RADIO OVER SATELLITE SOLUTIONS

Abstract

Communication requirements and channels have evolved drastically in the age of globalization and it has become imperative to enhance connectivity between organizations, world-wide teams, headquarters and employees on the field. Radio communications play an essential role in this, especially in public safety, fleet operations, mining and military applications. Most radio networks use line of sight propagation or have fixed repeater stations. Radio over satellite can extend each of these networks and provide essential connectivity between headquarters and field teams during natural disasters and mission-critical applications.

Remote radio networks can be unified with fixed landlines, cellular systems or Push-To-Talk (PTT) radios facilitating encrypted, real-time direct voice and data communications to headquarters, control centers or operations rooms. With the right systems engineering and technology partner, Radio over Satellite solutions are easy to manage and deploy. They can be operated remotely and can be left unattended once installed, making this a perfect solution for communication in uncertain environments.

Careful engineering is required to ensure audio quality, latency, jitter and bandwidth of digital radio systems over satellite. Testing has confirmed that there is no discernable degradation in audio quality using radio over satellite. Thorough planning and designing of network to maximize limited bandwidth usage due to cost and link budget are required.

Introduction

Radio communications using a combination of DMR, TETRA, LTE and Wi-Fi are essential for first responders, military operations and remote work camps. Usually, communications back to command centers, dispatch centers or headquarters is conducted via light of sight propagation through repeaters or terrestrial backhauls. When the radios are too far for light of sight or when terrestrial links do not exist or are damaged, satellite communications can provide connectivity between the radios and the command centers.   Satellite communications can also support temporary increases in capacity requirements due to special circumstances such as in natural disasters.

Traditional radio communications are narrowband, mostly Push-To-Talk (PTT) voice and short messages. However, broadband communications that include videos are becoming essential. Traditional PTT radio is being augmented with LTE and Wi-Fi mesh type communications with connectivity to body cameras and drones. Broadband communications also allow the sharing of large amounts of data, including maps, building schematics etc. While satcom can support any traffic type, IP traffic is common due to its high flexibility.

The challenges of satellite communications are latency, jitter, quality of the link (BER and availability), congestion and management of remote networks. Latency is due to the distance between the earth's surface and the satellite. The satellite link is more prone to errors than terrestrial links such as fiber and more vulnerable to rain fade. Jitter can be introduced by the baseband transport scheme (e.g. TCP/IP framing), encryption and the satellite access scheme (TDMA vs SCPC). A well-designed satellite link will provide enough capacity so there are limited congestion issues and will have margin against rain fade for error-free communications majority of the time. Testing has shown that the satellite link latency is not a serious problem, and voice quality is not impacted.

Satellite communications can be expensive, and there are always trade-offs between capacity and costs. Network planning, including QoS algorithms, can be used to minimize the traffic that will traverse the satellite link and minimize costs by allowing the link to be as small as possible. Deploying local command and control dispatch systems helps ensure local traffic remains local, and only the traffic that must go to the headquarters or the main command centers traverse the satellite link.Proper QoS algorithms and well-designed satellite access schemes can be used to minimize jitter.

Satellite communications can provide a secure and robust backhaul for remote radio networks as the main link, as a temporary solution in the case of extra capacity or when terrestrial backhauls are damaged. Satellite communications can also be an integral part of a radio network in the case of military exercises or remote camps/installations. Satellite communications equipment is flexible and can be small or large fixed installations, fly-away systems, vehicle-mounted COTP or COTM terminals in either maritime, land-based or airborne applications.

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RADIO OVER SATELLITE APPLICATIONS

Radio system communications transmitted via satellite is the only choice for of connectivity where terrestrial communications services are temporarily comprised, or for very remote areas where standard terrestrial network systems are not available. Figure 1 shows a typical radio over satellite system.
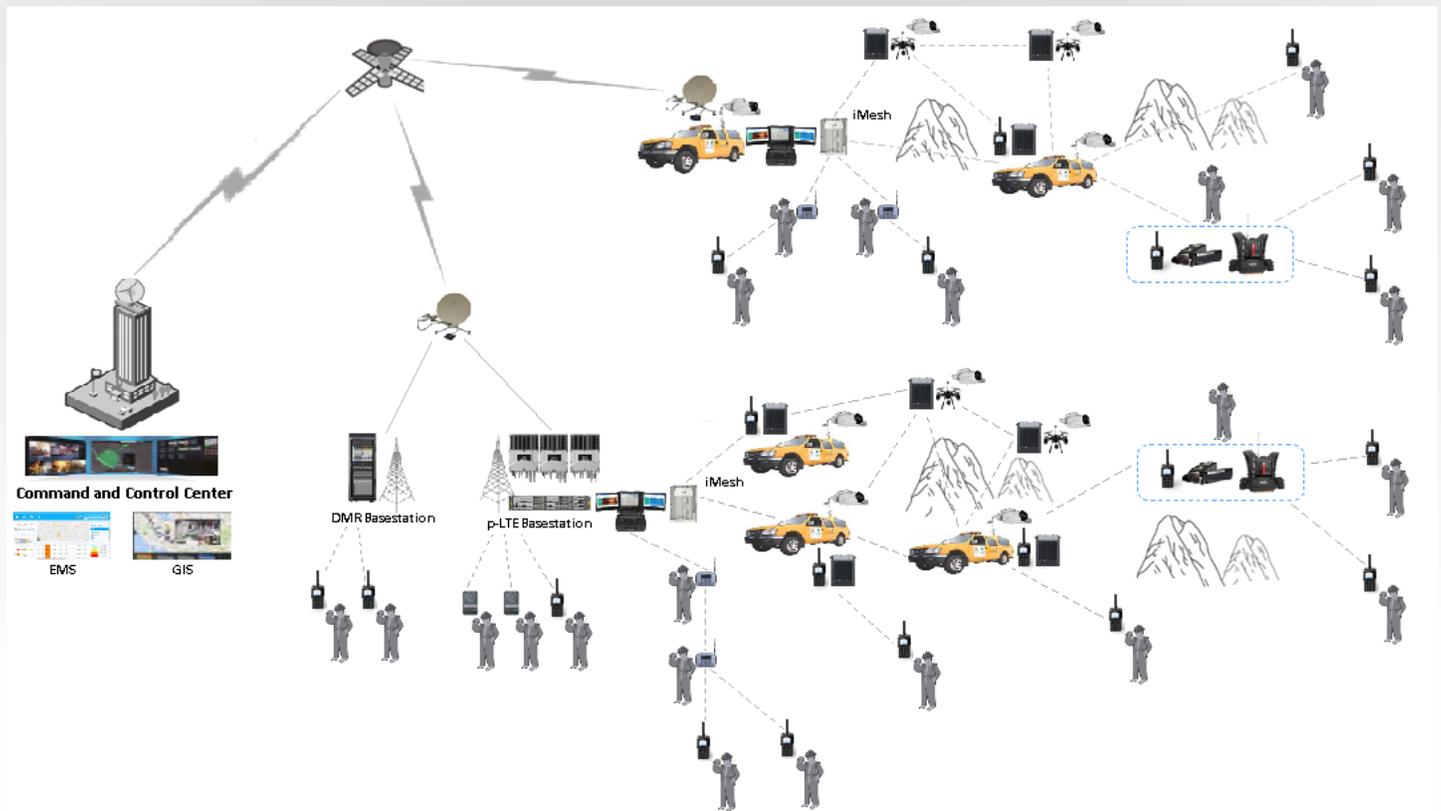

Figure 1: Switchable Path Configuration

Disaster Recovery

Public safety services for disaster recovery need reliable communications when a crisis occurs. During natural or accidental disasters such as earthquakes, hurricanes and forest fires, terrestrial network infrastructure and radio backhauls may be damaged and not available. Local communications are possible, but communications to headquarters and central command and control are interrupted.

Command and dispatch at headquarters must provide strategic orders and tactical plans to local command centers. On-site command and dispatch centers coordinate the first responders. Locally, additional capacity may be required when drones or vehicles with surveillance cameras are deployed for situational awareness of damage levels and conditions. The local command and dispatch centers prioritize the messages, voice calls and video.

Radio communication over satellite via IP can provide communication services immediately for emergency response and first responders. Satcom can re-establish the broken communications links to allow existing systems to regain connectivity with central command. It also allows new systems with additional capacity to be deployed. Since the satellite link may be the only connection back to the central command and control, it must work with all radio systems in the field, including DMR radio, LTE systems and Wi-Fi mesh networks. Communications at disaster sites are critical to quickly responding with a coordinated effort and may be required for weeks or months after the initial response as terrestrial infrastructure is repaired.

Military

The military usually operates in remote areas where terrestrial network connections are not available, hence radio over satellite may be the only way to communicate with command centers or headquarters.

Robust communications allow the headquarters or other command centers to provide strategic orders to units in the field, deliver supplies, or offer medical services for immediate rescue operations. Drones, vehicles, and individual soldiers with manpack radio nodes that extend video, voice and data communications from the main troop are necessary for even further remote area coverage. On-site command and dispatch platforms allow local commanders to communicate effectively with their assets in the field and to receive orders from regional or theatre command centers.

Remote Camps

Many mining, construction, oil drilling or exploration camps operate in very remote areas far from any terrestrial backhaul infrastructure. Satellite communications are the only way to provide connectivity back to headquarters. Communications within the camp and for those working outside the camp will often use PTT radios as well as other broadband systems. Safety of personnel is a primary concern, and having radios linked to both a local center at the camp and a head office greatly enhances this. Daily safety meetings with safety officers are often done via PTT radios. The satellite backhaul will also supply communications for day to day operations.

RADIO SYSTEMS

Digital Mobile Radio (DMR)

DMR, a narrowband standard for PMR radio systems, with its fast connecting PTT (push-to-talk) technology, predominates in voice and messaging applications. DMR Tier II and DMR Tier III are both digital communication standards that require licensing and use 2-slot TDMA (Time Division Multiple Access), both slots occupy 12.5 kHz of bandwidth. DMR Tier II uses licensed conventional radio and repeaters that interconnect dispersed sites quickly in a wide area. DMR Tier III, with its added trunking feature that allows dynamic allocation of frequencies to user groups and with the use of base stations, is more efficient and allows more user capacity compared to DMR Tier II.

Narrowband voice systems are still the key requirement in any mission-critical communications. Immediate high-quality voice calls from victims in a disaster, first-priority commands from head office, or voice and short messaging between assets in the field, are mandatory in completing the mission. All these were made possible via the DMR system.

Advantages of DMR include the PTT feature that minimizes the need for dialing and call initiating. No active receiver engagement is needed to accept and maintain active voice conversation. Also, DMR base station covers a larger area compared to Private LTE systems (P-LTE).

Private LTE

With public 4G LTE broadband technology, cell site coverage is limited with designated cell tower locations. On the other hand, p-LTE, with the use of micro towers and small cells, can operate independently of public LTE networks, and provide flexible and extended coverage and capacity in a LAN.

The disadvantage of narrowband DMR is that it can only handle relatively small amounts of data. When higher data rates are required, p-LTE would be one of the solutions, as it is convenient and efficient for data media services like video streaming. Challenges with transmitting data via the p-LTE system over satellite include latency and limited satellite bandwidth. In terms of voice communications, with the added feature of VoLTE (Voice over Long Term Evolution) in 4G, voice calls can be transmitted as part of data flows. However, the higher cost of voice calls via broadband p-LTE system made it a second choice compared to voice communications via a narrowband DMR system.

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iMesh

iMesh is a 4G broadband solution with intelligent data routing that can connect to satellite, fiber, p-LTE, and Wi-Fi. iMesh can either operate as an independent network of its own or directly connect to satellite link or wired backbone. iMesh can be applied as a robust backhaul for fixed or mobile base stations when deployment of fiber is not possible, or be connected to a p-LTE network to expand coverage areas at even more remote areas like deep valleys and mountains.

iMesh consists of portable radio nodes. The nodes can be mounted on walls and poles as fixed nodes, or in vehicles and drones as mobile nodes. The ad-hoc nodes are connected through a direct wireless connection to form star, chain, mesh, or hybrid topologies. The links between the nodes are automatically matched and established. Voice, video and data transmissions are routed between the iMesh nodes to communicate with end radio terminals.

The iMesh solutions also have an option for a local command and control center for both narrowband and broadband voice, video and data communications, which allows local dispatch within a geographical region. The command and control center can be connected to iMesh nodes for broadband communications. They can also be connected to narrowband radio mesh node to be used as an end voice radio terminal or to form an ad-hoc DMR network to route voice traffics.

CHALLENGES WITH RADIO OVER SATELLITE

The challenges of radio over satellite include latency, jitter, limited bandwidth and poor link quality. Careful network planning, including traffic flows, traffic estimates, and QoS (Quality of Service), is required to ensure satellite traffic, latency and jitter are minimized.

Latency

Geostationary satellites are in orbit about 36,000 km above the equator and from the earth appear to be at a fixed location in the sky. The propagation delay for an RF signal between the earth station at the ground and satellite is about 125 ms so the propagation delay between the transmitting earth station and the receiving earth station is about 250 ms. Satellite networks generally fall into three categories:

a) Point to Point;
b) Star networks; and
c) Mesh networks.

The round trip delay between a transmitting earth station and the intended earth station depends on the network topology.

A Point to Point network is the simplest network and involves a single transmitting earth station and a single receiving earth station. Typically, this configuration uses a Single Channel Per Carrier (SCPC) and provides the most efficient use of satellite bandwidth and has the lowest latency and jitter.

A star network is the most deployed satellite network topology, with all traffic routed through a central Hub Earth Station via satellite. The Hub Earth Station is often located in a headquarters facility or has a direct terrestrial connection to a headquarters facility. The Hub Earth Station controls the SATCOM network and IP network management and monitoring of the network. Satellite networks provide multiple access capabilities where many users share a pool of bandwidth. Multiple access techniques are available, including TDMA access schemes, dynamically assigned SCPC links and combinations of these. While multiple access techniques can save on bandwidth costs, they usually introduce additional latency and jitter.

Traffic from a remote earth station to the Hub is like the point to point network above in that it involves a single satellite hop (Remote-Satellite-Hub). If traffic is destined to the Hub Earth Station, then no further links are needed. However, if traffic is destined to another remote earth station, the traffic must be retransmitted to the satellite and back to the second remote earth station. This involves two satellite hops with a nominal propagation delay of 500 ms. Table 1 summarizes the total latency for various communication routes for Star and Mesh topologies. The total latency between end radio nodes is the propagation delay plus the system delay of the routers/switches, modem and other associated equipment connected to each Remote Earth Station and Hub.

In a Mesh topology, Remote Earth Stations communicate directly via satellite and do not go through a Gateway Earth Station. For this topology, more capable Remote Earth Stations with larger antennas are required to have strong satellite links for good throughput. Traffic from Remote Earth Station 1 to Remote Earth Station 2 would be via one satellite hop, with a typical propagation delay of approximately 250 ms. Return traffic from Remote Earth Station 2 to Remote Earth Station 1 would also be via 1 satellite hop. Hence, roundtrip traffic between the two Remote Earth Stations in the Mesh topology would be via two satellite hops, with a typical propagation delay of approximately 500ms. Again, actual latency will be higher due to lag through routers, switches repeaters connected to the earth station.

Table 1: Latency Estimates For Star and Mesh Topologies

	Total Latency via Star Topology	Total Latency via Mesh Topology
Remote Terminal to Hub Earth Station	250 ms + Propagation Delay + System Delays	250 ms + Propagation Delay + System Delays
Round Trip Remote Terminal to Hub Earth Station to Remote Terminal	500 ms + Propagation Delay + System Delays	500 ms + Propagation Delay + System Delays
Remote Terminal to Remote Terminal	500 ms + Propagation Delay + System Delays	250 ms + Propagation Delay + System Delays
Round Trip Remote Terminal to Remote Terminal and back	1000 ms + Propagation Delay + System Delays	500 ms + Propagation Delay + System Delays

Jitter

Shared bandwidth satellite networks typically have more jitter, while dedicated links generally have the lowest jitter. Encapsulation of application data into IP packets can also cause jitter. Processing of packets through routers implementing QOS algorithms can add to the problem. Jitter can affect the quality of voice and video. Increased jitter on shared bandwidth networks is due to the non-uniform allocation of bandwidth to a user. Techniques to minimize this include using smaller bandwidth allocations that spread out the total allocation making it more uniform.

Limited Bandwidth

Satellite bandwidth is expensive and is sometimes in short supply. In any case, satellite bandwidth is usually much less than what is available on a terrestrial network. Bandwidth can be shared amongst many users or dedicated to one user. Shared bandwidth uses a multiple access sharing mechanism such as TDMA (Time Division Multiple Access) and supports various remote terminals within a pool of bandwidth. Dedicated bandwidth means each earth station has a specialized carrier, SCPC (Single Carrier per Channel). A shared bandwidth scheme is best suited for applications that have multiple remote terminals where terminal traffic varies, and statistical multiplexing can reduce overall bandwidth requirements. Dedicated bandwidth is best suited for cases where there are only a few remote terminals or where user traffic is constant. SCPC links are the most efficient links in terms of overall throughput efficiency, and they have the lowest latency and jitter.

It is important to design and deploy a cost-effective satellite network considering the types of equipment, satellite network topology, traffic to be transferred, number of remotes and future scalability. Traffic estimates are based on the expected number of concurrent users, the different technologies used (DMR, p-LTE (private LTE), iMesh) and the applications in use (real-time applications, video streaming, audio, email, file transfer, video conferencing, broadcast). Once estimates of the traffic are determined, the bandwidth requirements can be determined using link budget analysis. The size of the transmitting and receiving antennas, transmit power satellite, earth station locations, BER performance requirements and availability are all factors. It may not be possible to meet all requirements, so some trade-offs will be required. The following table provides some estimates of the data rate needed for various applications.

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Table 2: Data Rate per Application

Data Type	Codec	Data Rate (kbps)
DMR Radio Overhead		88
DMR	per channel	20
P-LTE Overhead		128
Audio	G723	24
Video	H.264 480p	1000
Data	Ethernet	128

The traffic requirements for each earth station is estimated based on the number of each application required. Larger earth stations will be more capable in terms of transmitting and receiving data and will typically service a location with more traffic requirements such as a local command center. Once the earth station traffic requirements are estimated, the satellite bandwidth required is determined by doing a link budget analysis.

If actual traffic requirements are greater than the capacity of the satellite bandwidth allocated to the network, increases in latency, jitter and even lost data may be encountered. Different network deployments should be considered to optimize the use of bandwidth. For example, deploying EMS, GIS servers at the remote sites instead of the headquarters could be a consideration in reducing traffic that must be passed through the satellite. The network QOS can be used to prioritize traffic to ensure priority traffic is always delivered.

Link Quality

The satellite link is a hostile environment compared to most terrestrial backhaul links. The vast distances involved mean huge propagation losses. Rain fade, scintillation and background noise mean the Bit Error Rate (BER) of satellite link is lower than a terrestrial link. This can be overcome with careful design including choice of remote earth station equipment, Uplink Power Control (UPC), Adaptive Modulation and Coding (ACM), modulation, Forward Error Correction (FEC) coding and use of design margin. Despite these challenges, Quasi Error Free (QEF) links are routinely created.

MITIGATION OF CHALLENGES

Quality of Service (QoS)

QoS becomes extremely important to ensure the seamless integration of different traffic types and applications. QoS algorithms can be implemented in the SATCOM modem or an IP router connected to the modem. Different QoS priorities can be applied to various traffic types, applications and even remotes, thus ensuring preference is given to the highest priority traffic. Priorities can be defined but typically voice and real time applications are the highest priority

Service Level Agreements (SLA)

In a dedicated link scenario, all the satellite bandwidth is available to the remote user and QOS is used to prioritize. In a shared bandwidth scenario, there may be many remotes. The SATCOM network design will have a default SLA of Committed Information Rates (CIR) and maximum information rates (MIR) per remote user. These can be adjusted to ensure more bandwidth is available to the remote earth stations that need it.

TCP Acceleration

TCP/IP traffic does not handle latency well. Without some mitigation techniques, TCP/IP would be limited to about 100 kbps on a satellite backhaul. TCP Acceleration is a generic name used to describe various mechanisms such as SNACK (Selective Negative Acknowledgment), window scaling and flow control to improve efficiency and the quality of service of satellite communications. SNACK, which identifies specific lost or corrupted data packets, then resending these packets only, can quickly restore transmissions and make better use of satellite bandwidth. TCP acceleration supports Window Scaling, with window size that far exceeds the limit of 64 bytes for standard TCP window. TCP Congestion Avoidance and Control mechanism manages window size to avoid unwanted retransmission of packets by using fair share and dynamic right-sizing buffer managements.

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Bandwidth Compression

Traffic compression appliances are available that will compress both TCP/IP headers and payloads. These techniques are lossless, so no data is lost. Bandwidth compression can significantly reduce traffic requirements.

TESTING OF RADIO OVER SATELLITE

Testing has been performed to confirm that the typical latency and jitter associated with satellite links do not cause problems with call set-up, operation and audio quality. The testbed used for testing the voice quality with latency includes the following assumptions and conditions:

      1) Star topology
      2) TDMA scheme was used
      3) Radios were located at remote terminal
      4) Audio quality was determined by comparing recordings

Test 1 Remote Trunking Radio to Remote Trunking Radio

Figure 2 shows the equipment set-up and traffic flow for this test between a Police Digital Trunking (PDT) standard radio at a remote terminal and a second PDT radio at a second remote. For convenience, both PDT radios were located at a single remote terminal, but traffic flow and latency are the same as if they were located at separate terminals. The traffic flow is from PDT 1 through the satellite to the Mobile Switching Office (MSO) at the Gateway Earth Station and then back to PDT radio2 via satellite. The traffic flow encompasses four satellite hops. The tests show no discernable difference in the audio between the transmit and receive radios. A summary of the tests and results is provided in Table 3. All latency times are approximate and include call set-up and delays through modems, routers and other equipment.
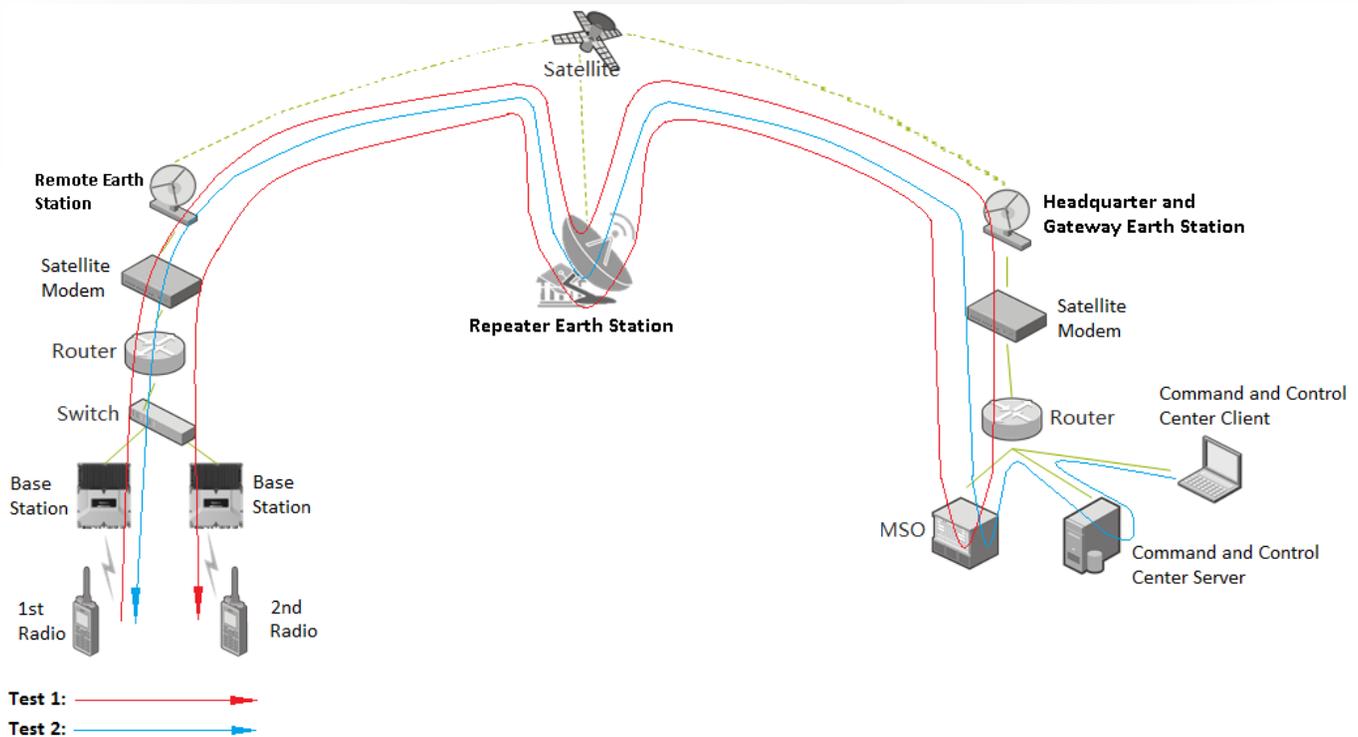

Figure 2: Test 1 Remote Trunking Radio to Remote Trunking Radio

Table 3: Remote Trunking Radio to Remote Trunking Radio Test Results Summary

Project	Description	Results
Single-call	Radio1 to Radio 2 Single Call	Pass. The voice quality is good, and the voice is delayed by about 1200ms from the sender to the end receiving.
Group call	Radio 1 to Radio 2 Group Call	Pass. The voice quality is good; the voice delay is about 2000ms.
Broadcast calls	Radio 1 to Radio 2 Broadcast Call callsPdtTerminal2	Pass. Good voice quality, voice delay1200ms。
Short message	Radio 1 to Radio 2 Short Message	Pass. Short message sent to receive delay1200ms。

Test 2 Remote Trunking Radio to Local Trunking Radio

Figure 3 shows the equipment set-up and traffic flows for a test between a Police Digital Trunking (PDT) standard radio at a remote terminal and a second PDT radio co-located with the MSO. The traffic flow is from PDT 1 through the satellite to the Mobile Switching Office (MSO) at Headquarters and Gateway Earth Station and then to PDT radio 2 located line site with the MSO. The traffic flow encompasses two satellite hops. The tests, again, show no discernable difference in the audio between the transmit and receive radios. A summary of the tests and results is provided in the following table. All latency times are approximate and include call set-up and delays through modems, routers and other equipment.
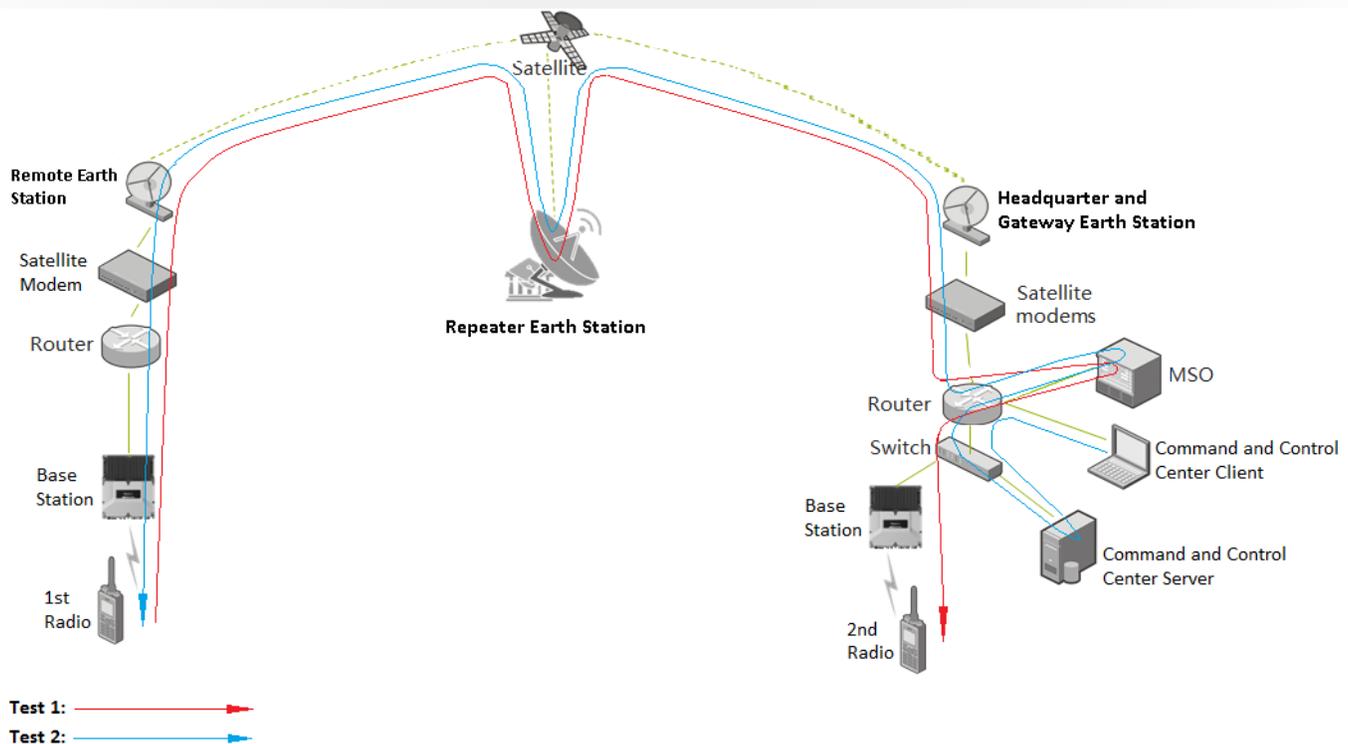

Figure 3: Test 2 Remote Trunking Radio to Local Trunking Radio

Table 4: Remote Trunking Radio to Local Trunking Radio Test Results Summary

Project	Description	Results
Single-call	Radio1 to Radio 2 Single Call	Pass. Good voice quality, delay1000ms。
Group call	Radio 1 to Radio 2 Group Call	Pass. Good voice quality, delay1100ms。
Broadcast calls	Radio 1 to Radio 2 Broadcast Call callsPdtTerminal2	Pass. Good voice quality, delay1000ms。
Short message	Radio 1 to Radio 2 Short Message	Pass. Short message reception is normal, delay is approximate 1000ms。

Test 3: Remote Tier II Radio to Remote Tier II Radio

A test using a set-up like Figure 2 was conducted using Tier II non-trunking radios. Each base station was replaced with a repeater that converts the DMR radio air interface to IP packets. The traffic flow is Radio 1 to the satellite hub and then back to Radio 2 via satellite. The traffic is simply routed back to radio 2 at the hub. The latency from radio 1 to radio 2 was about 700 ms. This latency includes call set-up and delays through modems, routers and other equipment. There was no discernable degradation in audio quality.

RADIO OVER SATELLITE COMPONENTS

A typical Radio over satellite set-up would include a headquarters site with a Gateway Earth Station, including an antenna system, RF transmit system, RF reception system and a SATCOM Network Hub. Co-located with the SATCOM system and connected by LAN/WAN are the command and control systems necessary to the remote systems including:

a) Firewall;
b) Routers/switches;
c) Command and control center (dispatch, CCTV, EMS, GIS) platform;
d) Servers;
e) Network Management System (NMS);
f) Mobile Switching Office;
g) Radio base stations;
h) Connection to external WAN; and
i) Connections to PSTN.

At remote locations, a simpler SATCOM system consisting of an antenna system, RF transmit system, RF receive system and a modem is connected via a LAN to different radio systems such as DMR, p-LTE, iMesh, and Wi-Fi. Figure 4 shows a typical set-up.
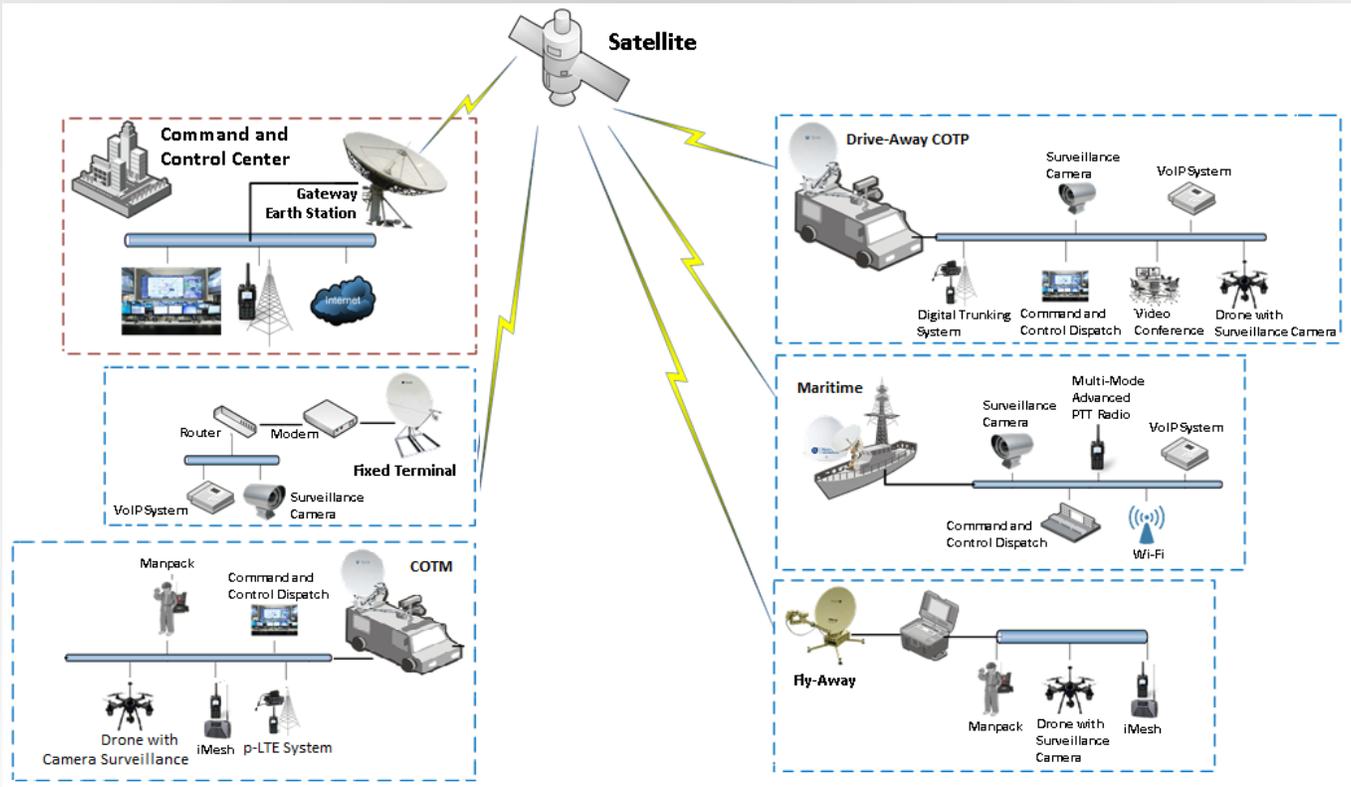
Figure 4: Digital Radio Systems over Satellite Components

SATELLITE TERMINAL CHOICES

Remote Satellite Earth Stations are usually VSATs (Very Small Aperture Terminal) with antenna sizes ranging from 45 cm to 3.8m and are designed to operating in C, X, Ku or Ka-band. These terminals can be used to either to communicate via Gateway Earth Station with a large antenna in a Star topology or to communicate with other Remote Earth Stations via Mesh topology. The different types and sizes of VSAT antennas are used for various applications, depending on bandwidth, network topology and environmental requirements. The main types of Remote VSAT terminals include fixed portable Fly-Away, Drive-Away COTP (Communications on the Pause), COTM (Communications on the Move), and maritime.

Figure 5: Types of Remote SATCOM Terminals

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Figure 6: Representative Satcom Solution with Different Types of VSAT

Fixed VSAT

Fixed VSAT terminals typically have antenna diameters between 1.2 to 3.8 meters and, as the name implies are used in applications where the antenna is not required to move. Regional headquarters that are not located at the Gateway Earth Station often use larger fixed VSAT terminals because they have better performance than portable terminals. Fixed VSATS are cheap relative to more portable terminals and are usually manually pointed. The larger antennas can accommodate higher transmit and receive throughput and are ideally suited to support local command and control centers (including CCTV, EMS and GIS). Operators can collect and analyze audio, video and data received from other sites and coordinate orders and commands to first responders and soldiers in the field.

Fly-Away (Portable)

A Fly-Away satcom terminal is a portable station with typical antenna diameters of 0.6 to 2.4 meters. It can be manually pointed or have automatic satellite acquisition capability. When it comes to disaster recovery and battlefield situations, a Fly-Away is an obvious choice being light-weight, easy to carry and fast to assemble. First responders can immediately set up the Fly-Away with other network equipment and radio systems and be able to communicate with the command and control center for coordinated responses. The Fly-Away can also be directly connected to a local command and control center in the field, to allow local dispatch for in-field personnel using iMesh broadband connections or DMR radios.

Drive-Away (COTP)

Communications on the Pause (COTP) antenna system are installed on vehicles and are stowed during transit. Once the vehicle arrives at its destination, the antenna is automatically deployed. COTP terminals generally have antennas from 1.0 to 1.8 meters. COTP terminals are ideally suited for mobile command posts with the satcom antenna mounted on the roof of a vehicle and the baseband equipment, radio equipment and other networking equipment located inside the vehicle.

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COTM

Vehicle-mounted COTM terminals antenna are smaller and less capable in terms of throughput than the other remote terminals discussed. Antenna sizes are typically 0.45 to 0.9 meters in diameter. The COTM terminal automatically acquires and tracks the satellite and can maintain normal communications, including voice, data and video while the vehicle is moving.

Maritime

Maritime terminals are designed for use at sea on various vessels. Antenna sizes are typically 0.6 to 1.5 meters in diameter. Like the COTM terminals above, maritime terminals automatically acquire and track the satellite and maintain communications while the vessel is underway.

CONCLUSION

Radio communications using a combination of DMR, TETRA, LTE and Wi-Fi are essential for first responders, military fleet operations and remote camps. Usually, communications back to a command center, dispatch center, or headquarters is via line of sight propagation, through repeaters or terrestrial backhauls. When the radios are too far for line of sight or when terrestrial infrastructure does not exist or are damaged, satellite communications can provide connectivity between the radios and the command centers. Satellite communications can also support temporary increases in capacity requirements due to special events or natural disasters.

Traditional PTT radio is being augmented with LTE and Wi-Fi mesh type communications for connectivity to body cameras and drones. Broadband communications also allow sharing large amounts of data, including maps, building schematics etc.

The challenges of satellite communications including latency, jitter, lack of bandwidth, quality of the link (BER and availability), congestion and management of remote networks, can be mitigated with careful planning, QOS, SLAs, TCP acceleration and bandwidth compression. While the latency due to the distance between the earth and the satellite is always present, testing shows that audio communications are usable, and good quality.

Satellite communications can provide a secure and robust backhaul for remote radio networks as the main link, as a temporary solution in the case of extra capacity or when terrestrial backhauls are damaged. Satellite communications can also be an integral part of a radio network in the case of military exercises or remote camps/installations. Satellite communications equipment is flexible and can be small or large fixed installations, Fly-Away systems, vehicle-mounted COTP or COTM terminals in either maritime, land-based or airborne applications.