Effective Brigade to Battalion Communications
THE DILEMMA FACING ARMED FORCES TODAY

One of the greatest challenges facing modern militaries is the types of missions they are expected to perform are changing. Communications systems purchased 10-15 years ago are no longer adequate to support the diverse nature of operations. The implementation of Network Centric warfare concepts and the shift in operational focus is demanding lighter, more agile systems with a much higher throughput capacity. The large number of vehicles required to transport previous generation systems limits deployment flexibility. The bandwidth provided is insufficient for the demands of modern network-enabled applications and the communications are vulnerable to interference and increasingly sophisticated electronic attack. Legacy or proprietary systems may limit interoperability with coalition allies. Difficult questions confront military planners - how to respond to the environment of ever-changing mission requirements? How can large, traditionally-hierarchical organizations become nimbler, and accomplish their mission objectives in a fast, flexible manner?

The concept of Network-Centric Warfare (NCW) provides some of the answers by promoting a network paradigm that adapts well to change. This is fine for the command and control philosophy, but what about the communications equipment underpinning the organization? What is needed to provide this required flexibility, with its ever-increasing traffic load both vertically to and from subordinate units and their headquarters, and increasingly, horizontally between units? This paper discusses some of the challenges facing traditional communications in modern tactical networks, and proposes solutions.

OPERATIONAL NEEDS

The operational needs of the Land Forces tactical communications systems can be summarized as follows:

- Modern Armed Forces require the flexibility to support new types of missions and the ability to react quickly to emerging threats.
- An effective communications network is the foundation for enabling the collection, analysis, fusion and sharing of information necessary to support a wide variety of mission objectives.
- A common IP network is required to provide seamless connectivity from the fixed infrastructure to mobile elements and further downward to the soldier level.

This IP network must deliver sufficient capacity in order to support increased situational awareness and the ability to connect sensors, decision makers and effectors. When a tactical force is deployed, the command structure is maintained by in-theatre tactical headquarters and command posts. These elements tend to follow the standard military hierarchy flowing from Division down to Company level. However, with the introduction of the Network Centric Warfare doctrine, vastly more data traffic is being exchanged on the network. As well, increased collaboration between peer units means that more lateral links in the network are required. In the past, it was common to deploy complete Divisions with a large transportable communications network to support them. Today, deployments tend to be Brigade-sized and there is a requirement for greater mobility at the Battalion and Company Command Post level. While larger headquarters may only be required to operate “At the Halt”, elements of the smaller
headquarters and command posts must be capable of operating while moving. This is referred to as On-The-Move communications, or OTM.

THE TACTICAL COMMUNICATIONS OBJECTIVE

The first objective is to provide reliable, high-capacity IP connections between the static deployed Brigade and Battalion headquarters and command posts in the tactical area. Two types of systems are used extensively for this: satellite communications and Line of Sight (LOS) microwave radio. Satellite is an attractive option for OTM operation. However, its high cost and limited bandwidth restricts its use to the beyond line-of-sight reach-back. Further, high-capacity satellite links come at the cost of reduced operational flexibility due to the greater amount of required planning and logistics. The LOS radio has been traditionally used to interconnect deployed headquarters and command posts. What has changed is the degree of requirements now being imposed on these radios as a result of the new operational demands.

OPERATIONAL DEMANDS FOR TACTICAL HIGH-CAPACITY LOS RADIOS

TYPICAL APPLICATIONS

Line of Sight radios have many applications in the tactical environment. To name just a few common examples, typical usage includes:

- Linking deployed tactical headquarters and command posts
- Linking the engagement control center with the firing units in an air defense application
- Providing a robust high-capacity backbone for ad hoc network clusters
- Providing a robust high-capacity backhaul for tactical cellular systems
- Connecting UAV ground stations to the network and distributing ISR video and SA

SUPPORTING TACTICAL COMMUNICATIONS

Everything-over-IP is fast becoming the standard architecture for tactical networks. Tactical radios are required to transport the IP network supporting all of the command and control, intelligence and surveillance requirements for the headquarters. Historically, most command and control was exchanged using voice communications. However, with the increasing availability of and reliance on situational awareness information, sensor video and collaboration tools, demand for bandwidth has increased exponentially.

Additionally, voice and video over IP applications have matured to become indispensable to commanders. This rapid growth of data traffic and migration toward an All-IP infrastructure is the principal reason why most currently deployed LOS radio systems are insufficient for today’s applications and totally inadequate for the missions of tomorrow.
DEMANDS OF TRANSPORTING ISR VIDEO

One of the drivers for more capacity in the tactical environment is the increasing use of UAVs to provide live video of operations and for reconnaissance activities. In the US, some of this UAV video is distributed by the Global Broadcast System. However, many countries do not have access to this type of service. In typical tactical deployments UAVs have a high-capacity directional link to their ground station. Once the information is on the ground the challenge is to distribute it to the command elements that require the information. This is where the capacity available in the tactical network becomes very important.

TACTICAL OPERATING ENVIRONMENT

The tactical operating environment is harsh and challenging compared to the commercial infrastructure. As everything is temporary and has to operate with limited planning, tactical radios have to be a lot more durable, much more flexible and considerably easier to set up than their commercial equivalents.

In the commercial world, operators license spectrum at a high cost, and can be penalized for operating outside their license. Accordingly, commercial radios can only operate over limited frequency ranges and the spectrum is fixed for a particular system. In the tactical environment, the military allocated spectrum has to be shared with other defense systems, with existing commercial and government infrastructure, as well as with coalition forces. This means that the military radios must offer flexible operating frequencies, and be able to perform in conditions where planning is much less controlled.

In most countries, the military is gradually finding itself pushed out of the lower-frequency bands by the pressure to free up spectrum for commercial operators. This forces tactical radios to operate over a wide frequency spectrum and have the ability to resist friendly and intentional interference as bands become crowded with competing signals. This is true both in operations abroad as well as in domestic operations such as training and disaster relief, where the encroachment of spectrum occupancy by commercial operators dictates a need for spectrum flexibility on the part of defense radios.

Headquarters and command posts are positioned for the protection of the command staff, not for the optimization of radio communications. LOS microwave radios, as the name suggests, require masts to raise the antennas clear of local obstacles such as trees or buildings and obtain a relatively clear line of sight to the next headquarters. This requirement for flexibility means that tactical radios must be quick and easy to deploy and set up in sub-optimal locations and conditions.

At the Brigade and Battalion level, the headquarters are usually deployed in several vehicles with attached tents. It is important that the radios and networking equipment take up as little space and prime power as possible.
The training and skill level of military operators is very different from the maintenance staff in commercial deployments. Furthermore, given the high-stress environments that soldiers often need to work in, military radios must be simple to operate and maintain. In commercial networks, provisioning errors or delays might irritate customers temporarily. In the tactical environment, the costs of provisioning errors or delays may be measured in lost lives or failed mission objectives.

PERFORMANCE CONSTRAINTS

Unfortunately, the laws of physics constrain bandwidth to finite limits. Modern technology has provided amazing increases in the amount of data that can be carried by radios, but there are always trade-offs which have to be made. Particularly in the tactical environment, where the radio link cannot be engineered to the same level as a fixed commercial radio link, these factors must be considered.

The first trade-off is Capacity vs Range. Achieving higher traffic throughput rates requires stronger signal levels. As a result, high-capacity links tend to have shorter range than lower-capacity links. The amount of spectrum required to transmit the data can also be traded off to increase the range by using more robust forms of modulation and coding.
Some commercial radios offer a feature called adaptive modulation, where the transmit channel size is fixed and the radio automatically adjusts the modulation format depending upon the range required and the operational terrain. On the one hand, this is good because the radio will maintain the link as the propagation loss increases, but it comes at the cost of always using the same amount of spectrum and not having a dependable throughput. A better approach is to have the choice of a number of different waveforms allowing the system planner to select the best waveform for the operational environment.

Radios designed for military use generally offer a choice of modulation and coding formats with a choice of throughputs. This permits the system planner to optimize the channel size, throughput, and range. These trade-offs make it very desirable for the tactical radio to support multiple waveforms and traffic rates so that the best performance for the particular tactical environment can be attained.

Crowded out of lower frequency bands, military LOS radios are now being allocated spectrum in the 4.4 to 5 GHz range. This is a good band for tactical LOS radios as there is sufficient spectrum to support high capacity links and the antenna size is small enough to give high gain on a tactical mast. While it may not be as forgiving of terrain and foliage obstruction as the 1350-2690 MHz band, the 4.4-5 Ghz is now the band of choice for most modern tactical systems. The remaining frequencies in the 1350-2690 MHz band are available for mobile communications systems supporting the Battalion to Company traffic.

THREAT ENVIRONMENT

The threat level to LOS radio links varies greatly from theatre to theatre, and mission to mission, but one certainty is that the increasing appetite for bandwidth will bring with it a corresponding need to mitigate the effects of mutual interference. LOS radios must be able to automatically avoid channels with interference and to engage powerful anti-jam capabilities when subjected to deliberate jamming.

THE HIGH COST OF KEEPING LEGACY INSTALLATIONS

In many tactical area communications systems presently fielded, the LOS radios and switching system are often carried in separate vehicles. Every additional vehicle requires soldiers to support it, maintenance staff, transportation to theater, fuel, and spare parts, and creates another potential point of failure.
With the currently available technology, the tactical LOS radio can be mast-mounted, reducing its size and power requirements. In a conventional system where the radio is inside the shelter there is a considerable amount of power wasted in the antenna feed cable. By mast mounting the radio this loss is removed. A single vehicle can carry the switching equipment and the radios, reducing manpower, transport, fuel and maintenance costs, as well as increasing setup and teardown speed.

This results in a saving of one vehicle and three men at each node of the network. The ability to remote these new radios allows better siting for the radio link as the deployment is no longer limited to places with vehicle access. In urban environments the roof of a building can easily be used to install a radio link.

COTS VS MILITARY LOS RADIOS

With shrinking budgets and mounting pressures to reduce costs, militaries around the globe are beginning to consider the use of commercial IP radios for their backhaul systems. When contemplating the use of commercial equipment, one must be careful to look at the full deployment picture. The low cost of commercial radios is attractive, however the user must bear in mind these radios are designed to meet a different set of requirements than the full tactical deployments described in this paper.

In applications where the limitations and constraints of commercial design can be accepted, COTS radios can sometimes be used successfully. For example, the US Army has used commercial-grade radios in Afghanistan to link static deployments, in an application similar to the commercial cellular world. Frequency agility was not required as the radios were used in areas where the US forces controlled the spectrum and the system could be set up in carefully selected locations by skilled technicians and then remain in place indefinitely. However, in a typical tactical environment these types of COTS radios would not work well, as links often cannot be carefully engineered and the spectrum is not well controlled.
EVOLUTION OF LOS RADIO TECHNOLOGY

By combining the latest software-defined radio modem with innovative new radio architecture, it is possible to provide a tactical LOS radio that satisfies all of the requirements of a modern tactical area communication system. The software defined radio architecture allows the operator to select the radio waveform appropriate for the operational need, providing a flexible, widely-applicable solution. Range and spectrum occupancy can be traded against required throughput as needed, something that is typically not feasible with commercial off-the-shelf products.

By supporting both frequency and time-division duplexing, this new architecture allows radios to be optimized for high-capacity and spectrum efficiency or anti-jam performance without changing any of the radio hardware. Simply by selecting the appropriate waveform, the same radio can support 200Mb/s aggregate spectrum-efficient links or robust full-band frequency hopping with error correction.

The radio uses a parametric modem approach which provides unparalleled waveform flexibility. The strength of this approach is that it allows the user the ability to add new application-specific waveforms to the waveform library with relative ease compared to other software defined radio products. This capability allows the customer to customize the radio to his particular operational constraints.

The ability to use the same radio for many different missions reduces the need for different types of radio and greatly increases the operational flexibility. Communications shelters can all have the same radio and can be configured for the operational mission by selecting the appropriate waveform. This reduces the support requirements and minimizes the training required.

The HCR and EHCLOS radios are the ideal tactical LOS radios for new tactical and air defense communications systems.

KEY BENEFITS AND DISCRIMINATORS
Based on user feedback from three generations of radio relay equipment the new HCR and EHCLOS radios are extremely easy for the user to set up and use, thanks the use of a software Wizard. The Wizard takes the operator through the set up using clear graphics and simple instructions. It takes the confusion out of link alignment, waveform selection and radio monitoring.

The radio is designed for a tactical environment and offers the highest throughput with the robustness required in this difficult environment. The same radio can be used for different operational missions ranging from benign high-capacity backhaul to operation in a high-threat jamming environment. The waveform flexibility provides the system planner with the ability to optimize the radios operation and to cope with real world constraints of threat environment, spectrum availability and propagation loss.

The small size of the HCR and EHCLOS is a key factor in its ease of deployment and the reduction in vehicles and staff needed to support the radio relay function. The radio can be easily added to existing shelters as being mast mounted it does not take up any rack space.

The HCR and EHCLOS radios represent a major breakthrough in LOS communications capability and have a place in any modern area communications or air defense system.

ABOUT ULTRA ELECTRONICS, TCS

Ultra Electronics, TCS is a leading supplier of tactical Line of Sight (LOS) radio relay equipment and systems and is based in Montreal, Canada. Ultra Electronics, TCS traces its roots back to the Canadian Marconi Company (CMC) when it started supplying tactical radio relay equipment to the US Army in the 1960’s. In 2002 the Military Communications Division of CMC was sold to Ultra Electronics and under the name of Tactical Communication Systems, it continued its focus on providing reliable and effective LOS communications to armed forces throughout the world.

The Ultra TCS head office is located in Montreal with facilities in the United States and Ottawa. The radio development and manufacturing capability is located in the Montreal facility, with IP switching expertise in the USA and Electronic Warfare specialization in Ottawa.

Ultra TCS has a team of systems engineers and designers who are very experienced in tactical communications systems. In radio design, Ultra TCS is an expert in the field of SCA and Software Defined Radio (SDR) products with a long legacy of RF technology development. Our products are known for their superior RF and system performance.

Ultra Electronics, TCS has delivered over 23,000 AN/GRC-103 radios, 7000 AN/GRC-226 radios, 5000 AN/GRC-512 ECCM radio kits and over 5000 AN/GRC-245 radios to more than 35 countries and has established a depot repair facility to support the US Army and other customers. Ultra Electronics, TCS has contractual commitments to several governments to support our radios for 20 years and we have more than satisfied this commitment with the previous generation AN/GRC-103 radio that was supported for more than 30 years.
Ultra TCS’ latest point-to-point products, the HCR and EHCLOS radios, are the ideal radios for modern area communications systems and can easily be reconfigured to operate in a multitude of different tactical environments. Using the Ultra TCS HCR and EHCLOS radios, various waveforms can be selected to support a large number of different missions. Effective ECCM is provided using frequency hopping at 2000 hops/second, diversity and error correction when required.

Ultra TCS has built a team of engineers with world-class experience in OFDM systems and solutions for on the move communications. Our systems engineers integrate these products with IP switches, encryption and gateway/access products to offer turnkey system solutions.

For more information on UltraMove, and other Ultra Electronics, TCS products, please visit: www.ultra-tcs.com