Remote Satellite Communications Using the ACU-M™

Purpose

This application note will discuss economical and improved communications through the use of the ACU-M in conjunction with remote satellite communications.

Introduction

Land mobile radios have been considered the primary communications tool used by our emergency first responders for over 90-years. Even as other unique communication technologies emerge, such as cellular phones, iDEN®, VoIP, not to mention the dozens of modulation schemes designed to pack more digitized-human-speech into our data streams, the use of the LMR will be around for many more years to come.

This is evident in the fire services, when in the early days firefighters didn't rely on radios, but utilized hand signals and face-to-face communications. Orders from team leaders and incident commanders were relayed to the firefighting teams using runners, and in many cases these techniques are still used to some lesser degree.

Many years ago it was unheard of for every firefighter to posses his or her own radio. But as safety concerns and forward thinking with regards to firefighting tactics have emerged the use of the handie-talkie is now a reality to many firefighters. No longer should a firefighter enter a burning building without proper means of receiving or transmitting communications.

In the unpredictable environment of a wildland fire, communication is paramount. But, even in the case of wildland fire crews, not all members carry radios, in fact more often, it is the responsibility of the crew leader to carry a single land mobile radio. Some state governments have been concerned with wildland fire safety by establishing mutual aid fire frequencies, and enforcing requirements that responding agencies must have specific communications equipment, frequencies and capabilities before participating in the wildland fire.

State, Federal and Forest Service agencies have even erected statewide and nationwide radio and microwave infrastructure comprising of a system of land mobile radio bases and repeaters, microwave links, and digital networks that reach into our most remote mountains, forests and desert locations, in anticipation of providing communications for our front line crews.

Even with this equipment and these procedures in place, wildland firefighters regularly battle fires in regions that are not supported by fixed communications infrastructure, and sometimes are cutoff from important information, such as weather reports, movement of the fire, aerial water drops, crew vectors, etc, not to mention emergency requests from the firefighters themselves.

Satellite voice communications technology is beginning to surface, as did land mobile radios, as an important tool for our first responders. They are more compact, easy to use, and reliable. But as with all promising technologies, for the time being, satellite communication remains out of reach for most agencies, as recurring costs of service is the main concern.

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Solutions

Wildland Fire Scenario

When hand crews enter remote locations to begin wildland fire suppression, their ability to communicate with the incident command post, company supervisor and crew boss is essential for properly applied tactics and most paramount, their personal safety.

Figure 1: "Hotshot" Team

The containment of wildland fires has become a science. It is a common site at a wildland fire incident command post to see charts, maps and computers displaying such things as, Burning Index, Drought Index, NOAA weather observation maps, fuel moisture content, Lightning Activity Level, relative humidity, Weather Information and Management Systems (WIMS). This information is used to help the hand crew and aerial operations direct the path of a fire, and subsequently, contain the fire.

The Incident Action Plan (IAP) is of no value unless the crews on the fire lines can receive orders and directives from the incident command. And as weather and other conditions change, so does the safety of the fire crews in those remote locations. The danger of crew entrapment becomes more of a danger with the lack of communications in these isolated locations (see Figure 2).

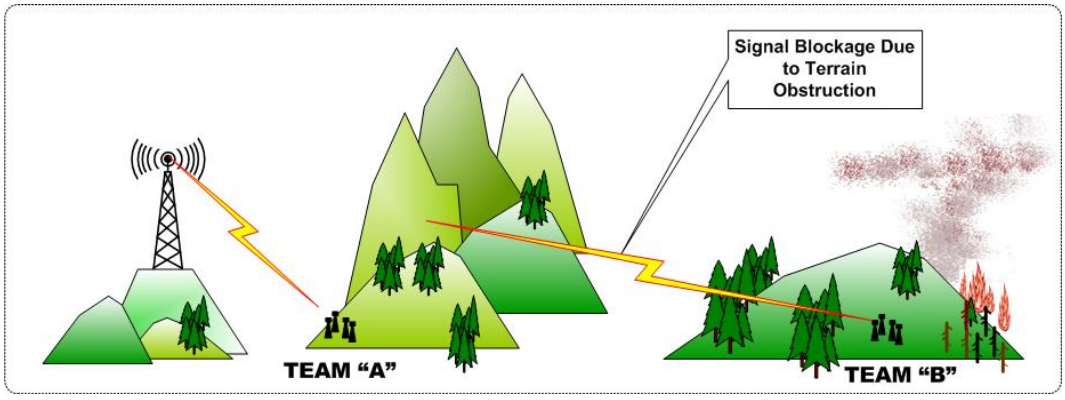

Figure 2: Isolated Communications of Remote Hand Crew "B"

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Portable LMR Repeater

Some fire organizations use portable LMR repeaters that, when properly located, will relay communications from the firegrounds to the main system repeater over obstacles such as mountain ridges, thus providing a link to the incident command post.

In Figure 3, an ACU-M is used as a portable gateway repeater site (see Application Note, *ACU-M Improving In-Building Communications - AN2306-1*). The Yagi directional antennas help localize the signals and improve reach by increased gain. Portable repeaters are easily transportable and can be placed in almost any location to improve communications. By using the ACU-M as the repeater controller, it inherently provides both radio interoperability and the repeater function.

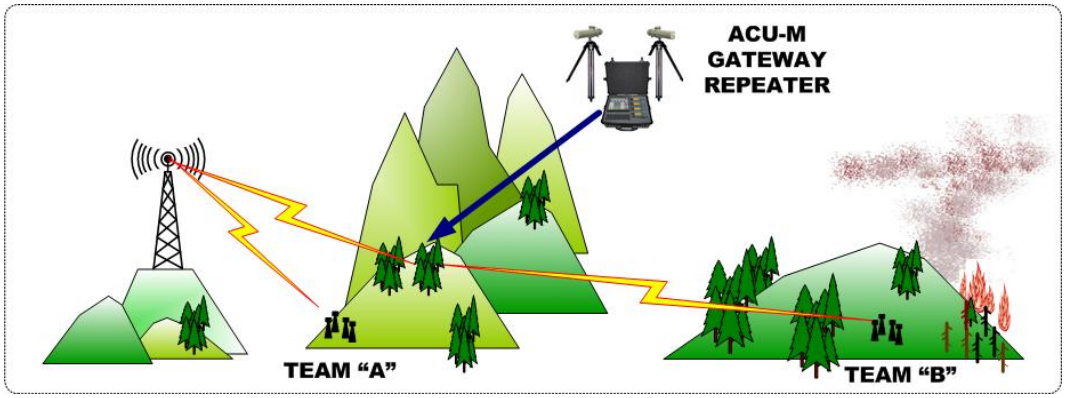

Figure 3: Portable ACU-M Gateway Repeater Site

One shortcoming when using a portable LMR repeater is that it must have an unobstructed view from the transmitter to the receiver, also known as line-of-site (LOS), of an available LMR repeater site and in some wildland locations, this is all but impossible. As hand crews are vectored to different locations, the portable LMR repeater will need to be repositioned to track the teams, thus LOS may no longer be achievable.

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Satellite Communications

A reliable form of communications that has become common place at the site of an emergency is satellite communications, usually in the form of handsets that resemble bulky cellular phones or portable terminals that have separate handsets and antenna assemblies. In all cases, these devices utilize satellites either in Low-Earth orbits (continuously moving relative to a ground location) or geosynchronous/geostationary locations fixed above the equator. Their main advantage is that they do not rely on the localized infrastructure (power, fiber, copper, or microwave) to secure a communications link. Known as a *Bent Pipe*, the satellite communication link utilizes a ground segment or ground station as the entry point to the terrestrial infrastructure (see Figure 4).

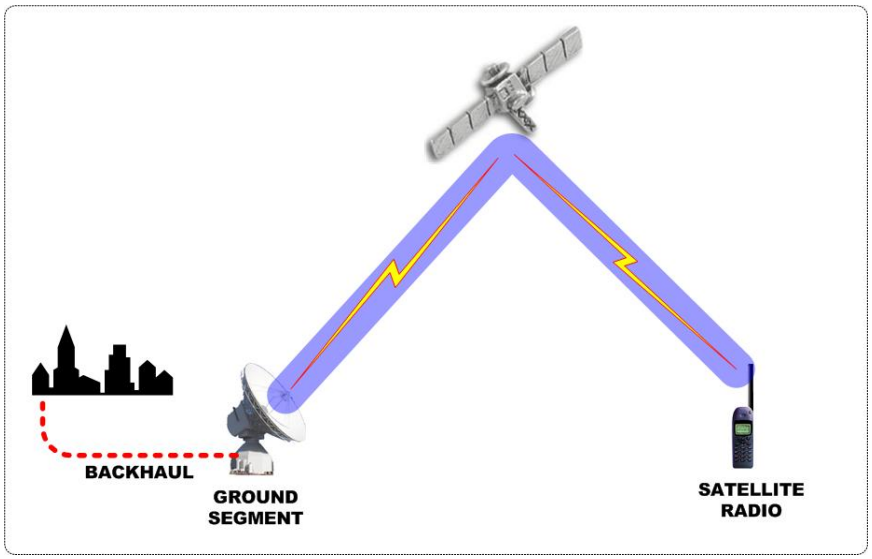

Figure 4: "Bent Pipe" Satellite Communications

In theory, as long as you have a clear view of the satellite, communication should be attainable from almost every location on the earth's surface. This feature, as well as the reliability of satellite phones and satellite radios, lends themselves well to remote wildlands fire communications.

i	Please refer to the satellite vendor's manufacturing specifications that define the satellite coverage on the earth's surface. By the nature of the their earth orbit, some low- and medium- earth orbiting satellites do not provide coverage at the north and south poles.

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Cost

As with all unique and emerging technologies, satellite communications is still out of reach of many emergency service agencies, and particularly wildland firefighting organizations. The majority of wildland fire crews are comprised of volunteers that, in some cases, must purchase their own equipment. The services provided by satellite telephones and satellite terminals are recurring costs that many of these agencies are unable to bear. The costs multiply as each crew member is outfitted with his or her own satellite phone or radio (see Figure 5).

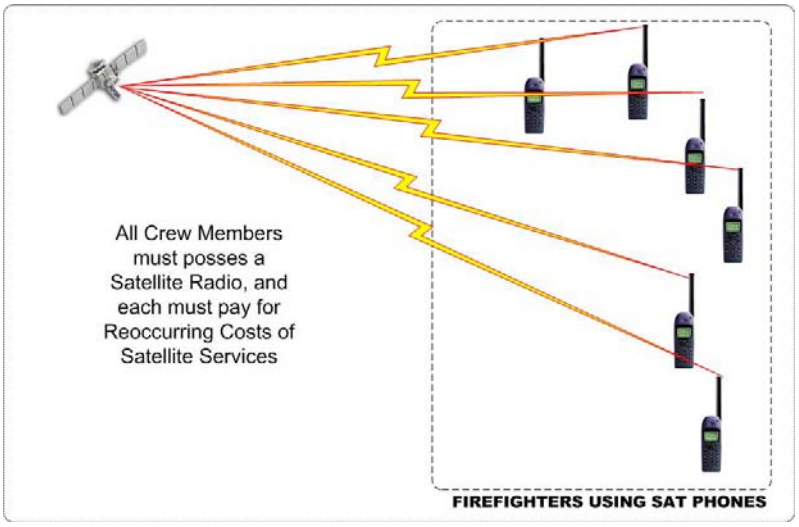

Figure 5: High Recurring Costs for Satellite Services

The ACU-M

The ACU-M is a miniature version of our powerhouse ACU-1000. The ACU-M is feature-rich, easy to use and can be networked and managed remotely. The ACU-M is an interconnecting device that will provide interoperability between 4 audio devices (radios and or satellite phones/radios/terminals), plus 2 VoIP channels and a local operator (see Figure 6).

Figure 6: ACU-M: Intelligent Interconnect

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The ACU-M incorporates the features of Raytheon's proven ACU® technology into a smaller package ideal for mission-critical deployment. With its comprehensive suite of DSP functions, the ACU-M offers high functionality at an affordable price.

The ACU-M can be operated with a computer using the ACU Controller software graphical user interface, or by its intuitive control panel which includes system status and diagnostic indicators. To facilitate quick set up and optimization, the ACU-M includes an internal radio template library for all supported communications devices.

The ACU-M offers optional network connectivity and control. Meaning the ACU-M™ will not only support tactical interoperability, but with the network option it can support RoIP communications and be controlled over an IP network, and be employed in Raytheon's Wide Area Interoperability System (WAIS™).

Shared Resource

The ACU-M unit provides sharing of baseband audio between a combination of (4) radios and satellite phone/radio/terminals. Communications nets (conferences) can be put together between any or all of the connected devices, as well as a local operator using the unit's handset & speaker.

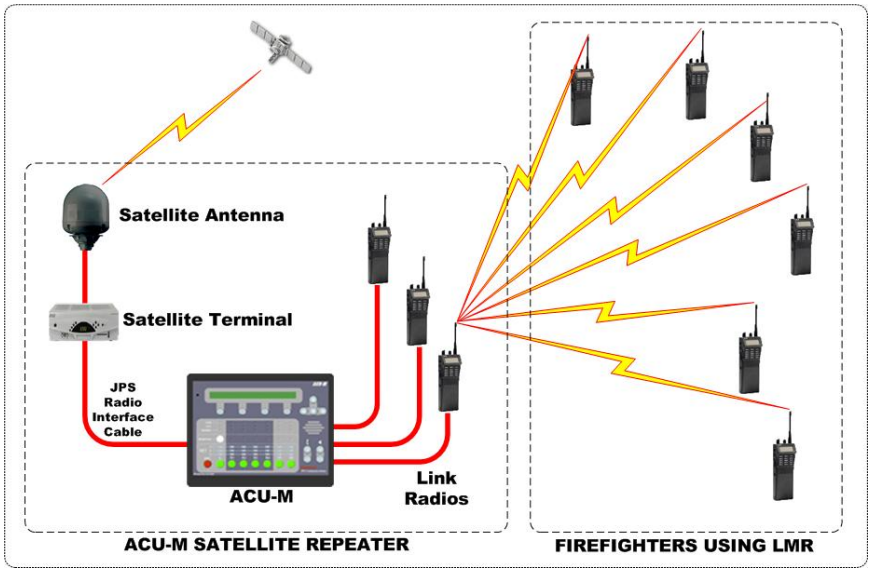

Figure 7: ACU-M Turns Single Satellite Terminal into a Shared Resource

Instead of each team or crew member being assigned a satellite phone, they can use the ACU-M to share a single satellite asset by linking communications from their current land mobile radio handie-talkies to the single satellite phone (see Figure 7).

The combination of the ACU-M, satellite radio, and land mobile radio creates a portable satellite repeater. All crew members able to transmit to the LMR link radio at the ACU-M satellite repeater can communicate to the Incident Command Post via the satellite backhaul method.

Since the crew can contact the satellite using their LMR hand held radios they can also communicate with the rest of the crew(s) using a single communications device, as compared to

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carrying an LMR hand-held plus a satellite radio. The ACU-M, satellite radio or terminal, and LMR link radios can be enclosed in a weatherproof case to be carried in a small vehicle or ATV (see Figure 8).

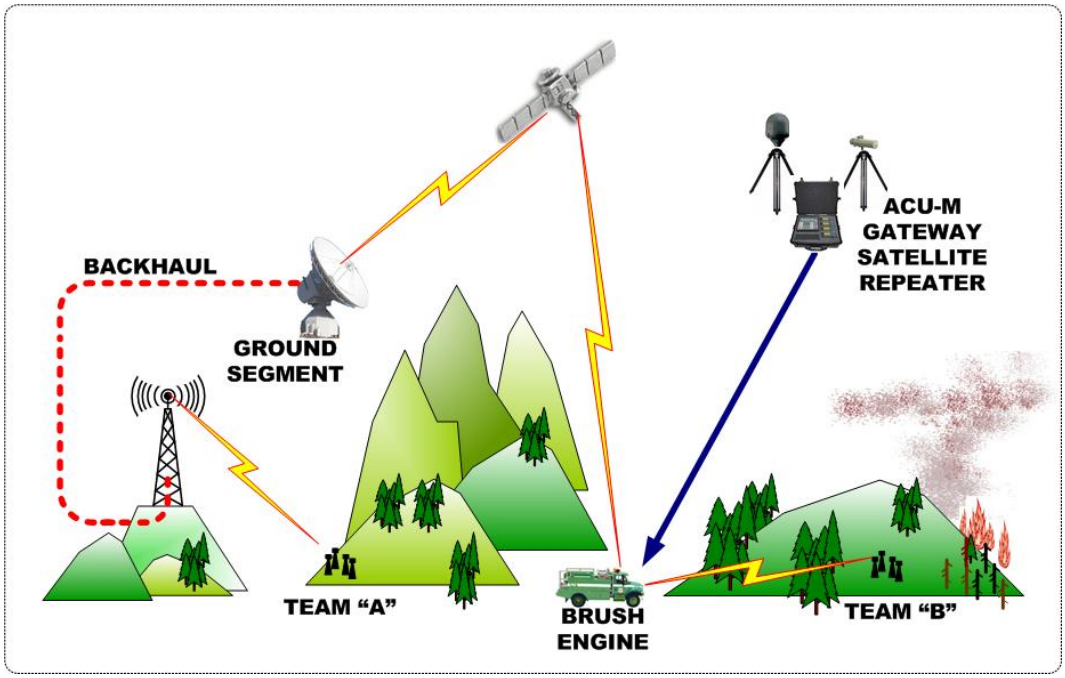

Figure 8: ACU-M Carried in Brush Engine or ATV for Transportability

This solution will provide the following:

- Reduced satellite equipment costs. Team members use existing LMR handheld radios
- Reduce recurring satellite services costs. Only one satellite phone or radio is needed
- Reduce amount of equipment carried by each team member. Existing LMR will link to satellite phone
- Also provides localized radio interoperability, by default

Each satellite terminal or satellite radio utilizes different techniques that will require the DSP port of the ACU-M that is supporting the satellite asset to be adjusted for compatibility. One such DSP parameter is Transmit Audio Delay. Some of the satellite terminals and satellite radios function in a similar manner as an LMR trunked radio system, in that they must contact the satellite system first, before acquiring a voice channel. This process delay can be as much as 2.4 seconds in some systems. If this process is not accounted for, in the form of Transmit Audio Delay in the ACU-M, there is some danger in losing the first syllable of the audio stream. Luckily, all of these satellite communications idiosyncrasies can be gracefully handled by the interface features provided by the ACU-M and are explained in the Application Notes provided by Raytheon.

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The ACU-M supports the following satellite communication devices:

- Hughes MSAT G2 / TU02100 Mobile Satellite Radio
- Motorola / Iridium 9505 Portable Satellite Phone
- Mitsubishi Mobile ST111 Satellite Terminal
- Mitsubishi Mobile ST121 Satellite Terminal
- Mitsubishi Mobile ST211 Satellite Terminal
- Mitsubishi Mobile ST221 Satellite Terminal
- Mitsubishi Mobile ST251 Satellite Terminal

The ACU Radio Application Notes specific to each of the satellite terminal devices referenced above are listed in the Reference Section of this Application Note. These ACU Radio Application Notes will address satellite terminal setup suggestions, hardware or programming modifications, cable diagrams, and DSP feature setting suggestions.

Powering the ACU-M unit, satellite terminal and LMR link radios will require power from a battery, generator, or solar array, which are all forms of power that are common place in remote locations. When determining the size of the power system it is important that the current draw of all the devices is cumulative. The ACU-M will draw ½ amps at 12 volts DC (nominal). Refer to manufacturer's amperage specifications for the satellite radio or terminal, as well as for the supporting LMR link radios.

Conclusions

By its ever improving reliability and cost effectiveness, satellite communications, like land mobile radios, has found its place in pubic safety, fire, and emergency services. By taking advantage of the fact that satellite radio and satellite phones do NOT rely on the localized infrastructure to provide communications, it has become a practical tool for remote operations, such as in wildlands fires and catastrophic disasters. It also leverages the ability of the low cost ACU-M Intelligent Interconnect to link disparate communication devices into interoperable networks, satellite communications can be coupled to land mobile radio communications commonly used by our first responders in these remote locations. Its size and portability means the entire system is easily transportable by hand, by brush trucks or by ATVs (see Figure 9).

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Figure 9: All Equipment can be Stored in a Portable Weatherproof Case

One satellite terminal can now support a crew of many members by using their existing land mobile radios, thus reducing satellite equipment numbers and recurring costs of satellite services.

Acronyms

iDEN: Integrated Digital Enhanced Network, enhanced specialized mobile radio network technology that combines two-way radio, telephone, text messaging and data transmission into one network.

LOS: Line-of-Sight describes an unobstructed free-space link from a source antenna to a receiving antenna.

RoIP: Radio over Internet Protocol, (compared to VoIP) not only converts voice to a digital format that can be sent over the Internet or other IP based network, but also converts PTT and COR control signals that are essential for seamless radio interoperability. Also included are extra delay and jitter compensation.

VoIP: Voice over Internet Protocol, is a method of sending voice communications across a digital network.

References

ACU-M Training and Resource CD, Raytheon

ACU Radio Interface App Note, 5961-271310-APP, *Hughes MSAT G2 / TU-2100 Sat Radio*

ACU Radio Interface App Note, 5961-291251-APP, *Mitsubishi Mobile Sat Terminal ST111*

ACU Radio Interface App Note, 5961-291251-APP, *Mitsubishi Mobile Sat Terminal ST121*

ACU Radio Interface App Note, 5961-291251-APP, *Mitsubishi Mobile Sat Terminal ST211*

ACU Radio Interface App Note, 5961-291251-APP, *Mitsubishi Mobile Sat Terminal ST221*

ACU Radio Interface App Note, 5961-291251-APP, *Mitsubishi Mobile Sat Terminal ST251*

ACU Radio Interface App Note, 5961-291300-APP, *Iridium Motorola 9505 Sat Phone*

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