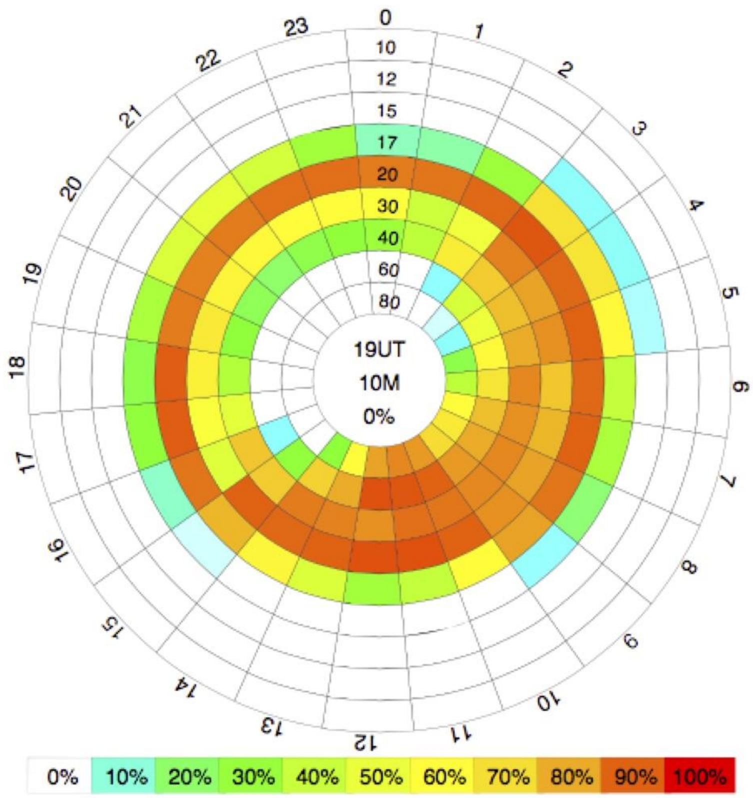

Fig. 4: Radio frequency conditions – Alaska/CONUS

Region 7 to Region 3 Transcontinental Circuit:

Communications from the Pacific Northwest to the East Coast was also impacted by poor propagation conditions. In this case, both radiotelegraph and digital assets were utilized to convey message traffic and the performance contrast is quite stark.

Despite poor radio frequency conditions, the high-speed radiotelegraph circuit performed flawlessly, providing excellent connectivity. This was likely due to several factors, including:

- The aforementioned characteristics of narrow-bandwidth and natural efficiency for record message traffic applications.
- NTS TCC assets are typically equipped with stations designed to facilitate long-haul communications, including directional antennas and RF power amplifiers.

- Operator training and experience was also an additional factor. Because NTS operates 365-days a year conveying routine message traffic, the TCC operating staff simply substituted the priority exercise message traffic for the routine message traffic handled during day-to-day operations.

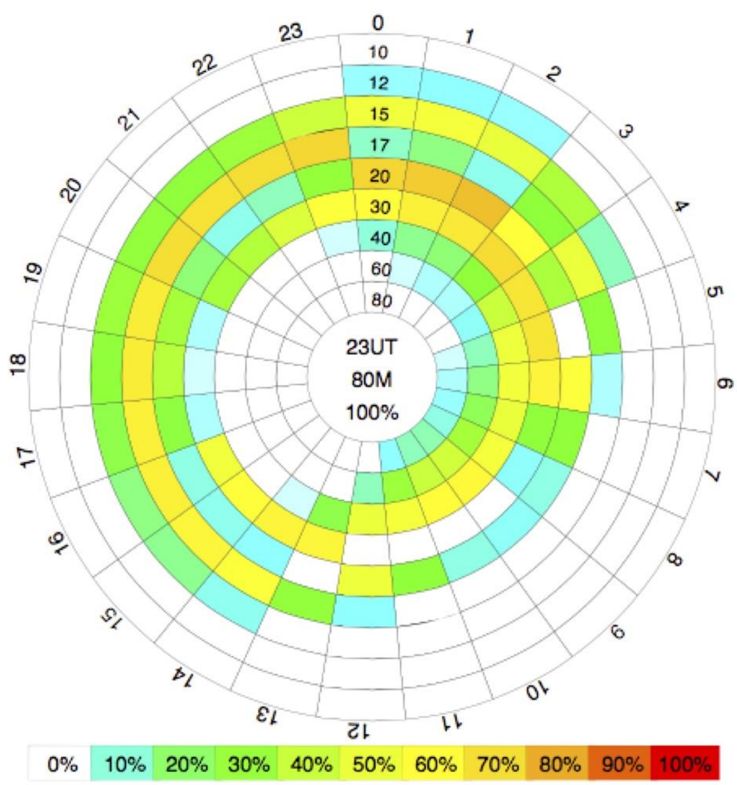

Fig.5: Radio frequency conditions - Washington State to Pennsylvania

NTS digital networks did not tolerate the poor propagation conditions as well. During the exercise phase one and three (daytime) components, propagation conditions were sufficiently degraded that some message traffic was significantly delayed. There are likely several reasons for this:

- NTSD hubs are designed to accept traffic from any direction. Therefore, the benefits of directional antennas are precluded.

- NTSD hubs typically operate at lower power in order to minimize possible interference in the very limited sub-bands the FCC allocates to automated data systems.

- The BPQ-32 message forwarding platform was not yet fully understood by NTS staff due to its recent implementation. Routing tables and other programming information was based on past experience and theory and had not yet been "tweaked."

When propagation improved, such as during the nighttime phase, overall connectivity and message propagation times improved dramatically. This indicates the need to make some adjustments to NTSD so that it is better equipped to support a national disaster operation under a wider range of radio frequency conditions.

Finally, it is important to reiterate that the NTS exercise design team chose to leave the network configured in routine mode to maximize the benefit of the exercise. Based on the results, NTS can now take proactive steps to configure NTSD for improved emergency communications response.

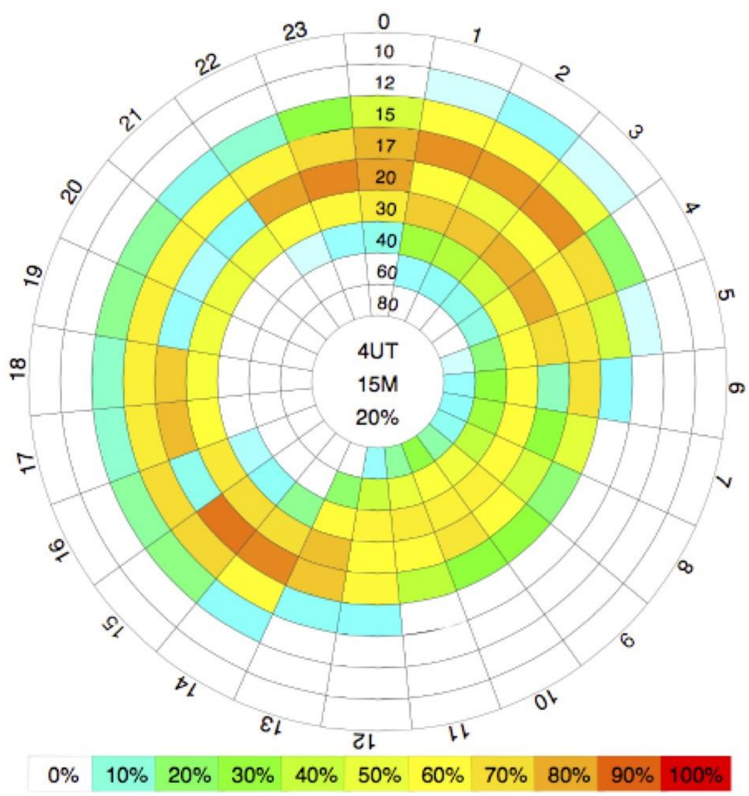

Fig. 6: Radio frequency conditions - Washington State to Indiana (intermediate NTSD hub) conditions.

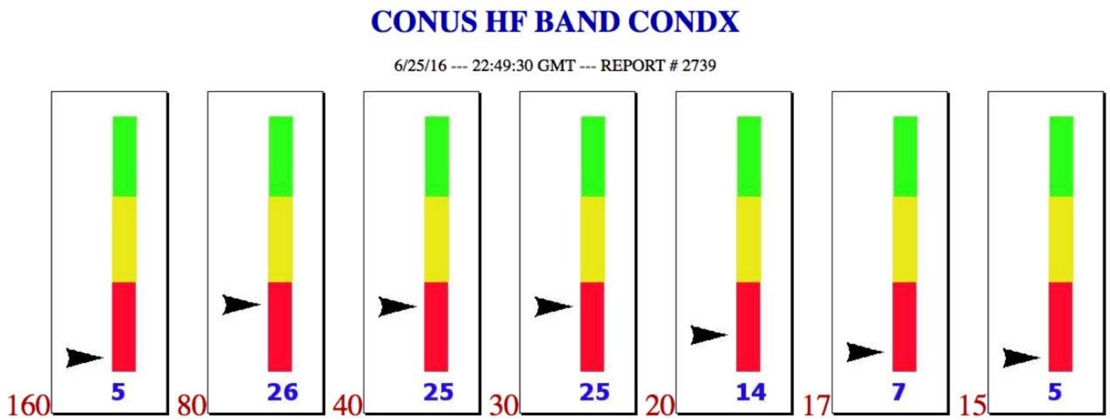

Fig. 7: Radio frequency conditions during daytime exercise phases one and three.

PART THREE
RECOMMENDATIONS

XVI Recommendations - radiotelegraph networks:

Radiotelegraphy once again proved its value during the "Cascadia Rising" exercise. The following factors proved highly beneficial:

- Narrow bandwidth allows for optimum use of available transmitter power output.

- The nature of radiotelegraphy as a hybrid between natural language and digital methods promotes efficient net procedures and a high level of accuracy.

- The universality of the mode is ideal for emergency communications. The fact that any radio transceiver in service is capable of being pressed into service using CW could prove of significant advantage in time of emergency.

- Radiotelegraphy would be an ideal mode for extended operation from catastrophic disaster areas.

This exercise verifies the wisdom of maintaining and promoting the "manual mode" voice and CW NTS networks. Simply put; without the radiotelegraph common denominator, NTS performance during Cascadia Rising would have been significantly degraded.

Recommendations include:

1. Transcontinental circuits require gateways and liaison stations with features such as:
    a. Directional antennas
    b. RF power output in the 500 watt or higher category.
    c. Quiet RF environment.
    d. Receivers with excellent sensitivity and dynamic range.

2. CW operators performing liaison functions may want to consider developing the skills needed to copy message traffic on a mill or word processor to prevent transcription errors. This will offer the added benefit of enhancing message exchange speeds.

3. One or more message center arrangements could be established at EOCs or well-equipped club stations. These could be a scaled down arrangement patterned after the older military message centers. This would facilitate simultaneous operation on two to three networks simultaneously (e.g. region level nets to Area or TCC level networks), thereby facilitating more rapid message exchange between circuits.

4. The use of message clerks (who are not skilled radio operators) could prove advantageous in an administrative support function at a key station or message center.

5. The exercise was broken into three phases, which stressed operations personnel in a manner that was sufficient to measure network performance. However, 24-hour operation would have required additional personnel. It is strongly recommended that NTS embark on an aggressive recruiting campaign to bring in additional highly qualified radio operators. Target demographics include:

    a. Retired military and maritime radio operators.
    b. Active "contest" enthusiasts with excellent CW skills and well-equipped stations.
    c. CW enthusiasts from outside the NTS community.

6. The capacity to stand watch on more than one frequency is a recommended capability for advanced NTS operators. Often an older communications receiver can be pressed into service in this capacity, without undue expense to the volunteer.

XVII Recommendations - Digital network:

The exercise reveals that the NTS digital network, if left operating in routine configuration, does not have the necessary resilience to support a disaster operation of this magnitude. Nonetheless, NTS digital holds promise. The nearly flawless performance during the Alaska Intrastate segment of the exercise shows the promise of automated digital "*PACTOR*" networks, particularly when utilized to convey properly formatted and administered record message traffic.

NTS digital could provide an excellent gateway for liaison to FEMA or a similar served agency, which is already equipped for high frequency operation. However, a number of modifications to NTSD are recommended:

1. All routing tables for the fixed network configuration should be reviewed and updated in a systematic manner in order to provide a better variety of channels to support connectivity under marginal conditions.

2. An alternate routing configuration should be developed and staged for disaster operations, which facilitates the use of *PACTOR* 2 outside the sometimes crowded automated digital segments.

3. When possible, an attendant ("sysop") should be present at each key node during a disaster operation to monitor node function and traffic throughput.

4. Improved antenna systems and, when possible, increased RF power output should be considered for key NTSD nodes. Grant funding or other assistance needed to upgrade these key facilities could be sought.

5. Alternate frequency tables should be developed and staged for rapid implementation in the event that it is necessary to avoid interference from radio contest events.

XVIII General Recommendations

The National Traffic System has not been exercised at the national level in at least four decades. While there are many reasons for this, which are outside the scope of this report; the fact remains that certain institutional knowledge and experience has been lost with time.

In order to prepare for this exercise, a draft "NTS National Response Plan" was created. This plan was incorporated into appropriate exercise guidelines in order to serve as the foundation for a national response. In addition to the technical and operating recommendations outlined above, it is recommended that the following steps be taken to better prepare NTS for rapid response to a national disaster:

1. The Mode/Frequency Matrix designed for the prototype response should be expanded to accommodate several operating environments. Of particular concern is the potential conflict between the now dominant "contesting culture" within Amateur Radio and the requirement for reliable emergency response. Four separate mode/frequency charts, perhaps defined as "Response Matrix A through D" could be developed, thereby providing defined frequency flexibility during the following situations:

    a. Routine Period (no contests)
    b. Major CW Contest
    c. Major SSB Contest
    d. Major RTTY Contest

    With several contests now scheduled for nearly every weekend throughout the year, NTS stands a significant chance of experiencing unwarranted interference during a contest event. Such an approach would limit harmful interference from high-power contest stations.

2. NTS should address the issue of initial alert and notification. Three related approaches could be defined in a NTS National Response Plan:

a. Self-alerting: NTS members self-activate by monitoring defined watch frequencies when they have knowledge that a major disaster, terrorist attack or other event has taken place.
b. Bulletin stations: Defined bulletin stations, such as W1AW would broadcast periodic bulletins activating NTS operators.
c. Automatic alerting: A simple "selective calling" arrangement could be developed with the assistance of a manufacturer. For example, something patterned after the old maritime "auto-alarm" arrangement used on 500-KHz could be set up. Volunteer radio operators could use an older communications receiver to maintain watch on an auto-alarm frequency. Upon receipt of the necessary coded impulses, a relay contact closure could sound an alert, thereby enabling the radio operator to establish communications on a defined emergency frequency.

3. Several NTS officials could be defined as emergency points of contact for FEMA to request activation of NTS to support emergency operations. Likewise, these key officials could have the capacity to notify the NRCC that a disaster has occurred should it not yet be known to FEMA officials.

Appendices

Appendix A: Radiotelegraph network data

Appendix B: NTSD network data

Appendix C: Alaska interstate network data

Appendix D: Exercise guidelines and associated documents.

Appendix E: A sample copy of controlled inject messages and sample ICS213 message as delivered to the NRCC.

Appendix F: FEMA Broadcast Message acknowledgments logged.

Appendix G: NTS and ARES Units participating & Individuals deserving recognition

Appendix H: Contact information for evaluation report (and copyright information).

Appendix A
Radiotelegraph Network Data

NTS Cascadia Rising Message Metrics

Color Code:	Phase One	Phase Two	Phase Three
	081701Z to 082200Z	090001Z to 090400Z	091401Z to 091800Z

Red indicates likely record-keeping discrepancy - adjustment made accordingly or data not used for calculations beyond accuracy check
Green indicates Alaska exercise consisting of an intra-state exercise (see separate data) and gateway to TCC exercise the results of which are highlighed in green below)
Purple indicates a message failure due to connectivity failure, operator error, excessive propagation time or other factor beyond accuracy errors.

IMPORTANT NOTE: Accuracy and propagation time measurements conducted only on NRCC traffic.

Msg No.	Msg DTG	Originator	DTG Injected	Mode (QSP)	DTG Received	Rcvd. From	Rcvd. By	Propagation Time	Fatal Errors	Non-Fatal Errors	Message Fail	Notes
1	081701Z	W7IZ	081701Z	CW	081703Z	W7IZ	WB8WKQ	2 min		1		**NRCC**
2	081703Z	W7IZ	081705Z	CW	081705Z	W7IZ	WB8WKQ	1 min				**NRCC**
3	081715Z	W7IZ	081732Z	CW	081815Z	WB8WKQ	AF4NC					
4	081717Z	K9JM	081720Z	CW	081739Z	W7IZ	WB8WKQ	19 min				**NRCC**
5	081718Z	K9JM	081723Z	CW	081742Z	W7IZ	WB8WKQ	19 min				**NRCC**
6	081719Z	K9JM	081728Z	CW	081803Z	WB8WKQ	AF4NC					
7	081719Z	WB6UZX	081801Z	CW	081909Z	K9JM	WB8WKQ	68 min				**NRCC**
8	081732Z	WB6UZX	081805Z	CW	081911Z	K9JM	WB8WKQ	66 min				**NRCC**
9	081728Z	WB6UZX	081810Z	CW	081950Z	N3SW	AF4NC					
13	081751Z	W3SMK	081818Z	CW	081917Z	K9JM	WB8WKQ	59 min				**NRCC**
14	081759Z	W3SMK	081823Z	CW	081919Z	K9JM	WB8WKQ	54 min				**NRCC**
15	081815Z	W3SMK	081826Z	CW	081921Z	K9JM	WB8WKQ					
16	081817Z	W6KJ	081817Z	CW	081834Z	K6YR	WB8WKQ	17 min		1		**NRCC**
17	081821Z	W6KJ	081821Z	CW	081837Z	K6YR	WB8WKQ	16 min				**NRCC**
18	081830Z	W6KJ	081830Z	CW	081927Z	N3SW	AF4NC					
19	**081835Z**	**WB6N**		**CW**	**081945Z**	**W7IZ**	**W1WCG**					**Inject time not recorded by originator**
20	**081845Z**	**WB6N**		**CW**	**081949Z**	**W1IZ**	**W1WCG**					**Inject time not recorded by originator**
21	**081855Z**	**WB6N**		**CW**	**082050Z**	**N3SW**	**AF4NC**					**Inject time not recorded by originator**
22	081901Z	AI7H	081901Z	CW	081959Z	W7IZ	W1WCG	58 min				**NRCC**
23	081910Z	AI7H	081910Z	CW	082002Z	W7IZ	W1WCG	52 min		1		**NRCC**
24	081917Z	AI7H	081917Z	CW	082050Z	N3SW	AF4NC					
25	081922Z	AL7N	082202Z	CW	082208Z	W7IZ	WB8WKQ	6 min				**NRCC**
26	081928Z	AL7N	082219Z	CW	082253Z	W7IZ	KB2QO	34 min				**NRCC**
27	**081933Z**											**Network management message not originated.**
28	081935Z	AL7N	090320Z	CW	090336Z	W7IZ	WB8WKQ	16 min		5		**NRCC**
29	081938Z	AL7N	090324Z	CW	090337Z	W7IZ	WB8WKQ	13 min				**NRCC**
30	081944Z	AL7N	090327Z	CW	091415Z	WB8WKQ	AF4NC					
31	**081937Z**	**AL7N**	**091209Z**	**CW**	**091345Z**	**W7IZ**	**W1WCG**					**Appraent record-keeping error - receipt data not recorded**
32	081941Z	AL7N	082338Z	CW	090021Z	W7IZ	K1NN	43 min		1		**NRCC**
33	081945Z	AL7N	082343Z	CW	090328Z	N3SW	AF4NC					
34	081955Z	AL7N	082346Z	CW	090021Z	W7IZ	K1NN	35 min				**NRCC**
35	082001Z	AL7N	082349Z	CW	090021Z	W7IZ	K1NN	32 min				**NRCC**
36	082005Z	AL7N	082358Z	CW	090328Z	N3SW	AF4NC					
37	082010Z	AL7N	090001Z	CW	090021Z	W7IZ	K1NN	20 min				**NRCC**
38	082013Z	AL7N	090004Z	CW	090021Z	W7IZ	K1NN	17 min				**NRCC**
39	082018Z	AL7N	090006Z	CW	090328Z	N3SW	AF4NC					
40	082023Z	AL7N	090011Z	CW	090021Z	W7IZ	K1NN	10 min				**NRCC**

41	082029Z	AL7N	090116Z	CW	090121Z	W7IZ	K1NN	5 min		**NRCC**
42	082033Z	AL7N	090125Z	CW	090328Z	N3SW	AF4NC			
43	082040Z	AL7N	090116Z	CW	090137Z	W7IZ	WB8WKQ	21 min	1	**NRCC**
44	082043Z	AL7N	090119Z	CW	090131Z	W7IZ	WB8WKQ	12 min		**NRCC**
45	082048Z	AL7N	090122Z	CW	090328Z	N3SW	AF4NC			
46	082055Z	AL7N	090124Z	CW	090145Z	W7IZ	WB8WKQ	21 min		**NRCC**
47	082058Z	AL7N	090125Z	CW	090148Z	W7IZ	WB8WKQ	23 min		**NRCC**
48	082059Z	AL7N	090127Z	CW	090328Z	N3SW	AF4NC			
49	082104Z	AL7N	090330Z	CW	090340Z	W7IZ	WB8WKQ	10 min		**NRCC**
50	082110Z	AL7N	090333Z	CW	090341Z	W7IZ	WB8WKQ	8 min		**NRCC**
51	082112Z	AL7N	090335Z	CW	091418Z	WB8WKQ	AF4NC			
52	082120Z	W7IZ	082129Z	CW	082128Z	W7IZ	WB8WKQ	1 min		**NRCC** - Likely minor error in time-keeping - defaulted to 1 minute.
53	082123Z	W7IZ	082132Z	CW	082131Z	W7IZ	WB8WKQ	1 min		**NRCC** - Likely minor error in time-keeping - defaulted to 1 minute.
54	082133Z	W7IZ	082136Z	CW	082205Z	N3SW	AF4NC			
64	082155Z	W0KCF	082155Z	CW	082259Z	W7IZ	KB2QO	56 min		**NRCC**
65	082157Z	W0KCF	082240Z	CW	082304Z	W7IZ	KB2QO	60 min		**NRCC**
66	082159Z	W0KCF	082244Z	CW	090125Z	WB8SIW	AF4NC			
79	090040Z	K9JM	090046Z	CW	090102Z	K6YR	K1NN	22 min		**NRCC**
80	090041Z	K9JM	090049Z	CW	090102Z	K6YR	K1NN	17 min		**NRCC**
81	090042Z	K9JM	090053Z	CW	090328Z	N3SW	AF4NC			
82	090050Z	WB6UZX	090055Z	CW	090106Z	K9JM	W1WCG	11 min		**NRCC**
83	090052Z	WB6UZX	090059Z	CW	090108Z	K9JM	W1WCG	9 min	1	**NRCC**
84	090055Z	WB6UZX	090103Z	CW	090328Z	N3SW	W1WCG			
88	090122Z	W3SMK	090129Z	CW	090137Z	K9JM	KB2QO	8 min		**NRCC**
89	090127Z	W3SMK	090133Z	CW	090328Z	N3SW	AF4NC	110 min	1	**NRCC** - Error in message serial number counted as one error data-point
90	090133Z	W3SMK	090136Z	CW	090224Z	W1WCG	N3SW			
91	090140Z	W6KJ	090140Z	CW	090156Z	K9JM	W1WCG	16 min		**NRCC**
92	090141Z	W6KJ	090141Z	CW	090158Z	K9JM	W1WCG	17 min		**NRCC**
93	090142Z	W6KJ	090142Z	CW	090328Z	N3SW	AF4NC			
94	090144Z	WB6N	090219Z	CW	090235Z	W7IZ	W1WCG	16 min	1	**NRCC**
95	090147Z	WB6N	090212Z	CW	090237Z	W7IZ	W1WCG	25 min		**NRCC**
96	090148Z	WB6N	090223Z	CW	090328Z	N3SW	AF4NC			
97	090150Z	AI7H	090150Z	CW	090224Z	K9JM	WB8WKQ	44 min		**NRCC**
98	090152Z	AI7H	090152Z	CW	090227Z	K9JM	WB8WKQ	35 min		**NRCC**
99	090153Z	AI7H	090153Z	CW	090328Z	N3SW	AF4NC			
100	090201Z	W7IZ	090243Z	CW	090242Z	W7IZ	W1WCG	1 min		**NRCC** - Likely minor error in time-keeping default 1-minute
101	090203Z	**W7IZ**	**090246Z**	**CW**	**090245Z**	**W7IZ**	**W1WCG**	**3 min**		**NRCC** - Negative value likely due to manual logging variations. Defaulted to 3-minutes
102	090205Z	**W7IZ**	**090251Z**	**CW**	**091408Z**	**WB8WKQ**	**AF4NC**			**Discrepancy in times cannot be explained. Assumed to be record-keeping error.**
112	090243Z	W0KCF	090247Z	CW	090257Z	W7IZ	WB8WKQ	10 min	1	**NRCC**
113	090248Z	W0KCF	090249Z	CW	090302Z	W7IZ	WB8WKQ	13 min		**NRCC**
114	090255Z	W0KCF	090255Z	CW	091410Z	WB8WKQ	AF4NC			
127	090350Z	K9JM	090351Z	CW	090403Z	K6YR	K1NN	13 min		**NRCC**
128	090353Z	K9JM	090353Z	CW	090403Z	K6YR	K1NN	10 min		**NRCC**
129	090354Z	K9JM	090356Z	CW	091422Z	K1NN	AF4NC			
130	091401Z	WB6UZX	091411Z	CW	091426Z	K6YR	WB8WKQ	17 min		**NRCC**
131	091403Z	WB6UZX	091414Z	CW	091428Z	K6YR	WB8WKQ	14 min		**NRCC**
132	091404Z	WB6UZX	091418Z	CW	091544Z	WB8WKQ	AF4NC			
136	091430Z	W3SMK	091435Z	CW	091443Z	K9JM	K1NN	8 min		**NRCC**
137	091433Z	W3SMK	091438Z	CW	091443Z	K9JM	K1NN	5 min		**NRCC**
138	091435Z	W3SMK	091440Z	CW	091536Z	K1NN	AF4NC			
139	091445Z	W6KJ	091445Z	CW	091452Z	K6YR	K1NN	12 min		**NRCC**
140	091444Z	W6KJ	091444Z	CW	091452Z	K6YR	K1NN	5 min		**NRCC**
141	091445Z	W6KJ	091445Z	CW	091540Z	K1NN	AF4NC			
142	091455Z	WB6N	091457Z	CW	091509Z	W7IZ	WB8WKQ	12 min		**NRCC**

143	091455Z	WB6N	091459Z	CW	091512Z	W7IZ	WB8WKQ	13 min		**NRCC**
144	091456Z	WB6N	091501Z	CW	091546Z	WB8WKQ	AF4NC			
145	091513Z	AI7H	091513Z	CW	091607Z	W7IZ	W1WCG	54 min		**NRCC**
146	091518Z	AI7H	091518Z	CW	091609Z	W7IZ	W1WCG	52 min		**NRCC**
147	091519Z	AI7H	091519Z	CW	091650Z	N3SW	AF4NC			
148	091530Z	W7IZ	091532Z	CW	091601Z	K0TER	W1WCG	29 min		**NRCC**
149	091535Z	W7IZ	091537Z	CW	091605Z	K0TER	W1WCG	28 min		**NRCC**
150	091536Z	W7IZ	091540Z	CW	091631Z	N3SW	AF4NC			
160	**091622Z**	**W0KCF**	**091635Z**	**CW**	**091607Z**	**W7IZ**	**K1NN**			**NRCC - Time recorded improperly**
161	**091625Z**	**W0KCF**	**091640Z**	**CW**	**091607Z**	**W7IZ**	**K1NN**			**NRCC - Time recorded improperly**
162	**091626Z**	**W0KCF**	**091646Z**	**CW**						**Time data missing from logs**
168										Message 168 not in control file. Excluded to expose possible accidental sequencing.
176	091730Z	N9JM	091731Z	CW	091744Z	W7IZ	W1WCG	11 min		**NRCC**
177	091734Z	K9JM	091734Z	CW	091745Z	W7IZ	W1WCG	11 min		**NRCC**
178	091735Z	K9JM	091735Z	CW	092217Z	N3SW	AF4NC			
179	091740Z	WB6UZX	091755Z	CW	091807Z	W7IZ	WB8WKQ	12 min		**NRCC**
180	091744Z	WB6UZX	091757Z	CW	091809Z	W7IZ	WB8WKQ	12 min	1	**NRCC**
181	091705Z	WB6UZX	091801Z	CW	092200Z	N3SW	AF4NC			Typographical error in controlled inject message. DTS should have read 091750Z

Notes:
1. Only traffic to NRCC scored.
2. Administrative network management traffic for internal use only

Totals: Average Propagation Time - Radiotelegraph (CW) 30.50 min

Accuracy Percentage Radiotelegraph:	99.998	%	15 errors within 10220 data points
Accuracy Fatal Errors		0	
Accuracy Non-Fatal Errors		15	

NRCC Message failures

CW:	1	Message Not Originated

NTS Cascadia Rising Message Metrics

Appendix B
NTSD Network Data

Color Code: Phase One 081701Z to 082200Z — Phase Two 090001Z to 090400Z — Phase Three 091401Z to 091800Z

Red indicates likely record-keeping discrepancy - adjustment made accordingly or data not used for calculations beyond accuracy check

Green indicates Alaska exercise consisting of an intra-state exercise (see separate data) and gateway to TCC exercise the results of which are highlighed in green below)

Purple indicates a message failure due to connectivity failure, operator error, excessive propagation time or other factor beyond accuracy errors.

IMPORTANT NOTE: Accuracy and propagation time measurements conducted only on NRCC traffic.

Msg No.	Msg DTG	Originator	DTG Injected	Mode (QSP)	DTG Received	Rcvd. From	Rcvd. By	Propagation Time	Fatal Errors	Non-Fatal Errors	Message Fail	Notes
10	081731Z	K7EAJ	081731Z	NTSD	081957Z	N3SW	AF4NC	146 min				**NRCC**
11	081738Z	K7EAJ	081738Z	NTSD	082005Z	W3JY	AF4NC	147 min				**NRCC**
12	081744Z	K7EAJ	081744Z	NTSD	082005Z	W3JY	AF4NC					
55	082140Z	**N7CM**	**082140Z**	**NTSD**	**091721Z**	**W3JY**	**AF4NC**	**[Delayed]**			**Delayed**	**NRCC**
56	082142Z	**N7CM**	**082140Z**	**NTSD**	**091721Z**	**W3JY**	**AF4NC**	**[Delayed]**			**Delayed**	**NRCC**
57	082144Z	N7CM	082140Z	NTSD	091722Z	W3JY	AF4NC					
58	082145Z	**K7EAJ**	**090245Z**	**NTSD**	**091723Z**	**W3JY**	**AF4NC**	**[Delayed]**			**Delayed**	**NRCC**
59	082146Z	**K7EAJ**	**090245Z**	**NTSD**	**091723Z**	**W3JY**	**AF4NC**	**[Delayed]**			**Delayed**	**NRCC**
60	082147Z	K7EAJ	090245Z	NTSD	091724Z	W3JY	AF4NC					
61	082150Z	**KK7TN**	**082150Z**	**NTSD**	**091724Z**	**W3JY**	**AF4NC**	**[Delayed]**		**5**	**Delayed**	**NRCC**
62	082151Z	**KK7TN**	**082151Z**	**NTSD**	**091724Z**	**W3JY**	**AF4NC**	**[Delayed]**		**2**	**Delayed**	**NRCC**
63	082152Z	KK7TN	082152Z	NTSD	091725Z	W3JY	AF4NC					
67	090003Z	N7OGM	090003Z	NTSD	090217Z	WB2FTX	AF4NC	134 min				**NRCC** - VIA VE7GN
68	090005Z	N7OGM	090005Z	NTSD	090218Z	WB2FTX	AF4NC	133 min				**NRCC** - VIA VE7GN
69	090006Z	N7OGM	090006Z	NTSD	090217Z	WB2FTX	AF4NC					VIA VE7GN
70	090010Z	**W7ARC**	**090002Z**	**NTSD**	**091726Z**	**W3JY**	**AF4NC**	**[Delayed]**			**Delayed**	**NRCC** - VIA VE7GN
71	090013Z	**W7ARC**	**090002Z**	**NTSD**	**091726Z**	**W3JY**	**AF4NC**	**[Delayed]**			**Delayed**	**NRCC** - VIA VE7GN
72	090015Z	W7ARC	090002Z	NTSD	091726Z	W3JY	AF4NC					VIA VE7GN
73	090016Z	**W7TVA**	**090016Z**	**NTSD**	**091718Z**	**W3JY**	**AF4NC**	**[Delayed]**			**Delayed**	**NRCC** - VIA VE7GN
74	090019Z	**W7TVA**	**090019Z**	**NTSD**	**091039Z**	**W3JY**	**AF4NC**	**[Delayed]**		**1**	**Delayed**	**NRCC** - VIA VE7GN
75	090020Z	W7TVA	090020Z	NTSD	091717Z	W3JY	AF4NC					VIA VE7GN
76	090030Z	N7CFI	090100Z	NTSD	090306Z	WB2FTX	AF4NC	126 min		1		**NRCC** - VIA VE7GN
77	090033Z	**N7CFI**	**090101Z**	**NTSD**	**091054Z**	**W3JY**	**AF4NC**	**[Delayed]**		**1**	**Delayed**	**NRCC** - VIA VE7GN
78	090034Z	N7CFI	090103Z	NTSD	091036Z	W3JY	AF4NC					VIA VE7GN
85	090105Z	**AG6QO**	**090105Z**	**NTSD**	**091030Z**	**W3JY**	**AF4NC**	**[Delayed]**			**Delayed**	**NRCC**
86	090107Z	AG6QO	090107Z	NTSD	090305Z	WB2FTX	AF4NC	118 min				**NRCC**
87	090108Z	AG6QO	090108Z	NTSD	090305Z	WB2FTX	AF4NC					
103	090210Z	N7CM	090215Z	NTSD	090248Z	WB2FTX	AF4NC	33 min				**NRCC** - Negative value likely due to manual logging variations. Defaulted to 3-minutes
104	090212Z	N7CM	090215Z	NTSD	090249Z	W3JY	AF4NC	34 min				**NRCC** - Negative value likely due to manual logging variations. Defaulted to 3-minutes
105	090215Z	N7CM	090215Z	NTSD	090248Z	W3JY	AF4NC					
106	090220Z	K7EAJ	090225Z	NTSD	090252Z	W3JY	AF4NC	27 min				**NRCC**
107	090225Z	K7EAJ	090225Z	NTSD	090251Z	W3JY	AF4NC	26 min				**NRCC**
108	090226Z	K7EAJ	090225Z	NTSD	090250Z	W3JY	AF4NC					
109	090229Z	**KK7TN**	**090229Z**	**NTSD**	**091718Z**	**W3JY**	**AF4NC**	**[Delayed]**			**Delayed**	**NRCC**
110	090235Z	**KK7TN**	**090235Z**	**NTSD**	**091718Z**	**W3JY**	**AF4NC**	**[Delayed]**			**Delayed**	**NRCC**
111	090240Z	KK7TN	090240Z	NTSD	091719Z	W3JY	AF4NC					
115	090301Z	**N7OGM**	**090301Z**	**NTSD**	**091720Z**	**W3JY**	**AF4NC**	**[Delayed]**		**1**	**Delayed**	**NRCC**
116	090304Z	**N7OGM**	**090304Z**	**NTSD**	**091721Z**	**W3JY**	**AF4NC**	**[Delayed]**			**Delayed**	**NRCC**

117	090305Z	N7OGM	090305Z	NTSD	091719Z	W3JY	AF4NC				
118	090310Z	W7ARC	090313Z	NTSD	090310Z	W3JY	AF4NC	3 min			**NRCC** - VIA VE7GN - negative value - likely time-keeping discrepancy - default 3-min
119	090313Z	W7ARC	090313Z	NTSD	090341Z	W3JY	AF4NC	28 min			**NRCC** - VIA VE7GN
120	090314Z	W7ARC	090313Z	NTSD	090340Z	W3JY	AF4NC				VIA VE7GN
121	090330Z	**W7TVA**	**090330Z**	**NTSD**	**091727Z**	**W3JY**	**AF4NC**	**[Delayed]**		**Delayed**	**NRCC** - VIA VE7GN
122	090333Z	**W7TVA**	**090333Z**	**NTSD**	**091728Z**	**W3JY**	**AF4NC**	**[Delayed]**	**5**	**Delayed**	**NRCC** - VIA VE7GN
123	090335Z	W7TVA	090335Z	NTSD	091728Z	W3JY	AF4NC				VIA VE7GN
124	090340Z	**N7CFI**	**091641Z**	**NTSD**	**092328Z**	**W3JY**	**AF4NC**	**[Delayed]**		**Delayed**	**NRCC** - VIA VE7GN
125	090343Z	**N7CFI**	**091642Z**	**NTSD**	**101017Z**	**W3JY**	**AF4NC**	**[Delayed]**		**Delayed**	**NRCC** - VIA VE7GN
126	090345Z	N7CFI	091644Z	NTSD	101414Z	W3JY	AF4NC				VIA VE7GN - EXPIRED
133	091412Z	**AG6QO**	**091413Z**	**NTSD**	**091915Z**	**W3JY**	**AF4NC**	**[Delayed]**		**Delayed**	**NRCC**
134	091415Z	**AG6QO**	**091414Z**	**NTSD**	**091920Z**	**W3JY**	**AF4NC**	**[Delayed]**		**Delayed**	**NRCC**
135	091416Z	AG6QO	091416Z	NTSD	091920Z	W3JY	AF4NC				
151	091550Z	**N7CM**	**091550Z**	**NTSD**	**092059Z**	**W3JY**	**AF4NC**	**[Delayed]**		**Delayed**	**NRCC**
152	091555Z	**N7CM**	**091555Z**	**NTSD**	**092053Z**	**W3JY**	**AF4NC**	**[Delayed]**		**Delayed**	**NRCC**
153	091556Z	N7CM	091555Z	NTSD	092054Z	W3JY	AF4NC				
154	091601Z	**K7EAJ**	**091600Z**	**NTSD**	**092054Z**	**W3JY**	**AF4NC**	**[Delayed]**		**Delayed**	**NRCC**
155	091605Z	**K7EAJ**	**091600Z**	**NTSD**	**092054Z**	**W3JY**	**AF4NC**	**[Delayed]**		**Delayed**	**NRCC**
156	091606Z	K7EAJ	091600Z	NTSD	092055Z	W3JY	AF4NC				
157	091614Z	**KK7TN**	**091614Z**	**NTSD**	**092036Z**	**WB9FHP**	**W3JY**	**[Delayed]**		**Delayed**	**NRCC**
158	091618Z	KK7TN	091618Z	NTSD	091731Z	WB9FHP	W3JY	73 min			**NRCC**
159	091619Z	KK7TN	091619Z	NTSD	101441Z	W3JY	AF4NC				
163	091649Z	**N7OGM**	**091649Z**	**NTSD**	**092000Z**	**WB9FHP**	**W3JY**	**[Delayed]**		**Delayed**	**NRCC**
164	091653Z	**N7OGM**	**091653Z**	**NTSD**	**092000Z**	**WB9FHP**	**W3JY**	**[Delayed]**		**Delayed**	**NRCC**
165	091654Z	**N7OGM**	**091654Z**	**NTSD**	**101408Z**	**W3JY**	**AF4NC**				
166	091701Z	**W7ARC**	**091718Z**	**NTSD**	**092000Z**	**WB9FHP**	**W3JY**	**[Delayed]**		**Delayed**	**NRCC** - VIA VE7GN
167	091704Z	**W7ARC**	**091718Z**	**NTSD**				**[Failure]**		**Failure**	**NRCC** - VIA VE7GN - **No Record of delivery - May have been record keeping oversight**
168											Message 168 not in control file. Excluded to expose possible accidental sequencing.
169	091705Z	W7ARC	091718Z	NTSD	101406Z	W3JY	AF4NC				
170	091707Z	**W7TVA**	**091707Z**	**NTSD**	**100245Z**	**W3JY**	**AF4NC**	**[Expired]**		**Expired**	**NRCC**
171	091709Z	**W7TVA**	**091709Z**	**NTSD**	**100246Z**	**W3JY**	**AF4NC**	**[Expired]**		**Expired**	**NRCC**
172	091710Z	W7TVA	091710Z	NTSD	101417Z	W3JY	AF4NC				
173	091715Z	**N7CFI**	**091901Z**	**NTSD**	**101020Z**	**W3JY**	**AF4NC**	**[Expired]**		**[Expired]**	**NRCC**
174	091720Z	N7CFI	091904Z	NTSD	092111Z	WB9FHP	W3JY	122 min			**NRCC**
175	091721Z	N7CFI	091906Z	NTSD	101412Z	W3JY	AF4NC				

Notes:
1. Only traffic to NRCC scored.
2. Administrative network management traffic for internal use only

Totals: Average Propagation Time - Digital (NTSD) 82.14 min — Calculated only for selected messages. See notes.

Accuracy Percentage: 99.997 % — 16 errors in 7008 data points

Accuracy Fatal Errors 0

Accuracy Non-Fatal Errors 16

Appendix C
Alaska Intrastate Data

Alaska - Intrastate Traffic Metrics

WL2K peer-to-peer **Target: CW gateway to CONUS**

Msg No.	Msg DTG	Originator	DTG Injected	Mode	DTG Received	Received From	Received By	Propagation Time	Fatal Errors	Non-fatal Errors	Notes
25		WL7MR	081922Z	WL2K	081923Z	KL7EDK-8	AL7N	1 min			
26		WL7MR	081928Z	WL2K	081929Z	KL7EDK-8	AL7N	1 min			
27		WL7MR	081946Z	WL2K	081934Z	KL7EDK-8	AL7N				Record keeping discrepancy - not scored
28		KL7JFT	081935Z	WL2K	082104Z	RMS	AL7N				Internet involved - not scored
29		KL7JFT	081938Z	WL2K	082110Z	RMS	AL7N				Internet involved - not scored
30		KL7JFT	081944Z	WL2K	082112Z	RMS	AL7N				Internet involved - not scored
31		KL5T	082000Z	WL2K	082000Z	KL7EDK-8	AL7N	6 min			
32		KL5T	082000Z	WL2K	082006Z	KL7EDK-8	AL7N	6 min			
33		KL5T	082000Z	WL2K	082007Z	KL7EDK-8	AL7N	7 min			
34		KL4CX	082001Z	WL2K	082009Z	KL7EDK-8	AL7N	8 min			At State EOC - KL7EOC
35		KL4CX	082008Z	WL2K	082017Z	KL7EDK-8	AL7N	9 min			At State EOC - KL7EOC
36		KL4CX	082014Z	WL2K	082017Z	KL7EDK-8	AL7N	3 min			At State EOC - KL7EOC
37		AD4BL	082010Z	WL2K	082020Z	KL7EDK-8	AL7N	10 min			
38		AD4BL	082013Z	WL2K	082020Z	KL7EDK-8	AL7N	7 min			
39		AD4BL	082018Z	WL2K	082020Z	KL7EDK-8	AL7N	2 min			
40		AL7N	090011Z	CW			AL7N				Originated directly at CW gateway
41		AL7N	090016Z	CW			AL7N				Originated directly at CW gateway
42		AL7N	090014Z	CW			AL7N				Originated directly at CW gateway
43		KL7EDK	082040Z	WL2K	082040Z	KL7EDK-8	AL7N	1 min			
44		KL7EDK	082043Z	WL2K	082043Z	KL7EDK-8	AL7N	1 min			
45		KL7EDK	082048Z	WL2K	082048Z	KL7EDK-8	AL7N	1 min			
46		WL7MR	082055Z	WL2K	082100Z	KL7EDK-8	AL7N	5 min			
47		WL7MR	082058Z	WL2K	082109Z	KL7EDK-8	AL7N	11 min			
48		WL7MR	082059Z	WL2K	082106Z	KL7EDK-8	AL7N	7 min			
49		KL7JFT	082104Z	RMS	081935Z	RMS	AL7N				Internet involved - not scored
50		KL7JFT	082110Z	RMS	081938Z	RMS	AL7N				Internet involved - not scored
51		KL7JFT	082112Z	RMS	081944Z	RMS	AL7N				Internet involved - not scored

WL2K: Indicates WL2K peer-to-peer *PACTOR* mode with no Internet or e-mail involvement
RMS: Indicates e-mail involvement.

Average Propagation Time = 5.5 minutes
Total Fatal Errors = 0 (zero)
Total Non-fatal Errors = 0 (zero)

APPENDIX D
EXERCISE GUIDELINES

OPERATING GUIDELINES

CASCADIA RISING EXERCISE

JUNE 8 & 9, 2016

Cascadia Rising Disaster Exercise Frequency and Network Management Guidelines Exercise Dates: June 8 and June 9, 2016

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I Scope of Exercise Guideline:

This document is intended to facilitate NTS planning and operations during the Cascadia Rising exercise. These guidelines include recommendations for:

- Expediting the flow of test priority and test emergency message traffic generated at the local level and addressed to the FEMA National Response Coordinating Center (NRCC).
- Establishing specialized point-to-point circuits using NTS TCC assets to connect the simulated disaster area within the Cascadia Region with the FEMA NRCC in Washington, D.C.
- Specifying sufficient frequency and mode combinations (circuits) to supporting a dynamic response to propagation conditions, thereby ensuring that connectivity is maintained regardless of time-of-day, solar cycle, and geomagnetic conditions.
- Providing a moderate level of communications security by protecting frequency and mode information from non-exercise participants.
- Providing basic guidance for section and region traffic flow should NTS support be requested at the local level.

II Exercise Purpose:

The NTS component should be viewed as a stand-alone, proof-of-concept exercise intended to test the NTS national messaging layer. This test of the NTS will be the primary responsibility of exercise participants. Additional responsibilities, such as conveying exercise traffic on behalf of local EMA activities is permissible, but nonetheless secondary to the primary NTS Cascadia Rising exercise functions.

This document addresses only the national "proof-of-concept" exercise. NTS volunteers should, however, also be prepared to support any local communications requirements, which may arise during the event.

III Methodology:

Preformatted "Inject messages" drafted by the exercise design team and the Federal Emergency Management Agency will be provided to selected NTS volunteers within the Cascadia Region. These "inject messages" are designed to test the NTS messaging layer by providing a measured and objective indication of message accuracy, completeness and reliability.

The inject messages will be originated via NTS at the times specified by the exercise design team. At the time specified, a message will originate via the ARRL National Traffic System, which will be routed to its destination using standard NTS net protocols. Upon reaching its destination, delivery to the Federal Emergency Management Agency will be performed using WebEOC.

A variety of controls will be built into the exercise process to support an objective and measurable evaluation process. Of particular interest are measures of *message completeness, accuracy and timeliness*. Exercise participants will be expected to record basic operational data during the exercise. This data will then be submitted to the exercise evaluation team at the conclusion of the exercise for subsequent analysis and the development of a post-exercise report. The following states will be active participants in this exercise.

- Oregon
- Idaho
- Northern California
- Alaska.

Some message traffic may also flow from the FEMA NRCC to the field. This will likely be in the form of specialized "bulletin" message traffic intended for wide distribution within a state to any emergency management agency or media outlets within the simulated disaster area. When one of these "QNC" bulletins is received by the NTS volunteer within the simulated disaster area, it may be distributed as instructed. More details on the management of this type of message traffic are provided below.

IV Exercise Message Flow:

As stated earlier, each exercise participant will be provided with a set of pre-formatted "inject messages." These inject messages will consist of radiograms enclosed in sealed envelopes, the outside of which are date and time-stamped to indicate the time at which the envelope is to be opened and the message(s) originated via one of the NTS TCC "watch frequencies" or NTSD. Inject messages may be originated using the mode/network the radio operator deems most expedient provided the message originates according to this network management plan.

A. Message Originations and Record Keeping

Each inject message will have a serial number assigned by the exercise design team. The originating station should NOT change the message serial number under any circumstances. The assigned inject message serial number will be used to track the message as it is moves through the NTS(D) network layers. This serial number will then be referenced at various tracking data points throughout the NTS network, the data from which will be used to determine network efficiency, accuracy and similar factors.

A limited number of messages may be originated at the FEMA NRCC for distribution to the disaster area. These messages will likely be in the form of bulletin messages (QNC) intended for distribution to local emergency management agencies, NGO relief agencies and/or broadcast and print media facilities. The following rules apply to the management of this type of incoming message traffic:

- If the NTS volunteer is aware of a local ARES program active in the disaster simulation, he should forward the bulletin to his local EOC utilizing the available ARES network. The bulletin message should be transmitted in its entirety using the original, correct, radiogram format.

- If no local ARES organizations are active in the disaster simulation, the message may be held with the appropriate time of receipt recorded.

- Bulletin messages may be distributed on other Amateur Radio circuits such as SATERN networks, MARS networks and the like at the NTS volunteer's discretion.

- *Bulletins intended for distribution to local broadcast, print or other media facilities should NOT be delivered or distributed* once they reach the NTS volunteer in the field. Instead, the message should be filed and the date and time of receipt recorded. This will prevent any possible misunderstanding should a message inadvertently end-up in the actual news-media stream.

It will be necessary for each NTS operator, who originates an exercise inject message, to populate the "station of origin" field with his station call sign and the signature field with his *last name only*, before transmitting the inject message. This will identify the station responsible for originating the message. This will further define network topography and facilitate evaluation of the exercise.

All operators responsible for facilitating message flow, either outgoing or incoming, will maintain an evaluation log indicating the times associated with the origination, relay, receipt and/or delivery of messages. This message log will be provided to all active stations as part of their exercise package provided by the exercise design team. This log, along with copies of all messages transmitted and received, should be retained and then submitted to the evaluation team immediately after the exercise. An SASE will be provided with each volunteer exercise packet to facilitate the rapid submission of event data. Please submit this data within 7-days of the conclusion of the exercise.

Essentially, the message traffic handling process is the same as that associated with the handling of routine message originations, only with an added layer of record-keeping and the use of unique injection points to facilitate traffic flow.

B. Role of Section Nets:

Section nets may be activated in response to a local request from ARRL Section Staff. However, from the standpoint of this FEMA proof-of-concept test, section nets will NOT be a primary player in this exercise. Instead, outgoing message traffic addressed to the FEMA NRCC will be originated using NTSD or one of the TCC radiotelephone or radiotelegraph watch frequencies specified in the frequency/mode matrix (Appendix. 2).

C. Role of Region 7 Voice and CW Nets:

The Region 7 Network (RN7) can be activated at the discretion of one or more section traffic managers within the exercise area. *However, the RN7 net will not be an active participant in the FEMA component of the exercise.*

D. Transcontinental Corps (TCC):

TCC, along with NTSD, will be the primary gateway to the FEMA NRCC. The TCC will maintain a set of watch frequencies (QSX), which will be monitored to facilitate the flow of test priority or test emergency radiograms destined for the FEMA NRCC in Washington, D.C. NTS personnel should utilize these point-to- point circuits only for test priority or test emergency precedence traffic. The TCC operators will be responsible for the following functions:

1. Ensuring that all watch frequencies are fully staffed.
2. Direct delivery of inject messages addressed to the NRCC via WebEOC (only after the message traffic has been conveyed via RF to the NTS Eastern Area).
3. Routing of NRCC messages received to the EPA Section Nets of NTS Region 3.

The TCC QSX frequencies are specified in the mode/frequency matrix (see Appendix 2 below). As can be seen in the frequency matrix, a variety of options exist to support propagation conditions. NTS personnel will need to exercise a degree of flexibility when selecting an operating frequency. If a TCC operator is unavailable on a particular frequency, please select an alternate frequency. Likewise, when standing watch as a TCC operator or when attempting to establish contact from the field, be certain to use a broader IF bandpass. A station may need to move slightly off-frequency to avoid adjacent channel interference. Narrow filters, such as those with 500 Hz or less bandpass may result in a failure to hear a calling station.

Additional TCC relay stations will also be available within the NTS Central Area to facilitate message flow in response to unanticipated propagation anomalies. In all cases, the TCC operators have been carefully selected to ensure reliability.

E. TCC CW Calling Procedures:

TCC operators will periodically identify their presence on a radio circuit in order to indicate their availability to receive traffic. The following net call format is recommended to indicate that a TCC liaison station is standing watch on a frequency:

"QSX NTS de WB8SIW K"

Stations in the simulated disaster area or serving as liaison to TCC may use the following calling format:

"NTS NTS de K8QMN QTC 2 TP K"

In this latter example, K8QMN is identifying the fact that he holds two test-priority (exercise priority) messages for the TCC circuit.

The TCC rep might respond in a format similar to:

"K8QMN de WB8SIW QRK 4 QRV K"

In this transmission, the TCC rep is providing a report indicating readability followed by an indication that he is "ready to copy."

Generally, the same CW traffic handling procedures used on daily NTS networks apply here, with just slight modification.

F. **Role of NTSD**

The NTS Digital Networks are now equipped with BPQ-32 software, which forwards traffic as soon as it is uploaded to the Region Hub. This greatly expedites the flow of traffic and also facilitates other features well suited to the processing of served agency traffic.

NTSD is available for all exercise traffic. Sufficient circuit capacity should be present to facilitate large quantities of NTS exercise traffic under most circumstances. Additional *PACTOR*-2 frequencies have been assigned to the WB6OTS hub for use in the event that WL2K traffic creates circuit capacity issues in the automated sub-bands.

A review of the frequency/mode matrix (Appendix. 2) identifies the Region 7 primary entry point for exercise traffic. This primary entry point, as well as the alternate entry point and Pacific Area Hub are highlighted in yellow. The primary entry points should be the first choice for uploading outgoing exercise traffic to NTSD.

In the event of propagation anomalies or interference, NTSD traffic can be uploaded to any hub within the system. Please note that the Pacific Area portion of the frequency matrix includes approximately 13 DRS stations. These DRS facilities typically poll the region hub and may not maintain a continuous watch on the frequencies indicated (although many do). Therefore, they should be utilized only for specialized point-to-point or alternate service if required.

V Network Selection:

In the event of a catastrophic disaster, it is anticipated that many volunteers at the local level would need to rely on standby power and renewable energy to support communications. This would include battery power, solar panels, and possibly generators during the initial hours of operation or until fuel supplies were depleted. Therefore, this exercise will emphasize not just the use of NTS digital resources, which require more complex and less portable equipment, but also radiotelegraph (CW) and radiotelephone (SSB) circuits.

In summary, these basic guidelines apply:

- Inject messages of test priority or test emergency precedence may be transmitted by any one of the three specified networks (TCC –CW, TCC-SSB or NTSD).

- Traffic of test welfare or routine precedence should be originated only by normal NTS network routings or via NTSD.

A. National Traffic System Digital (NTSD):

The destination section net associated with the FEMA NRCC, which will serve as the primary gateway for message delivery to the NRCC will be the *Eastern Pennsylvania Section* located within NTS Region 3. All inject messages routed to the NRCC via NTSD will be automatically routed to this section network. Do NOT change the address on any inject messages destined for the NRCC. The zip-code, in particular, is essential to the proper, automatic routing of this message traffic via NTSD. Furthermore, please note that this zip-code may not match the public address of record for the served agency.

The Digital Relay Station (DRS) function will be in place throughout the exercise period within the EPA destination section. This will ensure that a specific, predictable routing is in place for FEMA NRCC traffic transferred via NTSD.

NTSD capable stations should review the frequency matrix (Appendix 2) to ensure familiarity with various NTSD nodes throughout the Pacific and Central Area in the event that propagation dictates alternate injection points.

Assistance with NTSD technical problems can be obtained by contacting the Area Digital Coordinator (ADC).

B. TCC Radiotelegraph:

The radiotelegraph (CW) watch frequencies will be monitored throughout the exercise by qualified operators who are also trained and equipped to deliver traffic destined to the NRCC. These operators have been vetted and are of professional caliber.

Radiotelegraph is the *preferred manual mode* for the TCC function. CW circuits provide a degree of confidentiality in that media organizations are generally incapable of intercepting the message traffic. Furthermore, most radio amateurs without experience in NTS net operations will be unable to follow the progress of the network. Radiotelegraph networks also offer higher efficiency (more messages conveyed per hour) than voice networks. This combination of improved efficiency and confidentiality are preferable for FEMA traffic. Finally, CW would prove to be one of the more survivable modes during a catastrophic disaster due to its limited bandwidth and the simplicity of equipment involved, thereby allowing disaster area operators to use low power, simple transceivers.

C. TCC Radiotelephone:

The radiotelephone (SSB) watch frequencies will be monitored throughout the exercise by qualified operators who are also trained and equipped to deliver traffic destined for the NRCC.

Voice also has advantages, some of which include universal familiarity, a larger operator pool of NTS volunteers, and its position as a "common denominator" mode. However, it is also the mode most subject to interference and propagation anomalies. The SSB TCC function should be considered *secondary* to the TCC CW function.

Again, any of the three networks above may be used to relay exercise priority or exercise emergency radiograms from the Region/Section level to the FEMA NRCC.

VI Mode and Frequency Designators:

In order to limit potential interference with the exercise, a degree of communications security, consistent with FCC rules, is necessary. Therefore, we have designated each radiotelegraph and radiotelephone frequency with a three-letter frequency designator. These should be used to specify a frequency on which to meet or to which one might refer a station (QNY/QNV/QNQ).

These mode and frequency designators should NOT be published on the web nor should they be distributed on e-mail lists. As such, they are considered "confidential." However, they may be shared with those who are participating in the Cascadia Rising exercise as well as with NTS net members in good standing. When sharing this data, please ensure the member is briefed on these confidentiality requirements.

VII Cascadia Rising Network Topography:

Appendix 1 provides an overview of proposed network topography and message flow during the disaster exercise.

VIII Message Format:

All Cascadia Rising message traffic must be transmitted using the standard radiogram format. This format provides the necessary network management data and administrative tools needed to track and service messages within the national messaging layer. While all inject messages are pre-formatted in radiogram format, any messages, which are changed to a non-standard (other than radiogram) format will count as an exercise failure.

Most messages will be transmitted in the form of "circuit test" traffic. This is permitted under FCC regulations and it is designed to provide a superior test of NTS performance. This method also eliminates the possibility of an inject message originated to the NRCC from conflicting with inject messages (events) associated with local exercises.

A typical message format might be:

221 TP K8QMN 15 PORTLAND OR 2331Z JUN 10
FEMA NRCC
1 INDEPENDENCE MALL
PHILADELPHIA PA 19106

TEST MESSAGE X QRZJU TLZSR QRTTJ LRUCK ZDERN DWARY QUARL
TSCRJ MOUTS X TEST MESSAGE

RICHARDS

Another format may include operational status reports pertaining to NTS personnel:

31 TP K8QMN 16 PORTLAND OR 2331Z JUN 11
TOM MILLS AF4NC
NETWORK RESOURCE MANAGER
1 INDEPENDENCE MALL
PHILADELPHIA PA 19106

TEST MESSAGE X OPERATIONAL ON BATTERY AND SOLAR POWER EXPECTED OPERATIONAL
CAPACITY INDEFINITE X TEST MESSAGE

STEVENS

Yet an additional alternative format may outline the operational status of a local ARES group:

35 TP W8IHX 17 BOISE ID 1444Z JUN 10
TOM MILLS AF4NC
NETWORK RESOURCE MANAGER
1 INDEPENDENCE MALL
PHILADELPHIA PA 19106

TEST MESSAGE X AMATEUR RADIO EMERGENCY SERVICE ACTIVATED 33 OPERATORS OPERATING IN TWO SHIFTS X TEST MESSAGE

GRIFFITH

Delivering stations should change the "X" (X-ray) within message traffic to a period and the "query" to a question-mark when transcribing incoming messages addressed to the NRCC for delivery via WebEOC or other "hard copy" delivery methods.

Other operational notes:

1. When transmitting five-letter cipher groups via radiotelegraph or radiotelephone, please leave an extra pause between groups.

2. The receiving operator may want to repeat back the text to the transmitting station for confirmation, particularly when receiving messages containing cipher groups.

3. Save copies of all message traffic originated, received or otherwise processed through your station for submission during the post-exercise evaluation.

IX All-Cap Default:

While NTSD (digital network) is capable of conveying message traffic containing complex punctuation and mixed-case text, all traffic originated for "Cascadia Rising" will maintain the default "all-cap" or "case-insensitive" message format. Punctuation shall also be limited to the "X" for period and "Query" for the question-mark. This is done to enhance interoperability between digital modes and manual network modes. For example, a message may start or end its journey at a location in which an operator is utilizing a man-pack transceiver, a stack of self-carbon paper message forms and a pencil. Likewise, a message may originate on a public safety two-way radio frequency and then be transferred to NTS(D) for transmission to an EOC or coordinating center. By utilizing the "all-cap" default, one can accommodate any communications interoperability requirement.

X Cascadia Rising Network Frequency Matrix:

Appendix 2, defines the default frequencies and modes for Cascadia Rising. Please refer to this chart, particularly when interfacing with upper-echelon network functions

Please note that various frequencies and modes are identified, which are not specifically related to the NTS component of the exercise. These are provided to ensure that sufficient data is available to facilitate monitoring and evaluation of other network activities, or operations, which may be implemented on an as-needed basis in support of local requirements. Please pay close attention to all notes within the frequency/mode matrix to prevent inadvertent transmission of confusion during communications operations.

XI Cascadia Rising NTS Exercise Time Frames

The exercise will be conducted in three phases designed to test a variety of propagation conditions:

June 8 (UTC):

Exercise Phase One: 1701Z to 2200Z (081701Z JUN 2016 to 082200Z JUN 2016)

June 9 (UTC):

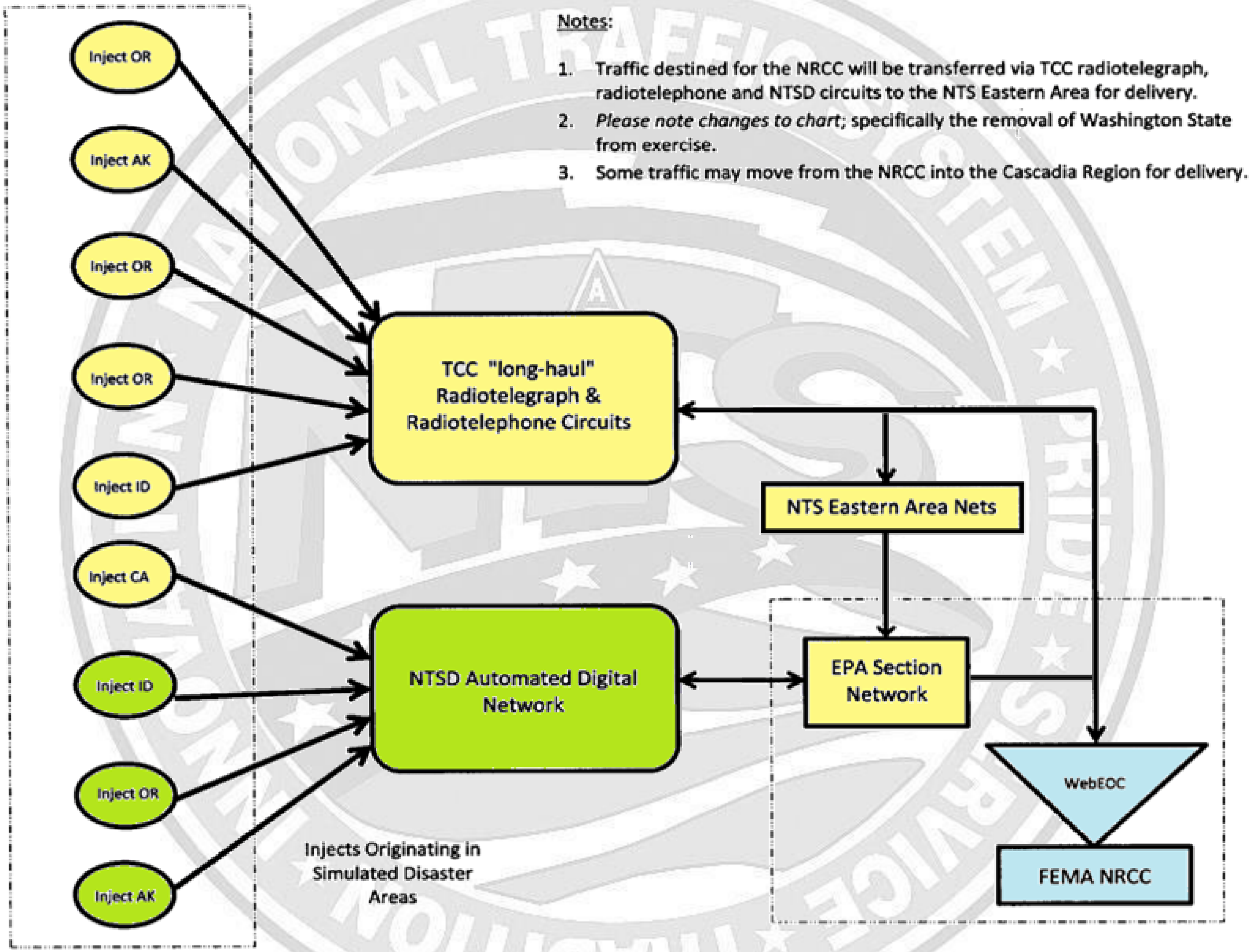
Exercise Phase Two: 0001Z to 0400Z (090001Z JUN 2016 to 090400Z JUN 2016)

Exercise Phase Three: 1401Z to 1800Z (091401Z JUN 2016 to 091800Z JUN 2016)

Questions regarding this document may be submitted to:

James Wades (WB8SIW)
NTS Cascadia Rising Project Manager
jameswades@gmail.com
269-548-8219

Appendix 1 – Cascadia Rising Network Topography



Appendix 2: Cascadia Rising Frequency/Mode Matrix

Cascadia Rising Mode-Frequency Matrix							**Final 4 May 2016**
	Primay frequencies and access points to NTSD highlighted in Yellow						
	NTSD frequency application RMS						
	TCC Primay QSX frequency and time period						
TCC Mode/Frequencies			DOCUMENT CONFIDENTIAL - DO NOT PUBLISH - INTERNAL NTS USE ONLY!				
Designator	kHz	Mode	Watch			Primary Time Periods	Notes
NAA	3563	CW	NIGHT				
NAB	3845	SSB	NIGHT				
NBA	7115	CW	NIGHT			090101Z - 090400Z	1. See TCC Duty Roster for further
NBB	7232	SSB	NIGHT				details
NCA	10115	CW	24 HOURS				
NDA	14115	CW		DAY		081701Z - 090300Z	2. See TCC Duty Roster for further
NDB	14345	SSB		DAY			details
NFA	21115	CW		DAY			
NFB	21345	SSB		DAY			
Notes:	3. All frequencies are +/- 5 kHz to accommodate other users						
	4. FEMA NRCC Liaisons please call "QSX FEMA de (call sign) periodically						
	5. QSX maintained throughout watch period specified						

Section Net Frequencies						**General Sessions**	
Designator	kHz	Mode	Watch			Primary Time Periods	Notes
Washington State:							
WAA	3563	CW	NIGHT			1430Z/0145Z	
WAB	7038	CW		DAY			
WAC	1818	CW	NIGHT				
WAD	3975	SSB	NIGHT			0100Z	
WAE	7268.5	SSB		DAY			
WAF	7238.5	SSB		DAY			
Oregon State:							
ORA	3569	CW	NIGHT			0130Z/0500Z	
ORB	7068	CW		DAY			
ORC	3920	SSB	NIGHT			0030Z	
ORD	3990	SSB	NIGHT				6. ARES Net
Idaho State:							
IDA	3572	CW	NIGHT			0245Z	
IDB	7043	CW		DAY			
IDC	3937	SSB	NIGHT			0200Z	
IDD	3990	SSB	NIGHT			1400Z	7. ARES Net
IDE	3939	SSB	NIGHT				
Region 7 Net							
Designator	kHz	Mode	Watch			Primary Time Periods	Notes
R7A	1818	CW	NIGHT				8. RN7 Not officially activated.
R7B	3560	CW	NIGHT			0230Z/0430Z	QSX encouraged to support
R7C	7042	CW		DAY			ARES
R7D	3925	SSB	NIGHT			1745Z/0815Z	
R7E	7235	SSB		DAY			

NTSD SCAN/ALE FREQUENCIES							
Pacific Area NTSD MBO							
Designator	QRG					Location	Notes
W5KAV	3587	3591	3597			Rochester, WA	9. Pacific Area Hub
	7100.4	7102.4	7104.4				
	10144	10145.9					
	14095.9	14097.9	14104.9	14113.9			
	18103	18108.4					
WS6P	3591.9	3593.9				West Point, CA	10. RN6 Digital Hub
	7102.4	7104.4					
	14112.4	14113.9					
K6HTN	7065.9	7102.4				Pasadena, CA	DRS
K7EAJ	3587					Hillsboro, OR	DRS
AC7AI	3587					Montesano, WA	DRS
VE7GN	3571.5	3587	3591.9	3593.9	3593	Babriolo, BC. Canada	RN7 Hub
	3597	3615					Primary Entry Point
	7065.4	7065.9	7091	7104.4	7100.4		
	7102.4						
	14064	14113.9					
KA7HRC	3587					Mount Hood, OR	11. Hood River Co. ARES
W7ARC	3587					Lynnwood, WA	
AG6QO	3586.5	3591.9				Winters, CA	DRS
	7103						12. Note VHF access
	14107.9						13. AG6QO-1 NTS & BBS traffic
	144.37						AG6QO-2 for BPQ chat
							AG6QO-10 WinLink gateway
							14. Liaison Yolo Co. ARES
N7JJ	3587					Shoreline, WA	DRS
WB6OTS	3587	3590.5	3597			Sierra Vista, AZ	15. Alternate Pacific Area Hub
	7094.9	7100.4	7102.4	7104.4			
	10144						
	14098.9	14105	14108.4	14110.4			

Pacific Area NTSD MBO							
Designator	QRG					Location	Notes
KC7ZZ	3591.9					Tuscon, AZ	DRS
	7102.4						
KC5ZGG	3591.9					Yuma, AZ	DRS
	7102.4						
KF7PVD	3591.9					Beaverton, OR	DRS
	7102.4						
W7JSW	3591.9					Scottsdale, AZ	DRS
	7102.4						
K7FLI	3591.9					Sahuarita, AZ	DRS
	7102.4						
K0TER	3591.9					Colorado Springs, CO	DRS
	7102.4						
	14113.9						
N5HC	3591.9					Rio Rancho, NM	DRS
	7102.4						
N7IE	3591.9					Layton, UT	DRS
	7102.4						
	10142.9						
	14113.9						
N7JCO	3591.9					Clinton, UT	DRS
	7102.4						
	14113.9						
NS7K	3587	3591.87				Clearfield, UT	DRS
	7095.77	7101.27	7103.25				
	10147						
	14114.75						

Central Area NTSD MBO							
Designator	QRG					Location	Notes
W5SEG	3589	3591				Segiun, TX	
	7091.5	7098.5					
	10143	10145					
	14111.5	14112.4					
WB9FHP	3591	3591.9	3593.9			Paoli, IN	
	7091.4	7100.4	7102.4				
	10140.9	10141.9	10142.9				
	14095.9	14097.9	14104.9	14112.4	14113.9		
	18108.4						
	21093.4						
KM0R	3591.9	3593.9				Columbia, MO	
	7100.4	7102.4	10140.9	10142.9			
	14097.9	14109.9	14112.4	14113.9			

Eastern Area NTSD MBO							
Designator	QRG					Location	Notes
WB2FTX	3591.9	3593.9				Butler, NJ	EAN DIGITAL HUB, 3RN backup
	7091.4	7094.9	7100.4	7102.4			
	10140.9	10142.9					
	14095.9						
KW1U	3591.9	3593.9				Concord, MA	EAN backup
	7091.5	7100.4					
	10140.9						
	14097.9	14112.4					
	21093.4						
WA4ZXV	3591.9	3593.9				Norcross, GA	
	7100.4	7102.4					
	10140.9	10142.9					
	14097.9	14112.4					
	21093.4						
W4DNA	3591.9	3593.9				Goldsboro, NC	
	7100.4	7102.4					
	10140.9	10142.9					
	14095.9	14097.9					
W3JY	3591.9	3593.9				Malvern, PA	3RN DIGITAL HUB
	7091.4	7102.4					
	10142.9						
	14112.4						
N3OS	3591.9					Dade City, FL	
	7100.4						
	10140.9						
	14112.4						
	18102.4						
	21093.4						

Cascadia Rising
Supplemental Instructions
Record-keeping and Data Submission

I Purpose of Record-keeping

Certain requirements must be met for an emergency exercise to be meaningful. These requirements include:

- The exercise must be realistic.
- The exercise goals must be attainable.
- The exercise must be objective.
- Metrics must be in place to support an objective analysis.

When conducting an evaluation of a communications network or other disaster telecommunications response function, it is not enough to simply determine whether radio operators show-up on scene or connectivity is established. Operator and network performance must also be evaluated. This is best done through the use of a carefully designed scenario, which provides the structure needed to measure such factors as:

1. Message completeness
2. Non-fatal messaging errors (do not change meaning/understanding)
3. Fatal messaging errors (change meaning or emergency response)
4. Message timeliness (average propagation time)
5. Message delivery as percent of total communications traffic
6. Identification of statistical outliers

Such measures are also valuable in that they provide baseline data for subsequent exercises, thereby allowing the exercise design teams to compare performance over time as a matter of quality control.

II Cascadia Rising Evaluation Requirements

The NTS component within "Cascadia Rising" is designed to test the performance of NTS as a "long-haul" telecommunications carrier. The purpose is not to compare NTS with commercial or government carriers, but rather, to measure performance in a situation during which the survivability and flexibility of Amateur Radio Service assets are required in the absence of regular telecommunications services.

As discussed in the "Exercise Guidelines" document, NTS volunteers within the simulated disaster area will be provided with controlled inject messages designed to provide a challenging, but attainable test of the above factors. Of particular importance is accuracy.

As will be seen, exercise traffic will consist of "circuit test" coded traffic. This is neither encrypted nor encoded message traffic, which is not permitted under FCC regulations, but rather the equivalent of a technical circuit test through which input on one side of the carrier (network) is compared against output at the other end of the carrier to determine the capacity of the organization and network to accurate convey complex information. This format selected by the exercise design team places a high value on metrics and enhances the objectivity of the test.

Accuracy is just one piece of the picture. Message propagation time and the identification of potential failure points within the network are also important factors. In order to identify these and other factors, a degree of "overhead" in the form of record keeping is required. Of particular importance are factors such as:

- Identifying the time at which individual messages pass certain "data points" within the network.
- Identifying network topology so that "choke points," "points of failure," and operational errors can be identified and corrected.
- Providing an analytical value reflecting the quality of "customer service" in terms of message accuracy and completeness.

The detailed data collected from each exercise participant is essential to accomplishing these goals.

III Record-keeping Procedures

The process of data collection is actually quite easy. A single, universal data collection form has been developed for use by all exercise participants. This will allow exercise participants to collect data for more than one activity. For example, an exercise participant may function as both the originator of exercise message traffic while, simultaneously, serving as a relay point between NTS network layers, in which case, the data collection form must support both activities.

Within this exercise package, one will find a set of 8.5 by 11 data collection forms, a copy of which is attached to this form. These forms are to be populated in association with each message originated, received, relayed or delivered. Please note the following requirements when utilizing these forms:

A. Complete the top section *of each page* by populating the "name" and "call sign" fields.

B. Be sure to print neatly or type when entering data. If one would like an executable "Excel" file containing a spreadsheet for use on a computer, please contact the exercise project manager at: jameswades@gmail.com

C. In order to save space, all date-time groups should be recorded using military "zulu" format. This format consists of the two-digit day, followed by the two-digit hour and then the two-digit minute. In this case, we dispense with the month and year because this is understood (it also saves space on the form). For example:

"081501Z" indicates the date of June 8 at 1501 UTC.

D. Please note that all record-keeping is in UTC (GMT). This prevents confusion when message traffic passes between time-zones.

E. *Also, please note that the new radio day starts at 0001Z*. In other words, a message transmitted at 7:00 PM PDT on June 8 would actually be transmitted on June 9 in UTC.

IV Sample of Log Entries:

A. Message data at point of origination:

National Traffic System - Cascadia Rising Message Log									
	Please print neatly - All data must be legible.			Submit log within 7 days of exercise conclusion.					
Name:____	John Q. Hamm				Call:__W6ABC__________________				
Msg No.	**Originator:**	**Transmited To:**	**DTG**	**Received From:**	**DTG**	**Relayed To:**	**DTG**	**Delivered To:**	**DTG**
33	*Yes*	*K8CBS*	*081523Z*						

B. Message data at intermediate relay point:

National Traffic System - Cascadia Rising Message Log									
	Please print neatly - All data must be legible.			Submit log within 7 days of exercise conclusion.					
Name:____	John Q. Hamm				Call:__W6ABC__________________				
Msg No.	**Originator:**	**Transmited To:**	**DTG**	**Received From:**	**DTG**	**Relayed To:**	**DTG**	**Delivered To:**	**DTG**
23				*W7IZ*	*082345Z*	*WB8WKQ*	*052349Z*		

C. Message data at point of delivery:

National Traffic System - Cascadia Rising Message Log									
	Please print neatly - All data must be legible.			Submit log within 7 days of exercise conclusion.					
Name:_____	John Q. Hamm				Call:__W6ABC___________________				
Msg No.	**Originator:**	**Transmited To:**	**DTG**	**Received From:**	**DTG**	**Relayed To:**	**DTG**	**Delivered To:**	**DTG**
27				W7IZ	080122Z			NRCC	080125Z

D. Message data at point of delivery with duplicate forwarded to EPA Section:

National Traffic System - Cascadia Rising Message Log									
	Please print neatly - All data must be legible.			Submit log within 7 days of exercise conclusion.					
Name:_____	John Q. Hamm				Call:__W6ABC___________________				
Msg No.	**Originator:**	**Transmited To:**	**DTG**	**Received From:**	**DTG**	**Relayed To:**	**DTG**	**Delivered To:**	**DTG**
				W7IZ	080233Z	W3JY	080239Z	NRCC	080225Z

V Data Submission:

A SASE is provided with your exercise packet, which may be used to submit all pertinent data to the exercise evaluation team at the conclusion of the exercise. Please do so via USPS to ensure that all materials arrive via the same method. This will prevent any data from being lost in an e-mail exchange or misplaced in electronic form.

At the conclusion of the exercise, all participants should submit the following documents to the exercise evaluation teams:

- All message logs (provided).
- Copies of all message traffic originated, received, relayed and delivered (original or photocopy).
- Optional: A narrative containing any qualitative comments about the exercise such as "lessons learned," constructive suggestions, or problems needing correction.

All Submissions should be sent to:

Cascadia Rising Exercise Evaluation Team
C/O: James Wades
PO Box 192
Buchanan, MI. 49107

Questions regarding this document may be directed to:

James Wades
NTS Central Area Staff
Cascadia Rising Project Manager
jameswades@gmail.com

National Traffic System - Cascadia Rising Message Log

Please print neatly - All data must be legible. Submit log within 7 days of exercise conclusion.

Name:______________________________ Call:______________________

Msg No.	**Originator:**	**Transmited To:**	**DTG**	**Received From:**	**DTG**	**Relayed To:**	**DTG**	**Delivered To:**	**DTG**

APPENDIX E

SAMPLE OF CONTROLLED INJECT MESSAGES AS ORIGINATED AND DELIVERED TO NRCC

Assigned to:

W7ARC

Instructions:

1. Insert your call sign for "Station of Origin"
2. Insert your location for "Place of Origin"
3. Insert your last name only for "Signature"
4. DO NOT change message serial number under any circumstances.

70 TP ____________ 14 ____________________ 0010Z JUN 9
FEMA NRCC
1 INDEPENDENCE MALL
PHILADELPHIA PA 19106

TEST MESSAGE X LRNOD QSYRY LINCO PURTZ ABCFD DROSP TWKRO MOCKO X TEST MESSAGE

____

71 TP ____________ 16 ____________________ 0013Z JUN 9
FEMA NRCC
1 INDEPENDENCE MALL
PHILADELPHIA PA 19106

TEST MESSAGE X ALMIN RSTIS IAMIE CAMPH RSONH QUROL RTABL JLION BORNS MORIL X TEST MESSAGE

____

72 TP ____________ [Insert Check] __________________ 0015Z JUN 9
TOM MILLS AF4NC
NETWORK RESOURCE MANAGER
1 INDEPENDENCE MALL
PHILADELPHIA PA 19106

[Insert brief message indicating operational status such as type of emergency power used (if any), any liaison maintained with local ARES or the like, Modes utilized. Please limit to 25 words or less. Begin and end with phrase "TEST MESSAGE"]

____

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Update Form

GENERAL MESSAGE (ICS 213)

GENERAL MESSAGE (ICS 213)		
TO: FEMA NRCC		**POSITION:**
FROM: TOM MILLS(AF4NC)		**POSITION:** NTS RADIO OPERATOR
SUBJECT: DRILL MESSAGE	**DATE:** 06/09/2016	**TIME:** 09:52:02
MESSAGE:		
70 TP W7ARC 12 LYNNWOOD WA 0010Z JUN 9 FEMA NRCC 1 INDEPENDENCE MALL PHILADELPHIA PA 19106 BT TEST MESSAGE . LRNOD QSYRY LINCO PURTZ ABCFD DROSP TWKRO MOCKO . TEST MESSAGE BT FRAZIER		
SIGNATURE: MILLS		POSITION: NTS RADIO OPERATOR
Reply:		
DATE: 06/09/2016	TIME: 09:52:02	SIGNATURE/POSITION:

Return to List | Print | Create PDF

Update Form

GENERAL MESSAGE (ICS 213)

GENERAL MESSAGE (ICS 213)		
TO: FEMA NRCC		**POSITION:**
FROM: TOM MILLS(AF4NC)		**POSITION:** NTS RADIO OPERATOR
SUBJECT: DRILL MESSAGE	**DATE:** 06/09/2016	**TIME:** 09:50:55
MESSAGE:		
71 TP W7ARC 14 LYNNWOOD WA 0013Z JUN 9 FEMA NRCC 1 INDEPENDENCE MALL PHILADELPHIA PA 19106 BT TEST MESSAGE . ALMIN RSTIS IAMIE CAMPH RSONH QUROL RTABL JLION BORNS MORIL . TEST MESSAGE BT FRAZIER		
SIGNATURE: MILLS		POSITION: NTS RADIO OPERATOR
Reply:		
DATE: 06/09/2016	TIME: 09:50:55	SIGNATURE/POSITION:

Return to List | Print | Create PDF

Update Form

GENERAL MESSAGE (ICS 213)

GENERAL MESSAGE (ICS 213)		
TO: FEMA NRCC		**POSITION:**
FROM: TOM MILLS(AF4NC)		**POSITION:** NTS RADIO OPERATOR
SUBJECT: DRILL MESSAGE	**DATE:** 06/09/2016	**TIME:** 09:36:30
MESSAGE:		
73 TP W7TVA 12 KEYPORT WA 0016Z JUN 9 FEMA NRCC 1 INDEPENDENCE MALL PHILADELPHIA PA 19106 BT TEST MESSAGE . TRMND GRZAB ROBNZ TBPRN ASRON TPAHS AROND HAMRO . TEST MESSAGE BT FELTEN AR		
SIGNATURE: MILLS		POSITION: NTS RADIO OPERATOR
Reply:		
DATE: 06/09/2016	TIME: 09:36:30	SIGNATURE/POSITION:

APPENDIX F

ACKNOWLEGEMENTS OF FEMA BROADCAST MESSAGE RECEIVED

FEMA Simulated Broadcast Bulletin

Verification of Simulated FEMA Broadcast Message

Message No. **311**

Received by	Time Received	Location
K9JM	091720Z	Grass Valley, CA
K6YR	091720Z	San Luis Obispo, CA
W3SMK	091720Z	Castro Valley, CA
WB6UZX	091720Z	Berkeley, CA
AL7N	091818Z	Fairbanks, AK (Alaska CW Gateway)
W0KCF	091852Z	Damascus, OR

Notes:
1. Message not tracked past arrival at state level
2. Verification by NTS evaluation logs

APPENDIX G
PARTICIPATING NTS AND ARES UNITS
INDIVIDUALS DESERVING SPECIAL RECOGNITION

Participating NTS and ARES Units deserving special recognition:

- Alaska ARES
- NTS Region 3
- NTS Region 6
- NTS Region 7
- NTS Digital Team
- NTS Transcontinental Corps
- ARRL Eastern Pennsylvania Section ARES
- ARRL Eastern Pennsylvania Section NTS

Individual NTS and ARES volunteers deserving special recognition:

- Linda Mullen, AD4BL
- Jerry Curry, KL7EDK
- Ed Trump, AL7N
- Martin Rudd, WL7MR
- Don Bush, KL7JFT
- Kent Petty, KL5T
- Carl Dan Knapp, KL4CX
- Jim Michener, K9JM
- Steve Hawes, WB6UZX
- Joe DeAngelo, AG6QO
- Steve King, W3SMK
- Ron Murdock, W6KJ
- Terry O’Keefe, WB6N
- Ed Stuckey, AI7H
- Scott Gray, W7IZ
- Claire Johnson, N7CM
- Ernie Johnson, K7EAJ
- Don Stettler, KK7TN
- Kevin Fox, W0KCF
- Ben Johnson, N7OGM
- Bill Frazier, W7ARC
- Jerre Felton, W7TVA
- Tom Smith, N7CFI
- Scott Walker, N3SW

- Walter Jones, WN3LIF
- Thomas Mills, AF4NC
- Robert Famiglio, K3RF
- Jeff Miller, WB8WKQ
- Frank C. Van Cleef III, W1WCG
- Jan Peter A. Schultz, K1NN
- John A. Thompson III, WA4BAM
- William R. Fagan, Jr., KB2QO
- Marcia K. Forde, KW1U
- John J. Bowles, N1OTC
- Larry B. Jones, WB9FHP
- David Struebel, WB2FTX
- Lawrence G. Hays, WB6OTS
- Charles R. Verdon, W5KAV

NTS Area Staff Chairmen:

- Robert Griffin, K6YR
- Steve Phillips, K6JT
- Joe Ames, W3JY

Our additional "thank you" to all the NTS members who assisted in any capacity to make this exercise a success.

APPENDIX H
CONTACT INFORMATION FOR EVALUATION REPORT

Evaluation Report prepared by:

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