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Examining the application of networking radios for dismounted combat

Since the advent of warfare, the ability to communicate clearly on the battlefield has been of paramount importance. From the trumpets and cornets of ancient Rome, to the carrier pigeons and runners of World War I, to modern software-defined radios, the ability for commanders to transmit orders to soldiers in response to a changing tactical environment is a key element of military endeavour.

It is only within the past few decades, however, that the dismounted soldier has been issued with an individual radio for communications between comrades within a squad, or section. Previously, use of hand signals and shouting was deemed adequate for the type of operations carried out within the relatively limited geographical scope of a dismounted infantry squad. The advantages of soldier radios soon became evident – primarily in enabling the close co-ordination of movements when screened or behind cover and at range.

Soldier radios also allow combatants to discuss and evaluate complex and dynamic situations in a secure and clear way that would not have been possible previously with hand signals. Take, for example, two fire teams approaching an objective in rolling terrain in arrowhead formation who receive enemy fire and manoeuvre to dead ground as a result. If the terrain obscures line-of-site contact between the two teams, a soldier radio can ensure the two teams can jointly evaluate the situation and take more effective action.

The challenge of dismounted communications

Ground to ground communications is inherently challenging due to the terrain, environment and obstacles. These issues are compounded for the dismounted soldier. They are typically moving, they may be low to the ground, and are using a body worn radio whose antenna can be shielded by their own body mass. There is a limit to the output power that can be safely emitted close to the body, so increasing radio power to improve communications is a limited option. In addition, higher power radios need more or bigger batteries, so increasing the weight burden on the soldiers. Raising the antenna height will certainly help the communications range but again, there are practical issues with elevated antennas on dismounted soldiers.

Traditional soldier radios have provided point-to-point communications over a limited range – perhaps up to 1km in open terrain. A squad would reasonably be expected to operate within these confines, not straying beyond the effective range of their primary weapons. However in operations such as those in urban or jungle environments, radio range can be significantly reduced when compared to more open terrain.

Particularly for body worn soldier radios, their relatively low output power, low antenna height and screening by natural or artificial obstructions make radio communications difficult. The resultant reduction in range can mean that soldiers within a squad are only able to communicate with nearer members of the squad, while those further away do not receive the transmission. If this is the case, and the commander is aware, then messages can be relayed manually. But this of course can lead to delay, potential distortion of commands, and ultimately the possibility that further away squad members still do not receive the information or orders.

In addition to output power and antenna height, another very important determinate of range is the bandwidth used by the radio. Narrowband waveforms are a very effective way to maximise range as they allow the transmitter power to be focused (like a laser) into a narrow transmission bandwidth, thus increasing range. Narrowband waveforms also have several other important advantages: they are harder to detect/direction find and are more efficient, so do not require as much battery power, all of which are key to enabling the dismounted user to be more effective.

Networked communications

In order to extend communication ranges, some radios provide an automatic rebroadcast function, enabling the radio to re-transmit a message that it has received from another radio. More complex devices provide mobile ad hoc network (MANET) functionality, in which each radio acts as a node and is aware of the relative locations and potential paths to other radios in order to ensure that a message is transmitted to all users on the network. The goal of rebroadcast and MANET approaches is to maintain communications as team members move in and out of any shielding resulting from terrain features that prevent direct communication between them and the message initiator.

Some relay solutions automatically rebroadcast every message to all locations, regardless of whether they may have received the message directly from the sender. This can be a wasteful use of the limited available battery energy, while the multiple RF transmissions triggered by a single message makes this kind of waveform more vulnerable to detection and location finding techniques.

A more sophisticated approach is where the path of each message is determined by issuing and receiving handshakes between radios prior to transmitting the message. This imposes a processing burden and timing delay on the network. The approach is less of a burden when nodes are static, but can be difficult to manage for constantly moving dismounted soldiers with resultant frequent network reconfiguration that can delay and interrupt transmissions.

Other radios provide a limited rebroadcast solution and maintain a frequently updated picture of their immediate network peers. When a transmission is made, the best route for re-transmission is already known.

All the approaches have their benefits and generally improve the reliability of the communications but some are more suitable for the dismounted soldier who requires low latency calls in a lightweight package with long endurance with minimal spectrum presence. Given these criteria, a combined approach where a radio with good point-to-point range and a few MANET network hops works best for dismounted soldier communications:

- Good point-to-point range maximises the probability that a direct transmission is successful
- Which minimises the number of hops required for a given coverage
- Which minimises the rebroadcast traffic needed, reducing bandwidth required, power required, spectrum usage and the network processing/management burden

Dismounted soldiers using this kind of radio have less restrictions on movement so can work in clusters as operations dictate, and do not have to disperse to position nodes simply to maintain their network coverage. Limiting network relays also means that waveform bandwidth can be reduced to a point where frequency hopping techniques can be applied to reduce visibility in the spectrum, maintaining stealth and preventing enemy detection.

Networking benefits for the dismounted soldier

The key benefit of networking radios for dismounted soldier communications is that they have the potential to extend the operational range of the radio. If the point-to-point range of a soldier radio is up to 1km in open terrain, then a hop enables this to be extended to a theoretical 2km. This can provide operational flexibility where troops need to spread out beyond the normal range of the radio, or where they are operating in environments where radio range is attenuated significantly by buildings, trees and suchlike, which would otherwise reduce their operational range.

Below are 2 examples that help to highlight where networking is and isn't beneficial in real world scenarios.

Example 1: A squad of twelve soldiers splits into three fire teams. Each of the fire teams occupies positions within dead ground (i.e. an area of ground that is outside the line of sight of the objective). Fire Team 1 and Fire Team 3 are not able to maintain line of sight with each other due to obstruction by urban buildings and trees. With a point-to-point radio, given the undulating terrain and distances involved, Fire Team 1 would have to ask for transmissions to Fire Team 3 to be rebroadcast manually by Fire Team 2. However a networking radio would extend the effective range of communication of Fire Team 1 by automatically relaying messages through Fire Team 2 to Fire Team 3 thus enabling all soldiers to remain in contact with one another with the need to manually relay messages.

Example 2: A squad of eight soldiers splits into two fire teams and are advancing over rolling terrain on a suspected enemy position on the edge of a treeline, Fire Team 1 is leading the assault. On approaching the position Fire Team 1 comes under effective enemy fire from the front and go to ground. The contact is reported and a plan developed that Fire Team 1 will return fire while Fire Team 2 move forward on the right flank into the trees and overrun the enemy position from the right. This plan relies on close coordination between the 2 Fire Teams to ensure that Fire Team 1 redirect fire when the Fire Team 2 assault begins. As Fire Team 2 move forward along low ground so they can manoeuvre without being seen by the enemy there is a risk the communications will be lost. In this case networking is of little benefit and mission success will depend almost exclusively on the point-to-point range of the radio.

Getting the best from MANET radios for dismounted users

MANET networking capability has the potential to offer range extension if radio locations can be optimised, and it also adds additional resilience to the network. Networking provides multiple simultaneous communications routes, with the receiving radio selecting the strongest signal from the multiple transmissions. This feature improves communications in difficult environments and minimises communications fading as soldiers move around. In addition, the combination of MANET networking with Frequency Hopping provides a low probability of detection and further resilience where the RF spectrum is congested and/or contested.

MANET networks supporting multiple hops can maintain a large network but tend to have a shorter point-to-point range as available power must be spread over a larger bandwidth in order to provide the capability needed for multiple re-broadcasts. This works well and provides good communications for a given area coverage when network nodes are dispersed evenly over the battlefield. However, in reality, it is seldom the case that nodes are evenly dispersed. Soldiers tend to operate in small clusters moving independently, with longer ranges between clusters, as illustrated in Example 2 above. Dispersing troops just to

provide radio nodes in order to maintain communications would be a significant limitation to operations and a planning difficulty so should be avoided.

For the kind of short-range communications needed within a dismounted infantry squad, simulation and real trials have shown that the benefit of additional hops diminishes quickly. On the battlefield, a radio with good point-to-point range completes 80% of transmission directly, so point-to-point range is the single most important factor in call success. The 1st relay then boosts call success to over 90%, with further relays having only a small impact on overall call success in the usual confines of a squad-level operation. If node locations can be optimised, particularly if a number of elevated relay nodes can be moved into place, then further communications robustness can be achieved. However, as noted above, it is not always possible to manoeuvre troops to optimise nodes and repositioning them regularly as an operation unfolds creates an additional planning burden.

To conclude, the benefits of soldier radios have been well-proven since their introduction. That dismounted soldiers can communicate between one another has enlarged the scope for infantry to co-ordinate operations in a way that was not previously possible. However, this capability can be further improved by providing soldiers with networking radios that extend range and provide more resilience to their communications.

MANET networking is beneficial for the dismounted soldier but has its drawbacks and should not be considered as a substitute for point-to-point range. Typically a MANET waveform is wideband to accommodate all the slots for the relay mechanism within the waveform structure – the more services or more relays required the wider the bandwidth. Bandwidth is a key determinate of range in the ground-to-ground environment so wideband MANET waveforms with their short point to point range rely on there being sufficient radios in the right locations to relay the communications to the wider network.

The Thales Solution

The Thales SquadNet Soldier Radio uses a lower transmission bandwidth and optimised MANET hops compared to other MANET radios to provide the mix of voice, data and position location tracking services a soldier needs. This narrower band transmission has several advantages: most importantly, it provides greater range. The range is achieved with lower output power, which translates in to longer endurance and less batteries to carry. In addition narrowband transmissions are more difficult to detect, keeping soldiers safer against RF direction finding and targeting technologies.

SquadNet achieves class leading range with only 250mW output power. Battery life is up to 24 hrs on a single 90g battery and the radio itself weights 160g. The radio can deliver a mix of simultaneous services including voice, text, picture and Blue Force Tracking. Services can be configured to provide multiple voice nets or higher data throughput.

The radio holds 100 pre-set channels so a user can select the mix of services required by changing channel.

Further, the SquadNet Radio has a Frequency Hopping capability that provides Low Probability of Detection (LPD) and Anti-Jam (AJ) capabilities while still delivering all the simultaneous services associated with the fixed frequency modes.

SquadNet is provided with its own fully integrated Battlefield Management Application that runs on an Android device enabling users to make an immediate capability uplift, or it can be integrated into other Battlefield Management Applications such as ATAK. ■

Search **SquadNet** online for more information or contact **Ciaran McCloskey**: ciaran.mccloskey@uk.thalesgoup.com