Comtech Troposcatter Family of Systems

November 2021

Proprietary/Confidential Notice

Troposcatter Transmission (TROPO) Systems Beyond-Line-of-Sight (BLOS) Capability

1 OVERVIEW

Comtech Systems (Comtech) brings extensive, industry leading experience providing troposcatter Beyond Line-of-Sight (BLOS) systems. Since 1975, Comtech has continuously supplied BLOS systems and equipment domestically and internationally. Comtech has provided more mobile and fixed troposcatter systems and equipment than any other troposcatter manufacturer in the world and has designed the most advanced, multi-megabit troposcatter equipment and systems available. Comtech's Troposcatter Family of Systems (FoS) are well suited to support an array of terrestrial Over the Horizon (OTH) communication links for backhaul of vital IP networks. Whether it is on the move or stationary our Family of Systems can meet your objectives.

COMET 70km Range

Modular Transportable Transmission System (MTTS)

Dual Diversity Range 190km Quad Diversity Range 258km

Figure 1 Comtech Troposcatter Family of Systems (FoS)

1.1 Comtech Troposcatter Family of Systems

Troposcatter has re-emerged over the last decade as a core communications requirement because it provides resilient, secure, and low latency communications over long ranges and operates independent of space assets. This capability is of key interest to missions that require high bandwidth communications over mountains, through urban environments, or OTH in the event of a congested, contested, or denied space environment. With those critical mission requirements in mind, Comtech has developed a troposcatter Family of Systems (FoS) to meet the demands of

today's military operations. Comtech's FoS consists of a range of troposcatter terminals that vary in size, pack out, and effective range while sharing common components, operational functionality, and logistical support requirements. System members of the troposcatter FoS support nominal link distances from less than 50km to more than 250km based on terrain, allowing mission planners to match terminals to mission needs.

The Small form factor offering of the FoS is the COMET terminal, offering medium range Beyond Line of Sight (BLOS) communications in an airline checkable pack out consisting of two (2) transit cases. This system is currently being fielded and tested by various agencies. It is the smallest tropo terminal in existence and has been proven to operate in LOS, obstructed LOS, diffraction and troposcatter propagation environments.

The Medium offering in the FoS is the Modular Transportable Transmission System (MTTS-PLUS) Dual Polarization Diversity terminal. It offers extended range while maintaining a pack out easily transported in land, sea, and air vehicles. It consists of one antenna and is easily packed into a HMMWV.

The Large offering in the FoS is the Modular Transportable Transmission System (MTTS-PLUS) Quad Diversity terminal. It offers the greatest effective range while maintaining a pack out easily transported in land, sea, and air vehicles. The Quad Diversity terminal consists of two antennas.

Regardless of size, weight, and pack out characteristics, Comtech's troposcatter FoS all share the benefits of Comtech's industry leading knowledge and experience in the design, production, and deployment of high-throughput, bandwidth efficient troposcatter systems. The core component of each of these systems is the CS67PLUS troposcatter radio. The compact, efficient, design of the CS67PLUS combines the functionality of multiple discrete components found in legacy troposcatter systems to deliver terminals that are smaller, lighter, and more powerful than the industry has ever seen.

2 CS67PLUS TROPOSCATTER RADIO

The Troposcatter Radio/Modem is the heart of any troposcatter terminal. The Radio/Modem's performance and capabilities dictate the overall performance of the system. All Comtech's Troposcatter FoS Terminals utilize the CS67PLUS Troposcatter Radio. This ensures over-the-air interoperability among all terminals.


CS67PLUS Troposcatter Radio

The CS67PLUS is the first software-defined tropo radio which provides an industry leading data throughput of 105Mbps in Single Stream operation and 210Mbps in Dual Stream operation. Dual Stream is an industry first, allowing one radio to transmit two independent data streams without any additional equipment (previously, transmitting two independent data streams over the same path required two modems). The CS67PLUS provides superior performance over previous troposcatter radios with its improved adaptive channel equalization algorithm and powerful Low-Density Parity Check (LDPC) Forward Error Correction (FEC).

The CS67PLUS radio utilizes a Zero-IF conversion method from digital data directly to RF, which eliminates the need for IF equipment and improves Size Weight and Power (SWaP). The radio provides four user-selectable channel bandwidths (2.5, 5, 10, 20MHz), each with its own set of Modulation and Coding (MODCOD) combinations based on varying FEC rates and modulation schemes from BPSK to 64APSK. This allows a range of data rate and FEC options to be utilized based on the operational channel bandwidth allocated.

CS67PLUS Radio Key Attributes

- Used in US Marine Corps Next Generation Tropo
- Extensive IA Hardening
- Software Defined Radio
- ACM Increases average Data Throughput > 30%
- DSSS Waveform provides implicit diversity gain, allowing for a decrease in EIRP and lowering the probability of intercept. Or maintain the same EIRP and increase range.

2.1 Modulation

The CS67PLUS radio allows the user to select a fixed data rate and modulation technique (BPSK to 64APSK) as shown in Figure 2 below, or to use Adaptive Coding and Modulation (ACM) which provides real-time throughput optimization for improved performance.

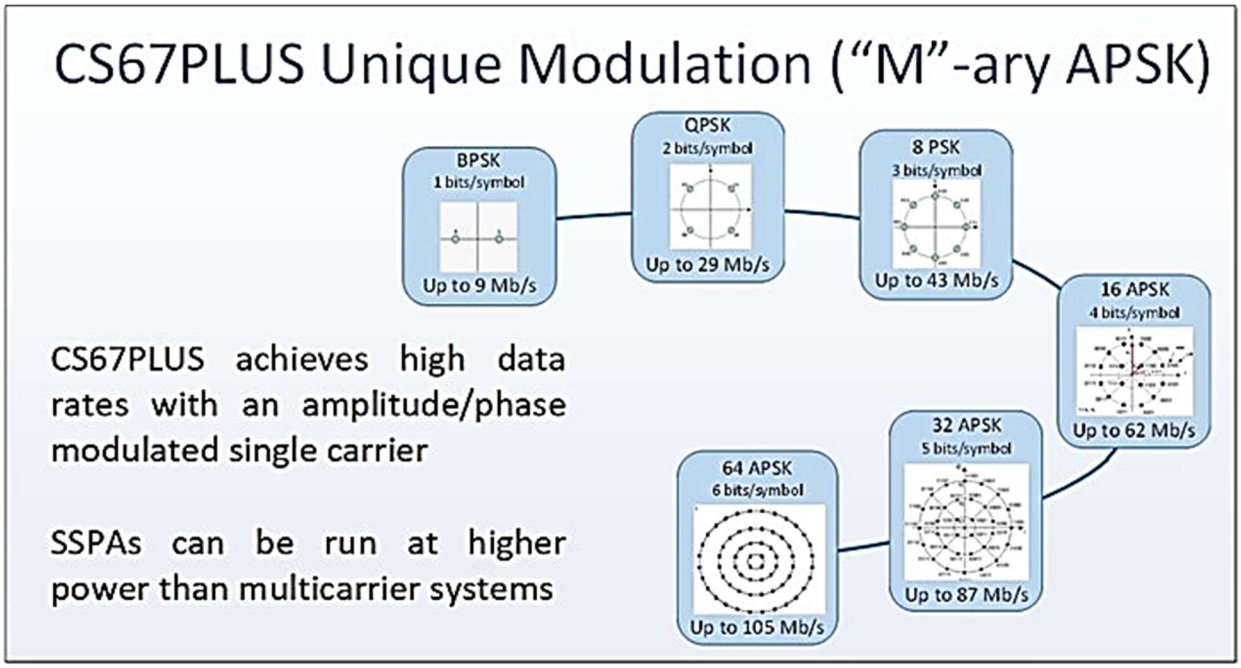


Figure 2 CS67PLUS Modulation Scheme

The hitless ACM feature can change modulation and coding on a frame-by-frame basis by tracking link conditions and maintaining the allocated bandwidth. This feature ensures that the user can utilize the maximum throughput that link conditions will support, while maintaining the desired link availability. Use of ACM results in higher average user data throughput with a lower tolerance to link errors. ACM is especially effective in Troposcatter links where rapid Rayleigh fading is present.

The CS67PLUS can also operate asymmetrically. In instances where one end of the link needs to transfer large amounts of data but does not need to receive as much data, the transmit side can transmit at full transmit power, while the receive side can operate at very low power to reduce its RF visibility. The CS67PLUS radio is packaged in a compact IP65 sealed module, capable of all-weather operations in harsh climates. The radio uses diversity combining receivers to detect and recover signals below -100dBm in a Rayleigh fading environment. Another key feature is Direct Sequence Spread Spectrum (DSSS) to further reduce RF signature or increase BLOS range.

2.2 Direct-Sequence Spread Spectrum (DSSS)

DSSS, a new waveform implemented by COMTECH, is a spread-spectrum modulation technique used to reduce overall signal interference, increase link range, or decrease system transmit power to reduce probability of detection. The direct-sequence modulation makes the transmitted signal wider in bandwidth than the information bandwidth. After the de-spreading or removal of the direct-sequence modulation in the receiver, the information bandwidth is restored, while unintentional and intentional interference is substantially reduced.

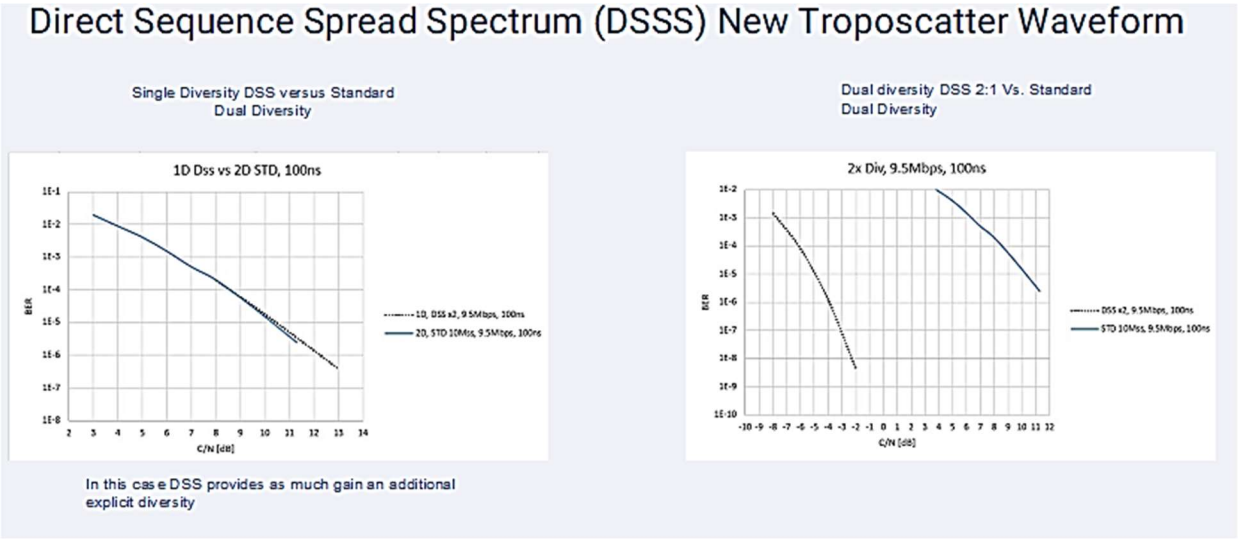


Figure 3 Standard Diversity comparison to DSSS Diversity

In the CS67PLUS, the User Selectable Symbol Rate is proportionate to the occupied bandwidth (OB). This means that 2.5 Msps uses 2.5 MHz, 5 Msps uses 5 MHz, 10 Msps uses 10 MHz, and 20 Msps uses 20 MHz of spectrum space. The DSSS technique effectively transmits 2.5Msps of information using eight (8) blocks of 2.5 MHz bandwidth, so the transmitted signal takes up the full occupied bandwidth of 20MHz. Similarly, at DSSS 5 MHz the radio transmits four (4) 5 Msps blocks to equal 20 MHz of OB and at DSSS 10 MHz, two (2) 10 MHz wide blocks are transmitted. In doing so there is a processing gain of up to 9.5dB.

In the image above (Figure 3), the graph on the left illustrates that the performance of a Single Diversity 10Msps DSSSx2 waveform (represented by the blue line) is approximately the same in performance as a standard Dual Diversity single carrier waveform (represented by the black line). The chart on the right (using the same color codes) compares a Dual Diversity standard waveform to Dual Diversity on a DSSSx2 waveform showing significant improvement in performance. DSSS

can provide an implicit diversity performance improvement when limited to using a single transmit frequency.

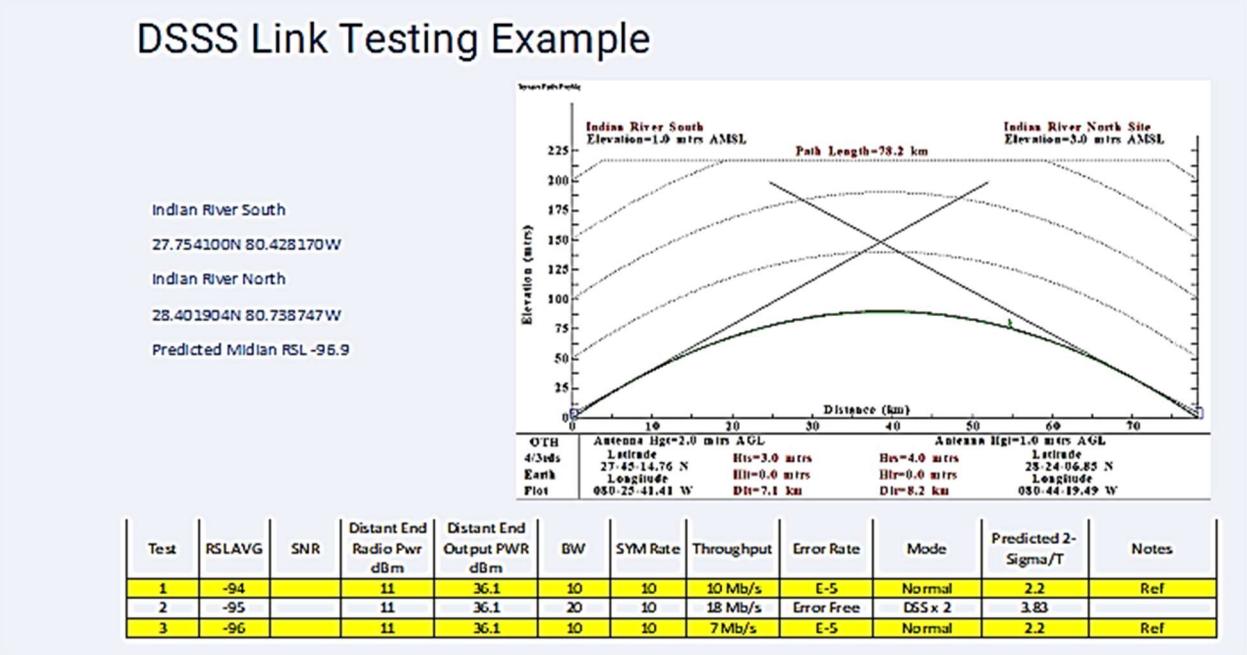
The image below (Figure 4) shows the results of a live trial using COMET over a range of 78.2km (noting the system is designed for links up to 70km) where three (3) measurements were taken. Note the output power was 36.1dBm (only 4W.)

The live trial of the DSSS feature was divided into three (3) test scenarios:

Test 1 utilized the standard waveform. This resulted in a data rate of 10Mbps with a Bit Error Rate (BER) of 1 x 10^{-5}.

Test 2 utilized the new DSSSx2 waveform (symbol rate of 10Msps transmitted x2 to yield an occupied bandwidth of 20MHz). This resulted in an increased data rate of 18Mbps with no errors. This waveform was demonstrated to be much more resilient and to provide greater throughput and link availability.

Test 3 reverted back to utilizing the standard waveform to rule out any changes in link conditions. This resulted in a data rate of 7Mbps with a BER of 1 x 10^{-5}.



Test	RSLAVG	SNR	Distant End Radio Pwr dBm	Distant End Output PWR dBm	BW	SYM Rate	Throughput	Error Rate	Mode	Predicted 2-Sigma/T	Notes
1	-94		11	36.1	10	10	10 Mb/s	E-5	Normal	2.2	Ref
2	-95		11	36.1	20	10	18 Mb/s	Error Free	DSSx 2	3.83	
3	-96		11	36.1	10	10	7 Mb/s	E-5	Normal	2.2	Ref

Figure 4 DSSS Performance in Real World Conditions

While conducting Test #3, the test team's assumption was that conditions had improved between Test 1 and Test 2 to produce the performance gains shown in the results of Test #2. In fact, the opposite was true, and conditions had gotten worse as shown by the change in average RSL between the tests. This deterioration of the link conditions resulted in the decreased performance of the system using the standard waveform.

2.3 Additional Radio Features

Other key features of the CS67PLUS radio include AES256 encryption and Automatic Link Power Control (ALPC). The AES256 on-board encryptor is currently in process to receive FIPS 140-2 validation. The on-board AES encryption feature allows user data to be encrypted at line speed without adding significant latency or overhead to the user data stream. ALPC is used to automatically adjust transmit power to a desired link receive level. The ALPC feature is important

in reducing the probability of detection and intercept. For example, the operator can set a desired receive level that will support the required link throughput and the radio will automatically reduce transmit power to maintain the desired receive level, thereby reducing the RF signature of the system.

3 COMPACT OVER-THE-HORIZON MOBILE EXPEDITIONARY TERMINAL (COMET)

The COMET member of Comtech's troposcatter Family of Systems provides persistent, high bandwidth terrestrial microwave communications. The smallest form factor troposcatter system ever created, COMET enables low latency operation for line-of-sight (LOS), obstructed line-of-sight (OLOS), diffraction, and over-the-horizon (OTH) communications. COMET systems utilize low-profile packaging and are transported in two (2) airline-checkable transit cases. The terminal operates with a 1m antenna, two (2) 10W SSPAs, and utilizes minimal prime power (<120W). Now, with COMET's small logistical footprint and ease of use, more units and missions can benefit from this technology down to the small unit level.

COMET in the Field COMET on Solar Power

Figure 5 COMET Terminal

3.1 COMET Overview

- Operates on the ground with a minimal communications equipment footprint, unlike Line-of-Sight (LOS) microwave radios which often require a mast or tower to communicate.
- Enables over-the-horizon communications with as low as ¼ of a watt of RF output power, providing a communications link with a LPI and LPD.
- Offers high data rate communications over obstructed paths due to man-made objects, trees, or terrain; critical where erecting a tower/mast for traditional LOS is not feasible due to safety, location, cost, or time.
- Transportable in two airline-checkable cases.
- Extremely low prime power requirements enable operations from a vehicle, battery, or solar with battery backup.

- Enables faster deployment and simpler logistical requirements than other troposcatter systems due to minimal equipment footprint and loadout (<15 minutes).

3.2 COMET Technology Description

The COMET is a small, low power, portable troposcatter terminal containing one CS67PLUS troposcatter radio, one (1) RF front-end kit, and two (2) 10-Watt solid state power amplifiers, all integrated with a 1-meter segmented carbon fiber antenna mounted on a lightweight tripod. The total terminal weight is 52lbs, excluding transit cases. Designed for ease of mobility, the terminal is packed in two (2) airline-checkable cases and can be setup by one person in 15 minutes. The radio module is interoperable with all Comtech's Troposcatter Family of Systems

COMET Key Attributes

- JF12 Approval in Committee sponsored by SOCOM
- Transports in 2 airline checkable cases
- One person setup in less than 15 minutes
- Capable of utilizing existing fielded, small battery storage devices
- Uses CS67PLUS Radio with its full set of features
- Interoperable with all Comtech's Troposcatter

The standard version of the COMET operates in the 4.4 to 5.0GHz frequency range in a Dual Frequency Diversity (two transmit frequencies per side). In a highly congested RF environment, the standard terminal can operate in Dual Polarization Diversity (one transmit frequency per side of the link) without any equipment modifications. The COMET is a native 24 VDC system and can run for 8+ hours using a BB-2590/U battery based Portable Power System.

Table 1 COMET C-band Standard Specifications

Item	Specification
User data capacity	Up to 105 Mbps Single Stream (full duplex), up to 210 Mbps Dual Stream (full duplex)
Frequency	4.4 GHz to 4.65 GHz and 4.75 GHz to 5.0 GHz in 100kHz increments
User Data and M&C	Two RJ45 10/100/1000Base-T
Diversity (one antenna)	Single Diversity, Dual Polarization Diversity, Dual Frequency Diversity
SSPA Power, P-Rated	40 dBm (10W) Standard
EIRP	<71 dBm with SSPA at full 10W output
Input Voltage	24VDC +/-1V
Total Prime Power	125W, max
Antenna Size	1 meter
Antenna Height	1.5-meter AGL
Antenna Gain Mid Band	31.8 dBi minimum @ 4.7GHz
Terminal Weight	52lbs without transport case
Transport Weight	115.4lbs in 2 airline-checkable cases. Case 1 = 59.4lbs, Case 2 = 56lbs
Operating Temperature Range (sun at any angle)	-20°C (-4°F) to +60°C (+140°F)

3.3 Troposcatter Communications On-the-Move (OTM)

Comtech is pioneering the use of troposcatter technology to enable OTM communications for multiple applications. Most recently, Comtech conducted a series of BETA Tests of a Maritime BLOS application. The testing proved that low power troposcatter is a viable means of providing high throughput communications from ship to shore while underway and in motion. The Maritime BLOS test utilized two (2) variants of the COMET system: a Shore Terminal and an OTM Terminal. For this application test, the Shore Terminal was positioned at a fixed location on the water's edge and the OTM Terminal was temporarily installed on a small craft vessel. The composition of the test systems and results of the individual tests are detailed below. The OTM terminal operated with SSPA output levels at 4W or less due to the RF input limits of the steerable array antenna.

Shore Terminal consisted of:

- 1 meter antenna
- 2-axis tracking positioner with tracking software
- Low Power Troposcatter Radio and RF Assembly
- CS67PLUS Radio
- RF Front end (10 Watt SSPAs, LNAs and Diplexer Assembly)
- Gigabit ethernet interfaces (x2)
- Tripod mounted
- Three (3) Transit Case Solution
- 15-minute setup

Figure 6 COMET with Auto Tracking Pedestal

Power Requirements: 24VDC or 110/220 VAC < 140 Watts

On-the-Move Terminal utilized an ultra-fast (sub-500ns) 24 micro-sector array antenna. This solid-state and compact FAST antenna proves ideal for highly mobile environments where minimal space is available, such as on a vehicle or small vessel.

On-the-Move Terminal consisted of:

- Electronically Steerable Array
- Low Power Troposcatter Radio and RF Assembly
- CS67PLUS Radio
- RF Front end (10 Watt SSPAs, LNAs and Diplexer Assembly)
- Two, gigabit ethernet interfaces
- All equipment pole/mast mountable

Figure 7 On -the Move Terminal

Power Requirements: 24VDC or 110/220VAC < 140 Watts

Testing Results:

Test 1: was a high-speed run to test the tracking speed of the shore antenna. At approximately 4km from the shore site, the boat traveled a path perpendicular to the shore site attaining a maximum speed of 70kph. At the point of closest approach (<600m), the shore antenna was able to successfully track the boat movement speed at a slew rate of 2 degrees per second in azimuth. The link was maintained with 100% availability.

Test 2: was a maneuver test, during this test the boat made multiple low and high-speed turns to test the tracking capability of the ultra-fast array antenna on the boat. The antenna was able to successfully track to the shore site and the link was maintained with 100% availability.

Test 3: was a distance test, the system successfully maintained 87Mbs data throughput at varying boat speeds (0 to 70kph) along with a video link out to the maximum distance of the lake (50km/31 miles) while link availability was 100%. During this test, pitch and roll of the boat was up to 20 degrees with no loss of link.

Test 4: was a distance test, the system successfully maintained 175Mbs data throughput at varying boat speeds (0 to 70kph) along with a video link out to the maximum distance of the lake (50km/31 miles) while link availability was 100%. During this test pitch and roll of the boat was up to 20 degrees with no loss of link.

Note: With an Antenna Height of 12 feet at shore and 9 feet on the boat, the radio horizon was 19.4km; distances beyond 19.4km are over-the-horizon.

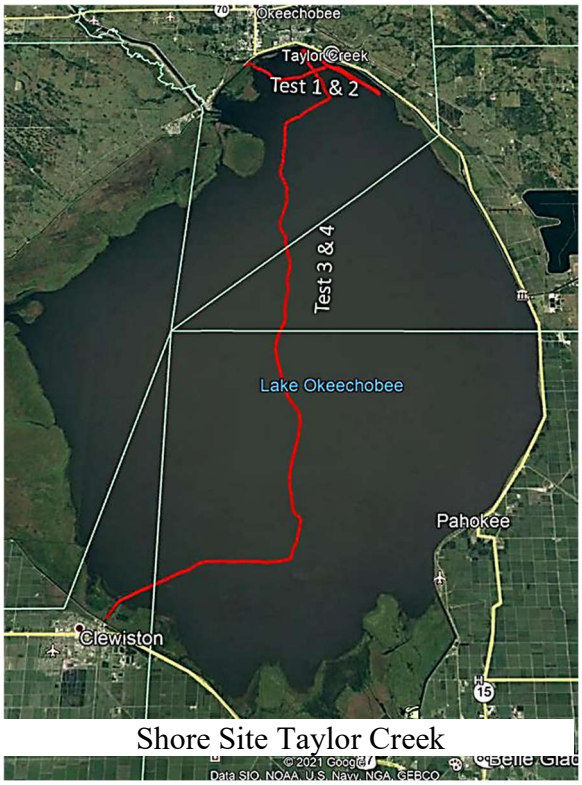


Figure 8 On-the-Move Boat Route

Testing Summary: The initial testing proved that Terrestrial BLOS communications using troposcatter technology is possible while in motion, out to distances well beyond line-of-sight. The results of this testing show that even greater distances are easily achievable with this small form factor system. Further testing was later accomplished into the Atlantic Ocean to evaluate the maximum effective range of the systems in this configuration. The system was able to communicate up to 70 miles if at sea state 4. Future testing will also validate maritime vessel to maritime vessel communication demonstrating applications where both terminals will be OTM.

4 MODULAR TRANSPORTABLE TRANSMISSION SYSTEM (MTTS)

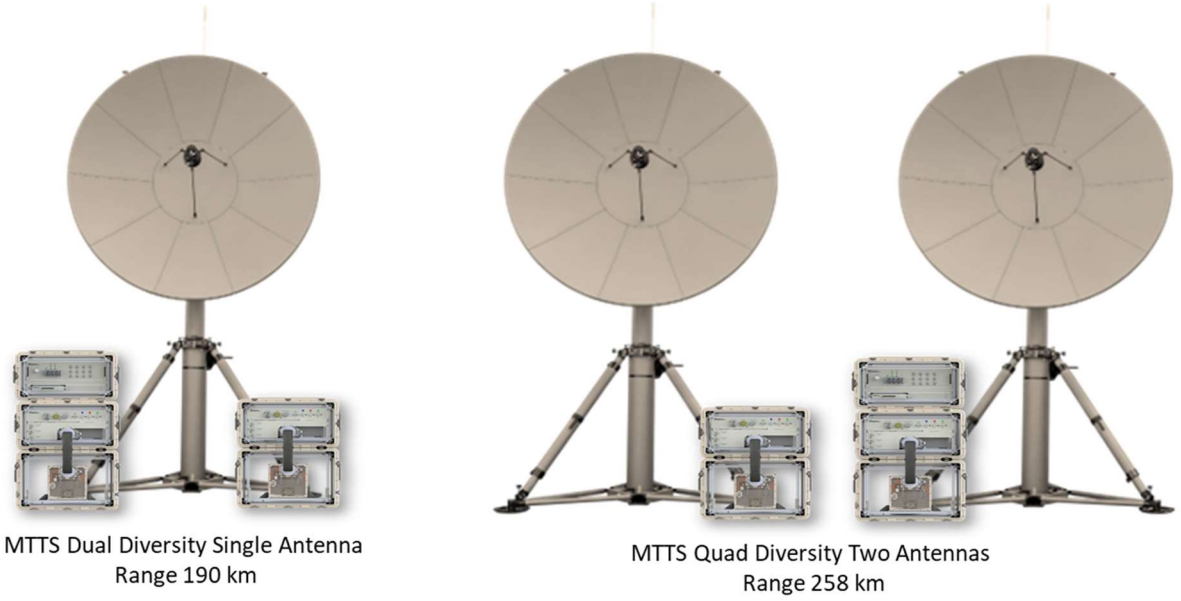


Figure 9 Modular Transportable Transmission System (MTTS)

4.1 MTTS Overview

The Modular Transportable Transmission System (MTTS-PLUS) is the largest terminal in the troposcatter FoS and yet still significantly smaller than legacy troposcatter terminals. The MTTS utilizes Comtech System's newest and most advanced troposcatter equipment and software to solve many of the past issues associated with tactical troposcatter systems. Comtech was the first company to reduce troposcatter equipment size enough to remove it from the shelter and fit it into a transit case form factor. Transit case-based systems offer the modularity that has become a standard requirement of most militaries. The MTTS, first introduced in 2008 by Comtech Systems, solved many issues for the tactical planner. Modular and scalable, the MTTS met the technological challenges of reduced size, weight, and power (SWaP) while increasing system throughput, range, and transportability. The modular design requires that only the cases needed to meet the mission requirements need to be deployed. This reduced footprint simplifies deployment efforts by reducing transport cargo space required and reducing logistical support and manpower.

MTTS Key Attributes

- Up to 250km Range
- Modular Multiband Transit case Terminal
- Automatic Antenna Alignment without GPS
- Two-person setup in one hour
- Uses CS67PLUS Radio with its full set of features
- Interoperable with all Comtech's Troposcatter Family of Systems

4.2 MTTS Technology Description

After over a decade of actual deployments of the MTTS by Militaries around the world, Comtech has redesigned the MTTS to meet new requirements for smaller and lighter weight systems that provide increased capabilities and are easier to use. The redesigned MTTS-PLUS meets these requirements by incorporating the advanced Comtech CS67PLUS Radio capable of transmission

rates of up to 210 Mbps, an optional X-band capability, and new GaN SSPAs. Combined, these enhancements provide more range and greater efficiency. The valuable feedback from soldiers and commanders has resulted in a completely new generation of troposcatter terminal. Redesigned MTTS terminals have been evaluated on multiple United States Army Test Ranges as far back as 2018 and are currently being fielded by the United States Marine Corps.

The suite of MTTS-PLUS modules/cases includes the Radio Baseband Transit Case (RBTC) – which is common to all configurations, C or X-Band Tunable Filter Cases, C or X-band 500-Watt Solid State Power Amplifier (SSPA) cases, and antenna cases. This compliment of cases allows users to add or remove transit cases as needed to meet mission requirements. The MTTS-PLUS is scalable from Dual diversity to Quad diversity to improve system throughput and range. The MTTS-PLUS provides frequency agility by offering C or X-band frequency cases. The availability of both C and X-Band SSPA Cases allows planners to select the appropriate frequency to meet the mission requirements.

Throughput and Range: With a variety of diversity configurations, the Comtech MTTS-PLUS can provide throughputs of up to 210Mbps and achieve ranges up to 250 km depending on link conditions and terrain. Performance is always terrain and climate type dependent but the MTTS-PLUS system's modularity allows for simple scalability based upon required throughput and path parameters.

Radio Baseband Transit Case: All communications systems benefit from more throughput, range, reduced size, and ease of use. These needs drove the development of the Radio Baseband Transit Case (RBTC). At the core of the RBTC is CS67PLUS Software-Defined Troposcatter Radio, the RBTC can accommodate a single CS67PLUS Radio module or two CS67PLUS radio modules for redundancy operation or for relay operation, where each radio can operate independently to provide two (2) dual diversity links. Also contained in the RBTC is a DISA APL approved Managed Layer 2 Switch allowing for multiple data interfaces via fiber or ethernet.

Figure 10 Radio Baseband Transit Case (RBTC)

RF Filter Transit Cases come in two different frequency ranges. The current C-band case operates at 4.4 to 5.0 GHz and the current X–Band case operates at 7.125 to 7.75 GHz frequency bands. An optional X-band design operating from 7.9 to 8.4 GHz can be designed easily based on a prototype design in this band proven in 2016. The system employs bandpass filters which are motorized and remotely tunable across their entire respective frequency bands. These filters provide outstanding frequency rejection outside the desired frequency channel. This is extremely important in the Transmit channel to eliminate interference with collocated systems that share the same spectrum. Equally important on the receiver channel, these filters provide isolation from local emitters operating is the same spectrum. These filters allow the MTTS-PLUS to operate with only 70MHz transmit to receive frequency separation, thereby allowing more systems to operate in a single location. This frequency agile capability increases the potential to establish reliable C2 communications in frequency congested or jamming environments.

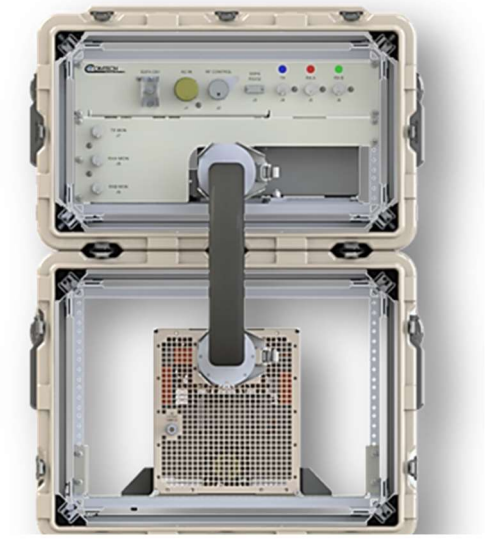


Figure 11 C-Band Filter Case and 500 Watt SSPA

Solid State Power Amplifier Transit (SSPA) Cases have the highest power efficiency and the smallest size by utilizing Gallium Nitride (GaN) technology, which provides double the output power without increasing the size. The SSPA Transit Cases are 500W in C or X-Band. All SSPAs utilize the same sized transit case, which keeps the operational and transport footprint the same. Using state-of-the-art GaN technology, Comtech SSPAs provide rated power of 500 W while maintaining the linearity required for Troposcatter applications. Comtech SSPAs are MIL STD 461 qualified and sealed, making them ideal for transportable and tactical applications. These state-of-the-art amplifiers use power combining technology to produce a high-power output from multiple stages. The SSPAs include a graceful failure mode and contain automatic fault detection circuitry. This allows for quicker diagnosis of detected faults that have occurred and helps expedite repair/replacement of the faulty component. Unlike other manufacturers, Comtech SSPAs offer a host of enhanced built-in features including temperature compensation, output sample ports, forward and reverse power monitors, power factor corrected supplies, and full remote monitor & control (M&C) capabilities. These standard features greatly enhance system maintainability. A built-in event history log is included, recording critical operational parameters (such as temperature, output power, mute status, etc.) at time stamped intervals, allowing users to quickly gather intelligence about not only the unit itself, but also its operational environment.

Figure 12 C-Band 500 Watt SSPA

Transit Case Antenna: The 2.4m antenna is an ultra-light weight, high gain portable system with automatic pointing capability. The rugged, rigid, and easily deployable flyaway antennas are designed for worldwide operation. The antenna is supplied with a troposcatter band feed assembly operating in the 4.4 to 5.0 GHz frequency range but can also operate from 7.125 to 7.75 GHz by changing the feedhorn only. The antennas are composed of carbon fiber structure, segmented reflector panels, and are equipped with motorized positioners. The antenna design is extremely light-weight and rugged with exceptional stiffness for optimal performance, even under high-wind conditions. The prime focus optics with troposcatter matched feed, coupled with the excellent profile and surface accuracy achieved with the unique carbon fiber reflectors, results in unrivaled sidelobe and cross-pol isolation performance. Antenna systems are packaged in nine rugged cases for ease of transport and protection. The MTTS-PLUS can be paired with any suitable C or X-band antenna. MTTS-PLUS terminals have been deployed with 2.4 m

Figure 13 2.4m Transit Case Antenna

Comtech parabolic antennas and 2.4 m GATR inflatable parabolic antennas. These transit case-based antennas are easily transportable and can be set-up in less than one hour by two trained personnel. Both antenna types feature auto pointing without the use of GPS when used with Comtech's Integrated Management System (CIMS). Troposcatter link acquisition (antenna sweeping) has always been the most difficult step in establishing a troposcatter link, usually requiring a seasoned operator to sweep antennas. Comtech's CIMS software accurately performs this function in as little as 20 minutes with a push of a button.

Table 1 Antenna Specifications

Description	Specification
Frequency	4.4 GHz to 5.0 GHz
Diameter	2.4 meters
Antenna Efficiency	> 60%
VSWR	≤ 1.06 : 1
Impedance	50 Ohms
RF Power	2 kW CW
Antenna Gain Mid Band	39.3 dB minimum @ 4.7 GHz
Radiation Pattern	per ITU-R F.699 reference radiation pattern recommendation
Elevation Range	-5 to +45 degrees, minimum, when deployed
Azimuth Range	+/- 60 degrees, at 10 ft., when deployed
Pointing Accuracy	+/- 0.2 degrees (Azimuth and Elevation)
Monitor and Control	Via GUI and SNMP
Input Power	48 VDC
Antenna Height	1.83 meters (6 feet) retracted 3.05 meters (10 feet) extended
Wind	Operating: Operate safely in sustained wind speeds up to 50 mph (80 km/h), gusting to 67 mph (108 km/h) Erected and lowered in steady winds of 25 mph (40 km/h) and wind gusts of up to 34 mph (54 km/h)

5 MONITOR AND CONTROL SOFTWARE

5.1 Monitor and Control Software Overview

Comtech has created a pair of complimentary PC-based applications that are designed to ease the operation and planning tasks associated with deploying Comtech's troposcatter Family of Systems. From an operations perspective, the Comtech Integrated Management System (CIMS) aids in the provisioning, operation, and monitoring of terminals in the FoS. From a planning perspective, the Quick troposcatter path analysis tool aids planners in predicting the performance of links before terminals are deployed. Both applications are standalone tools that are compatible with typical workstations used in the field. The applications are not reliant on in the field internet access to operate and can be used in coordination with NetOps and EM&C tools.

Comtech Integrated Management System (CIMS) is an PC hosted application that allows the engineers to stay home. CIMS simplifies configuration, link activation, and operation by consolidating control into a single user interface and guiding the operator through all procedures necessary to establish and maintain a link. With CIMS, it is no longer necessary for the operator to use separate programs to monitor and configure equipment. CIMS controls and monitors the Radio, Antenna Control Unit(s), and SSPA(s) and configures the equipment automatically for the task at hand (Calibration, Antenna Alignment, and Mission Configuration). CIMS has been designed to guide operators through the entire process of setting up a link. All MTTS-PLUS manageable components have SNMPv3 interfaces and MIBs for each component and can be published to work with 3rd party Monitor and Control applications to support NetOps and EM&C initiatives.

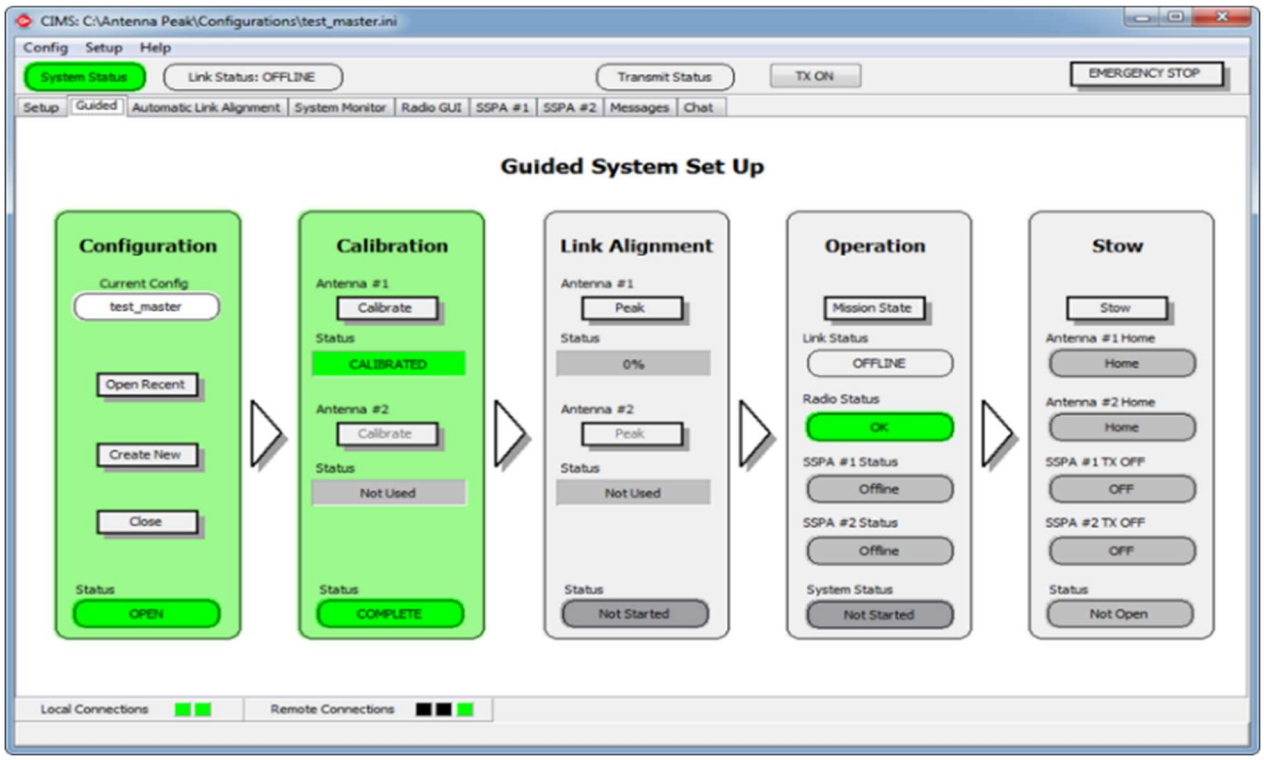


Figure 14 CIMS Guided Setup Screen

Quick Troposcatter Path Analysis Tool is software used to calculate troposcatter link performance predictions. Quick's performance prediction method is derived from well-known principles and models, such as the National Bureau of Standards (NBS) Troposcatter theories in Tech Note 101, ITU-R climate types, Hartman & Wilkerson coupling loss research, Bello delay dispersion, and Brennan diversity combining techniques. Comtech created the Quick Program so that operators can use the proven Troposcatter analysis method to perform accurate path analyses.

The main advantages of the Quick Program are speed and simplicity. After entering the station coordinates, a complete analysis can be completed in less than two (2) minutes. This allows the operator to make changes in the station coordinates and perform multiple analyses so that the optimum path can be determined for a given set of parameters in a timely manner.

The Quick Program is intended for use as a tool to quickly determine the feasibility of an OTH radio path using tactical troposcatter systems. Once an equipment file is established, the Quick Program calculates the path performance with only entering the station coordinates. While the results do not guarantee that the link will perform as profiled, the results do give the user an estimate of how the link will perform with a specified confidence level. If a path does not perform as expected, the tactical system can be relocated to a location that yields better results.

One of the most important components of a troposcatter path analysis is the terrain path profile. The Quick Program automatically reads elevation data along the path from digital terrain maps and generates a terrain path profile for the user. Automating this process greatly reduces the training necessary to derive a profile and removes inaccuracies due to human error. The Quick Program is compatible with .DT1, .HGT, and .DEM digital map data files. Data from Shuttle Radar Topography Mission (SRTM) is readily available from the United States Geological Survey (USGS) in these compatible file formats.

Quick Path Analysis
Key Attributes

- Automatic conversion between coordinate systems
- Site location optimization
- Great circle distance between two (2) sites
- View and change site locations on a map
- Antenna pointing azimuths
- Automatic path profiling via use of Digital Terrain Elevation Data (DTED) maps
- Path angular parameters
- Automatic selection of Climate Type and Refractivity based on station coordinates
- Troposcatter and Diffraction path loss and variability
- Digital modem performance under multipath conditions

Comtech has used this calculation method with consistent accuracy for virtually every type of Troposcatter path in all climate zones of the world. It has been applied to every practical equipment configuration, frequency band, and antenna size used for Troposcatter systems. Analysts have compared the measured performance of actual completed systems in order to verify results from previous system calculations and enhance the accuracy of future designs.

6 SUMMARY

Comtech has significantly reduced the complexity of deploying and operating Troposcatter systems to the point they have the same ease of use and training requirements as modern LOS and SATCOM systems found within the industry today. Comtech's Troposcatter Family of Systems are the culmination of 50 years of experience in the troposcatter industry successfully deploying systems to the U.S. Armed Forces, other countries, and commercial partners around the world.

Figure 15 Deployed Around the World