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TDMA NETWORKING WAVEFORM (TNW) FOR RF-7800V, RF-7850M, RF-7850A, RF-7850S

OPERATION GUIDE

HARRIS® TECHNOLOGY TO CONNECT, INFORM AND PROTECT™

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TDMA NETWORKING WAVEFORM (TNW) FOR INTERNATIONAL VHF AND MULTIBAND RADIOS

OPERATION GUIDE

This manual is based on Firmware Version 4.3.0.

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OPERATION 1

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PURPOSE

This operation guide provides information on the Time Division Multiple Access [TDMA] Networking Waveform (TNW). TNW operates using the Electronic Counter-Counter Measures (ECCM) feature. This information applies to international VHF and MultiBand (MB) radios with an advanced feature set.

TNW OVERVIEW

Three modes of operation are supported by TNW; voice and Situational Awareness (SA) data, SA data only, and Voice Repeater (VR-TNW) with SA. This waveform supports between four and 64 radios in a net. TNW is a hopping waveform that requires a TNW channel access and 25 kHz bandwidth. Global Positioning System (GPS) position reporting requires that the radio operate in Cipher Text (CT) mode with an Advanced Encryption Standard (AES) 256 bit encryption key assigned. When TNW is operated in Plain Text (PT) mode, voice and user data are supported (no GPS reporting).

TNW STARTUP

Upon startup, the TNW network synchronizes, assigning the best station to be the Time Master (TM). The TM ensures all radios stay synchronized with each other. Once the TNW network is ACTIVE at the TM, the TM waits for the outstations to become ACTIVE before broadcasting any data or voice (for example, TM waits about two seconds for an 8-user net; the wait increases for more users, or decreases for fewer users).

See Figure 1. Front panel indications upon net formation are:

- The number of 1-hop neighbors currently active is reported on the front panel.
- TM and User Nodes (UN) display the time source that they are tracking. The UN will always report a TM as their time source, while the TM will report GPS or CLOCK (the radio's internal real time clock) as the time source based on availability.

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Figure 1 shows a TNW display in Cipher Text (CT). The selected net must be programmed for TNW. Keys must be programmed when operating in CT mode. For basic TNW operation:

a. Place rotary switch in a TNW net.

b. Observe on page 1:

   1. **TNW** appears as the NET TYPE.

   2. Correct encryption (**CT** or **PT**), and **POWER** are used.

c. Select **[ ] (0)** to go to the next screen.

d. Observe on page 2:

   1. The STATE is SEARCHING before the Time Master is determined (usually the radio with the lowest Wireless Media Access Control [MAC] address), then the STATE becomes ACTIVE.

   2. RAD indicates the number of radios currently in the network.

   3. The current time.

e. Select **[ ] (0)** to go to the Tac Chat IP screen.

NOTE

Depending on which radio type this waveform is being used in, the speaker symbols may or may not be present.

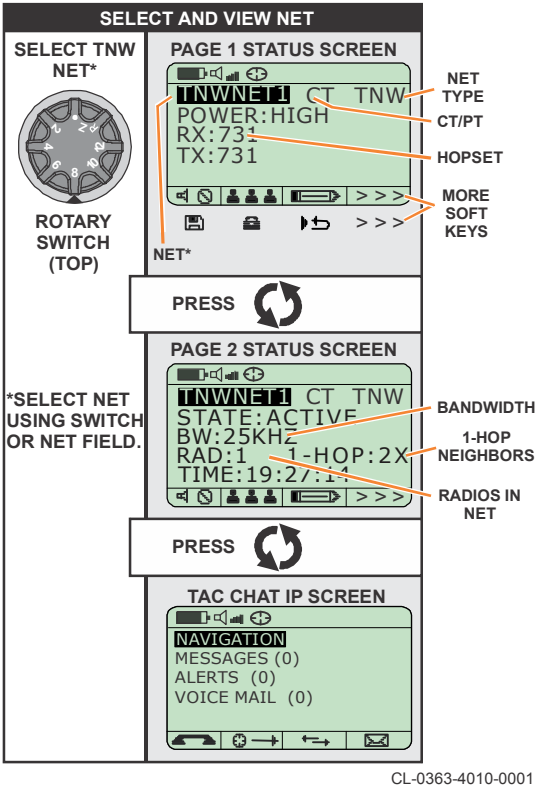

Figure 1 . TNW Front Panel Displays

VOICE OPERATION

This section describes voice and Voice Repeater operation.

Voice Channel

Once a TNW network has become ACTIVE and configured for “Data and Voice” or “Data with Voice Repeater”, there is a single (half-duplex) voice channel for all users.

Hold Off Tone

When PTT is pressed for voice transmission, a variable hold-off tone occurs while attempting to get channel access, or when the channel is in use. The user will hear at least ½ second of hold off tone. If the hold off tone is longer than ½ second, then another user has already acquired the voice channel.

Voice Break-In

If the PTT is held down through five seconds of hold-off tone (the channel is in use), an emergency break-in will occur. A voice break-in results in the radio transmitting over any other radio currently using the channel.

Voice Repeater

The TNW Voice Repeater (VR) feature allows a radio to be used as a relay station without the need of a back to back connection with a secondary radio on a secondary network. This allows for a single narrowband repeater station that can receive and transmit voice in black (unattended) or red (attended) modes.

With VR activated on the repeater radio, transmissions are achievable to more distant out stations using the same network configuration and frequencies. If the outstations are mobile, they can move in and out of the repeater connection range without making changes to the configuration. The connection depends on the best Bit Error Rate (BER) found by radios in the network. BER is used to select between the voice from the repeater and the originator.

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Black Repeater

When the radio is configured as a Black Repeater, the repeater radio does not use an encryption key for the network (it operates in PT). In this net arrangement, TNW outstations still use AES encryption (they operate in CT). The repeater radio will retransmit all audio fully encrypted, as the audio is forwarded without the repeater's knowledge of the actual voice information. This makes it possible to leave the repeater radio unattended.

SITUATIONAL AWARENESS (SA)

GPS Situational Awareness (SA) reports are transmitted during the user's assigned data slot. GPS position reporting options are: auto timed and/or auto position, or triggered by Push-To-Talk (PTT). GPS reports use an entire data slot (18 bytes). Consider data throughput rates for the network when using GPS reports. A SA contact list is also supported. The radio will default to the station Media Access Control (MAC) Identification (ID) if a contact list is not configured.

Position Server Options

A Position Server collects received GPS SA reports and forwards them as IP packets through an Ethernet connection for collection by other software. The reports are used to track, display, map, and so forth. The Position Server configuration settings specify whether report forwarding is on or off, the IP address to which reports are forwarded, and at what interval reports are forwarded. Custom IP format settings are Harris SA, Keyhole Markup Language (KML), and NATO Friendly Force Information (NFFI).

USER DATA

User data is sent using either the User Datagram Protocol (UDP) / Internet Protocol (IP) proxy service for short broadcast messages or Asynchronous DTE. In addition, TNW delivers Situational Awareness (SA) data and 2400 bps digital voice. The radio supports IP data transfer via the Universal Serial Bus (USB) interface for both Plain Text and Cipher Text modes of operation. IP data is transferable via a UDP/IP based proxy port as determined by the user, for maximum throughput rates. IP is supported by Ethernet adapter, or RNDIS via USB.

Table 1 provides data throughput rates for a given 21 byte parcel. All times are shown in seconds (sec).

Table 1. TNW Data Throughput Rates (21 Byte Parcel)

# Radios	Data Only Net	Data and Voice Net	Data and Voice with Voice Repeater Net
64	6.48 sec	8.10 sec	10.8 sec
48	5.04 sec	6.30 sec	8.55 sec
32	3.60 sec	4.50 sec	5.85 sec
24	2.79 sec	4.05 sec	4.95 sec
16	2.16 sec	3.15 sec	3.60 sec
12	1.62 sec	2.70 sec	3.15 sec
8	1.08 sec	1.80 sec	2.25 sec
6	0.90 sec	1.80 sec	1.80 sec
4	0.63 sec	1.80 sec	1.80 sec

Asynchronous Data

Using the RS-232 DTE data port, the radio can send and receive 2400 bps, 9.6 kbps, or 115.2 kbps Asynchronous (Async) digital data in TNW in CT fixed frequency and ECCM modes. This is supported with the same configuration and cabling that is required for sending and receiving 64 kbps Synchronous (Sync) digital data. To support this mode, configure the externally connected DTEs to be identical for either 2400 bps, 9.6 kbps, or 115.2 kbps with 8 data bits, no parity and 1 stop bit, for example. Data throughput rates from Table 1 still apply.

Hopsets

TNW uses Wideband or list hopset types. A wideband hopset is defined by a start and stop frequency. A list hopset can have up to 30 frequencies assigned. All frequencies are multiples of 25 kHz. In both the list and wideband cases, frequencies defined in locksets will be not be used.

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TNW NETWORK

TDMA is a generic communications protocol in which each transmitting radio shares a transmission medium by being assigned a time slot in which to transmit. The TNW network is considered a Narrow band Networking waveform using a form of Mobile Ad-Hoc Networking (MANET). The TNW network controls both the time alignment of radios to one another as well as the slot assignments for transmitting devices. Furthermore, it can adapt relatively quickly to changes in network topology to guarantee the continuation of data services. The topology of a TNW network is agile and allowed to form, merge, and detect separation of TNW Groups on the fly. With this system, all radios configured for the same network have the potential to communicate.

Time Master (TM)

The TNW network requires time synchronization among individual stations for data transmission. TNW will automatically determine the best station to be a Time Master (TM), which will provide synchronization information to ensure all radios stay time aligned with each other. The startup process requires radios to contain identical configurations as well as time synchronization, provided either by enabling GPS or entering a manual time within ±1.5 minutes of any other radio within the network. Once the network has been selected, the radios will immediately begin to transmit timing and network configuration information to one another in an effort to determine the TM and form a group.

Once a radio is selected to be the TM, the others are considered User Nodes (UN). It typically takes one to two more epochs of time for all User Nodes to complete the process of joining the TM's group. The TM radio allows some time after switching from a "Searching" state to an "Active" state in order to ensure all voice and data is received by the UNs. The total group formation time could be 10 seconds for a network with four UNs, or up to one minute for a network of 64 UNs.

Group ID

The Group ID is equivalent to the MAC ADDRESS of the TM radio. Each radio in the network must be configured with a unique wireless Media Access Control (MAC) ADDRESS setting. The MAC ADDRESS is in the range [1 to N], where N is the number of TDMA channels (up to 64).

SUMMMARY

The TNW network controls both the alignment of radios to one another as well as the slot assignments for transmitting devices. It has the ability to adapt quickly to changes in the network topology. All radios configured for the same TNW network can communicate. TNW groups are based on channel performance and time and are a subset of the network. The group ID is equivalent to the Media Access Control (MAC) address of the Time Master (TM). The front panel displays the number of radios in the group.

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TNW MESSAGES

Information display (or voice prompt in some cases) messages for TNW are listed in Table 2.

Table 2. Information Messages

Message	Action/Description
CANNOT SEND GPS REPORT: TNW TIME BEHIND GPS TIME	This indicates the user attempted to force a GPS report to the network while the current waveform's time of day is behind the time of day indicated by GPS.
REPEATER BREAK-IN DISABLED	When a TNW black repeater is actively repeating, the PTT cannot break-in over the repeated data.

Warning display messages for TNW are listed in Table 3.

Table 3. Warning Messages

Message	Action/Description
NO NETWORK ID FILLED	Network ID was not configured on a net that requires one.
NO TEK FILLED	Cipher Text (CT) net has no encryption key. Reprogram plan adding CT keys.
NO TNW HOPSET FILLED	TNW Hopset not programmed on a TDMA net.
NO TRANSEC KEY FILLED	TNW net with no TRANSEC KEY selected.

TNW CONFIGURATION

The TNW mode supports the following configuration. Refer to the radio operation manual for information on specific programming parameters.

Bandwidth	25 kHz
Channel Access	TNW
TRANSEC	TNW
Crypto	PT or CT
Circuit Type	Not Applicable
Modulation	TNW
Demodulation	TNW
Hopset	predefined Wideband or List
Vocoder	MELP

[PGM] > TRANSEC

Transmission Security (**TRANSEC)** is used to program TRANSEC keys. Use Electronic Counter-Counter Measures (ECCM) Manager to set up Time Division Multiple Access [TDMA] Networking Waveform (TNW) parameters. Refer to Table 4 for descriptions of the menu items.

Table 4. [PGM] > TRANSEC Menu Items

Item	Description
TRANSEC MANAGER > NARROWBAND KEY	Program TRANSEC keys.
ECCM MANAGER	Set up WIDEBAND or LIST HOPSET and LOCKSET parameters for TNW. TNW does not support separate Rx and Tx hopsets.

[PGM] > NET MANAGER

NET MANAGER is used to program up to 25 nets. Press EDIT in a TNW net or set up the CURRENT NET using the TNW specific menu structure shown in Figure 2. See Figure 3 for the APPS portion of the net structure. Refer to Table 5 for descriptions of the menu items specific to a TNW net.

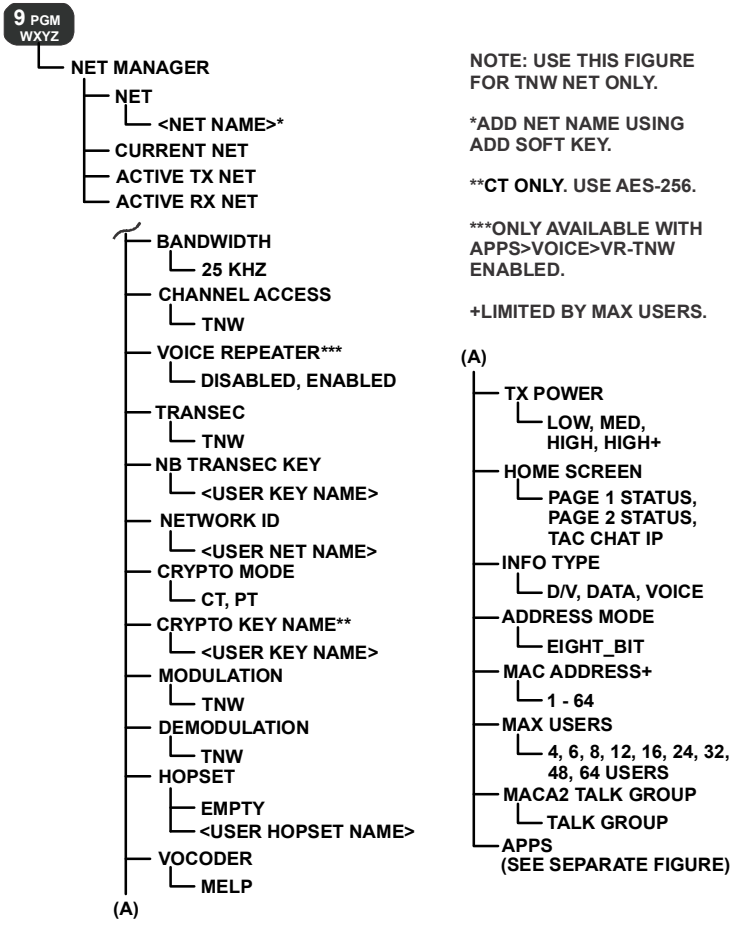

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Figure 2. [PGM] > NET MANAGER (TNW Only) Menu

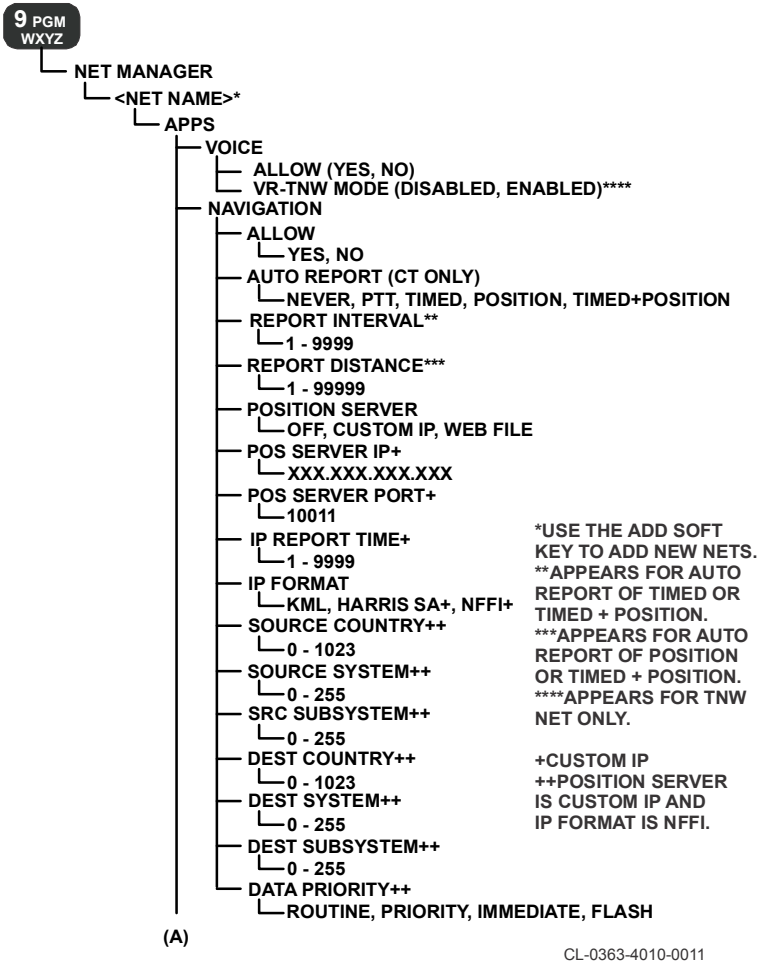

Figure 3. [PGM] > NET MANAGER (APPS) Menu (Sheet 1 of 2)

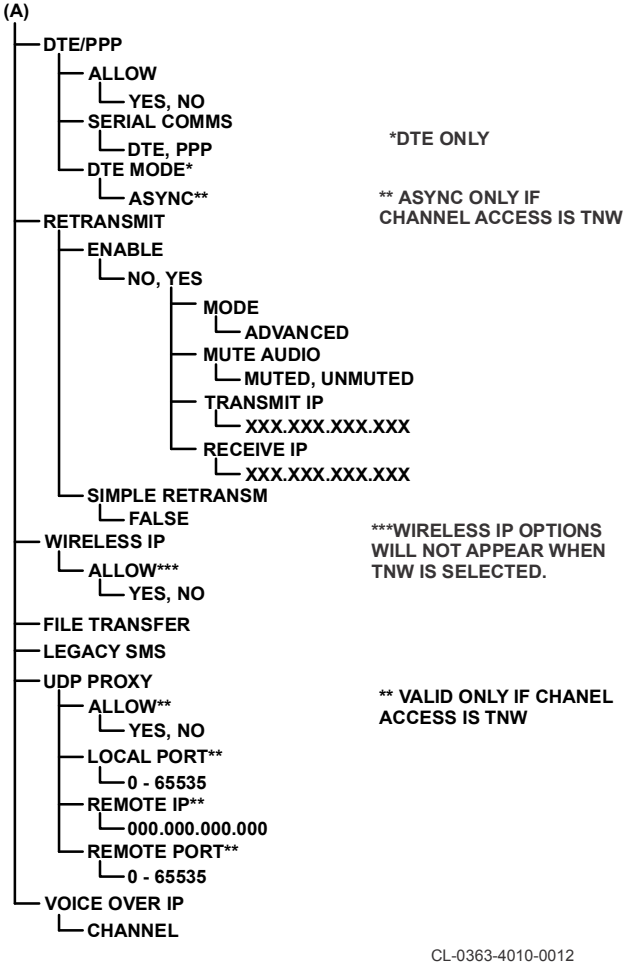

Figure 3. [PGM] > NET MANAGER (APPS) Menu (Sheet 2 of 2)

Table 5. [PGM] > NET MANAGER TNW Menu Items

Item	Description
2	Net Name (or Number) can be any net, **1** - **25**.
Net Name **> BANDWIDTH**	The 25 kHz bandwidth allows channels spaced in tight 25 kHz increments.
Net Name **> CHANNEL ACCESS**	Select TNW net.
Net Name **> VOICE REPEATER**	Select Enabled to activate this radio as a voice repeater. Only one radio per net should be set as the repeater station.
Net Name **> TRANSEC**	TRANSEC is set to TNW to correspond to type of channel being used.
Net Name **> NB TRANSEC KEY**	Select programmed Narrowband TRANSEC KEY.
Net Name **> NETWORK ID**	Specify a unique network identifier for TNW.
Net Name **> CRYPTO MODE**	Select Plain Text (PT) (unencrypted) or Cipher Text (CT) (encrypted).
Net Name **> CRYPTO KEY NAME**	If crypto is CT, select programmed key.
Net Name **> MODULATION** Net Name **> DEMODULATION**	Property is preset to TNW for a TNW net.
Net Name **> HOPSET**	Select hopset name. Refer to [PGM] > TRANSEC, p16.
Net Name **> VOCODER**	Voice encoder/decoder (VOCODER) is set to Mixed-Excitation Linear Predictive Vocoder (MELP) for TNW.
Net Name **> TX POWER**	Note that HIGH+ may or may not be available depending on the radio type.
Net Name **> MAC ADDRESS**	Enter Media Access Control (MAC) address of radio. This is used when configuring a TNW wireless IP net. Valid entries are 1 - 64 (and is limited by max users). Use the same number as the last octet of the IP address.
Net Name **> MAX USERS**	Set TNW net to maximum of 4, 6, 8, 12, 16, 24, 32, 48, or 64 users.

Table 5. [PGM] > NET MANAGER TNW Menu Items (Continued)

Item	Description
NOTE: See Figure 3 for menu details not described below. Also refer to radio operation manual.	
Net Name **> APPS > VOICE > ALLOW**	Select YES to allow voice communications functions.
Net Name **> APPS > VOICE > VR-TNW MODE**	Select Enabled to allow repeater functionality in TNW network. Note that Net Name **> VOICE REPEATER** must be enabled to activate the repeater function.
Net Name **> APPS > NAVIGATION > ALLOW**	If YES, GPS functions are allowed.
Net Name **> APPS > DTE/PPP > ALLOW**	Select YES for Data Terminal Equipment (DTE) functions. DTE is used for data communications.
Net Name **> APPS > DTE/PPP > SERIAL COMMS**	Select DTE.
Net Name **> APPS > DTE/PPP > DTE MODE**	This will be ASYNC if channel access is TNW.

CONFIGURING VOICE REPEATER

Set one radio in the TNW network as the Voice Repeater from the front panel as follows. See Figure 4.

Complete these steps for every radio on the network.

a. Select a TNW network by moving the rotary switch (handheld radios) or up/down button (vehicular radios) to a TNW net.

b. Press the **EDIT** soft key to access the CURRENT NET.

c. Navigate through the menu to **APPS > VOICE** and press **[ENT]**.

d. Observe that ALLOW is YES and VR-TNW MODE is DISABLED.

e. Select DISABLED for VR-TNW MODE and press **[ENT]**.

f. Select ENABLED by pressing button 2 or 8 and press **[ENT]**.

g. Select to return to the CURRENT NET menu level by pressing **[CLR]** twice.

Complete these additional steps for the one repeater radio on the network.

h. Navigate through the CURRENT NET menu to VOICE REPEATER. This parameter appears when TNW is configured and VR-TNW MODE is ENABLED.

i. Change the VOICE REPEATER value to **ENABLED** and press **[ENT]**. Only one radio in the net should be set as a repeater.

j. Navigate back to the main screen by pressing **[CLR]**.

k. Select the **SAVE** soft key.

CONFIGURING BLACK REPEATER

Configure a black repeater as follows.

a. Select **[PGM]**.

b. Navigate through the PGM menu to **CAM** and press **[ENT]**.

c. Set **ENABLED** to FALSE if necessary.

d. Select **[CLR]** twice to go back to the main screen.

e. Navigate back to the main screen by pressing **[CLR]**.

The black repeater radio must also be in PT mode (no encryption keys loaded). The other radios in the network should be in CT mode. A black repeater makes it possible for the radio to be unattended and therefore unable to decrypt the voice it is repeating.

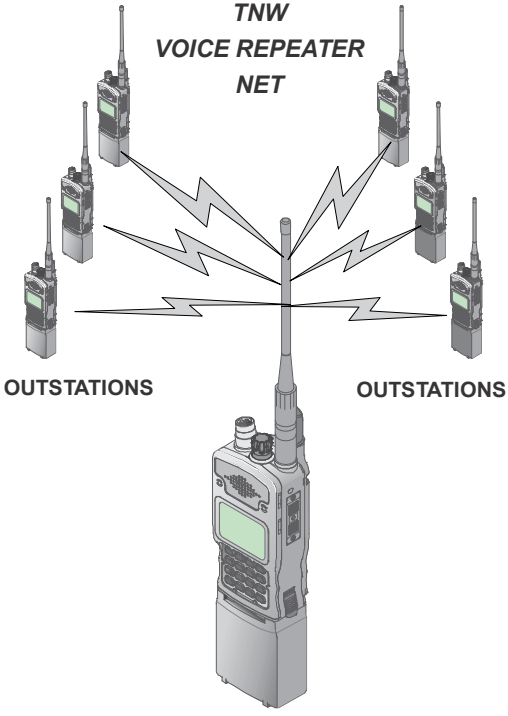

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Figure 4. TNW Voice Repeater Net

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-Menus/Controls-

[APPS]	Application menu
[CLR]	Clear
[ENT]	Enter
[PGM]	Programming menu

G

-A-

AES	Advanced Encryption Standard
APPS	Application(s)
Async	Asynchronous
Auto	Automatic

-B-

BER	Bit Error Rate
bps	Bits per second

-C-

CLR	Clear
CPA	Communications Planning Application
CT	Cipher Text, encrypted voice or data
CVSD	Continuously Variable Slope Delta. A method of digitizing typically encrypted voice.

-D-

DTE	Data Terminal Equipment

-E-

ECCM	Electronic Counter-Counter Measures
ENT	Enter

-F-

-G-

GPS	Global Positioning System. A system using satellites to provide position location, system clock.

-H-

-I-

ID Identification
IP Internet Protocol
ITAR International Traffic In Arms Regulations

-J-

-K-

k kilo or 1 x 10^3
kbps kilobits per second
kHz Kilohertz
KML Keyhole Markup Language

-L-

-M-

MAC Media Access Control
MANET Mobile Ad-Hoc Networking
MB Multiband
MELP Mixed-Excitation Linear Predictive Vocoder
MHz Abbreviation for megahertz, or millions of cycles per second.

-N-

Net A group of radios that share common communications parameters, such as frequencies, etc.
NFFI NATO Friendly Force Information

-O-

-P-

PGM Program
PPP Point-to-Point Protocol
PT Plain Text
PTT Push-to-Talk

-Q-

-R-

RF	Radio Frequency
RX	Receive

-S-

SA	Situational Awareness
SW	Software
Sync	Synchronous, synchronization

-T-

TDMA	Time Division Multiple Access
TEK	Transmission Encryption Key
TM	Time Master
TNW	TDMA Networking Waveform
TRANSEC	Transmission Security
TX	Transmit

-U-

UDP	User Datagram Protocol
UN	User Nodes
USB	Universal Serial Bus

-V-

Vocoder	A circuit that converts analog voice to digital
VR	Voice Repeater

-W-

-X-

-Y-

-Z-

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