Future Trends in Defence Antenna Technology

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In this article, the author reviews the different roles of some of the frequency bands available for military communications. Increasing frequency brings the possibility of wider bandwidths, but raises a variety of new problems and constraints. The article refers particularly to the role of antenna design in exploiting available possibilities.

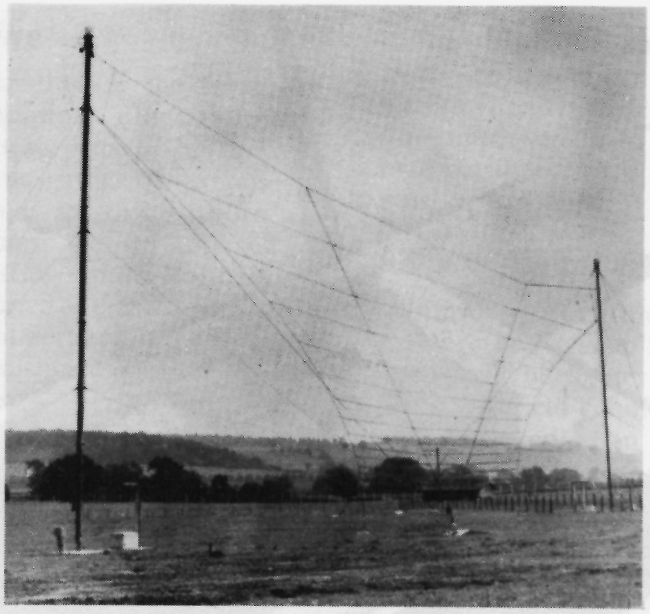
Until the end of the last century a military commander was limited in the options of strategy and tactics open to him by the extraordinary difficulty of communicating with his troops, scattered over a wide area of action. Communication was by flag, light, bugle or a man on horseback. The first two were quick, but could only be used to initiate moves which had previously been planned. The written or spoken word travelled slowly but was more flexible and informative.

The advent of real personal communications opened completely new possibilities in strategy and tactics. Field telegraphs, telephones and then radio extended the Commander's ability to gather information on the current state of affairs, as well as to plan and direct new operations as a response to current conditions. Radio communications are subject to interception by the enemy so messages were encoded or encyphered—not a new technique as the messenger on horseback was also subject to interception by the enemy. The enemy quickly found that as well as intercepting his adversary's signals he could block communication by radiating his own strong signals on the frequency being used for communication, or he could radiate deliberately misleading signals.

The growth of military communications has realised its own version of Parkinson's Law, demand always exceeding capacity. The emphasis still lies in obtaining the necessary bandwidth, reliability, security from interception and ability to withstand the efforts of others to disable the system by jamming. An alert enemy will use the very presence of various classes of transmission and the locations from which they originate as inputs to his intelligence machine.

The HF Band

Using a suitably chosen frequency where ionospheric propagation is active, a small HF transceiver provides a cheap voice or data channel over distances up to several thousand kilometres. It remains the only terrestrial medium for use when a chain of relay stations is impracticable. The traditional drawbacks of the HF medium are its variability and the ease with which an enemy can intercept and jam transmissions. These activities are comparatively easy on HF as — especially from simple antennas — signals propagate in almost every direction and a remote high-power jammer will disable a number of low-power links using the same frequency.



Even simple wideband log-periodic HF antennas are large and difficult to erect quickly in the field. The need for tall supporting masts is a major problem.

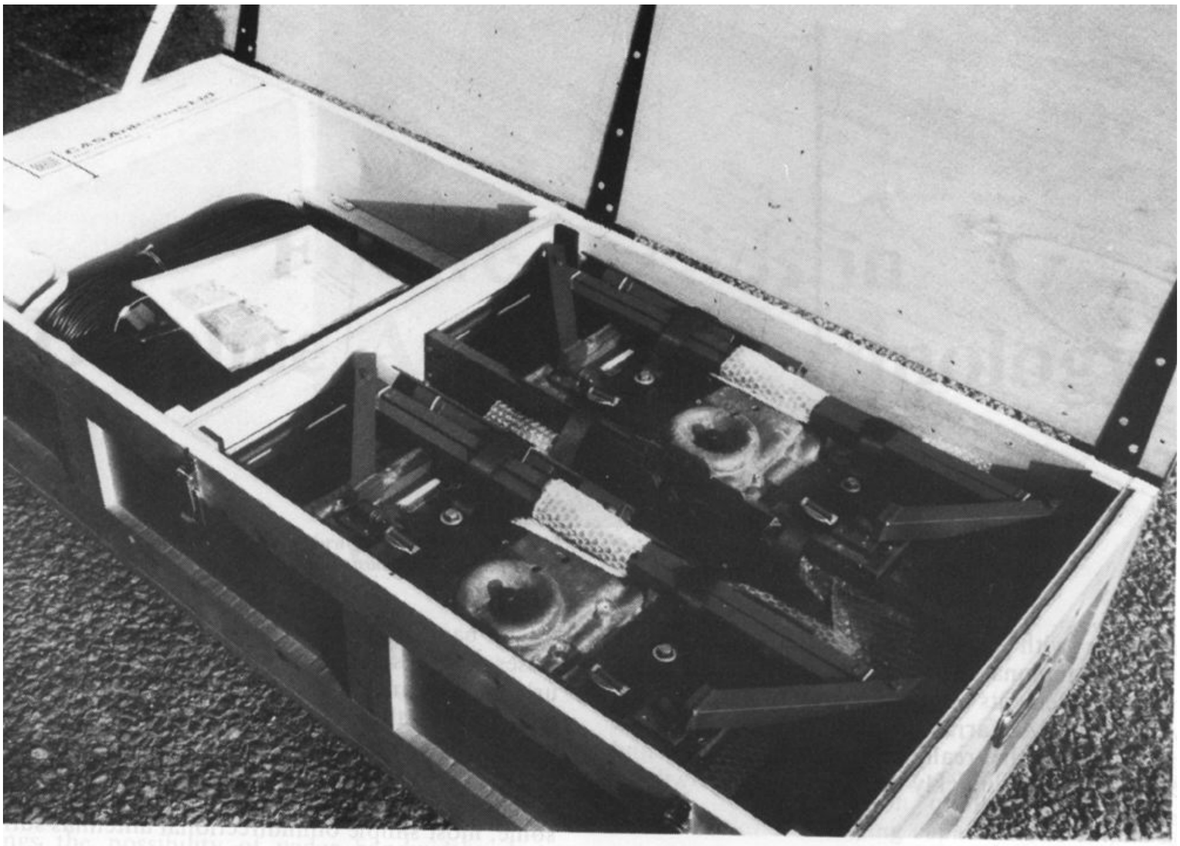
Transportable antennas usually take the form of dipoles or inverted 'L'antennas for short ranges and sloping-Vee antennas for longer paths. The major problem with high gain antennas for field use is

that they are slow and effort-consuming to erect or restow. They are unsuitable for use in tree cover and are conspicuous on open ground. A more satisfactory link configuration uses low-gain transmitting antennas with high performances transportable receiving antennas. The small physical size of active receiving elements allows an array to be concealed very easily. An array of four elements will out-perform any other really transportable antenna and can be erected quickly even in undergrowth or uneven ground.

To reduce susceptibility to interception or jamming, the operating frequency may be changed frequently in a manner unpredictable to the enemy. This technique (frequency hopping) requires a wideband antenna or a simple antenna used in combination with a quick acting ATU. It has become more readily achieved with the advent of equipment which can be controlled by a data bus.

Further development of directional HF transmitting antennas may also be anticipated; the objective will be to provide sectors of very low radiated energy to reduce the possibility of detection by the enemy.

HF communications are also used at frequencies which lie above the frequency at which the ionosphere acts as a reflecting layer (the MUF). In this role, HF is used in the same way as the lower VHF band but has the advantage of lower diffraction losses over obstacles and of lower attenuation with distance in the ground-wave mode.



Using an active receiving array, a high performance antenna is reduced to a compact boxful.

VHF

Together with that part of the HF band Iying above the MUF, the lower part of the VHF band— up to around 80 MHz—is used for a wide variety of links. These include communications to vehicles, armoured and unarmoured, manpacks and longer fixed and transportable voice and data links.

The band enjoys comparatively low diffraction losses over obstacles, giving reasonable coverage in urban areas and in rolling wooded country. High gain transmitting or receiving antennas are bulky and fragile and the band is too wide for most simple antenna types to cover the whole of it. Log-periodic antennas of even modest gain are large and cumbersome; most simple omnidirectional antennas suffer limited efficiency if their dimensions are made too small. These restrictions are most problematical on vehicle equipment, especially if further height or space restrictions are imposed by operational requirements. In such cases a narrow band antenna may be provided with servo-controlled matching components.

The VHF band is in heavy demand by civilian services including television and mobile radio. This severely restricts the availability of frequencies for military links. The occasional occurrence of ionospheric propagation in this band causes problems for all users, extending the transmission range of every user — friend or foe — by hundreds or even thousands of kilometres.

Frequency hopping may be used to reduce susceptibility to interception and jamming.

UHF

Various frequency bands are available for tactical communications in the upper VHF and lower UHF bands. These include the 225-400MHz, 830-960MHz and 1300-1800MHz bands. Transmission in these bands is by normal quasi free-space tropospheric propagation. Once beyond the line of site the signal diminishes rapidly in normal conditions. However, in abnormal conditions of superrefraction or ducting, signals may be propagated much further than normal. These phenomena are very frequent in occurrence in some parts of the world where propagation will surprise operators accustomed to West European conditions.

The 225-400MHz band can be covered by a single compact directional antenna of medium gain. Such an antenna will have a low level of radiation outside the main beam, so the probability of interception is lessened compared with the HF and lower VHF band. In the higher frequency bands, antenna performance increases further so that at 1800MHz the accuracy with which the antenna must be pointed in the right direction becomes an important constraint. This practical constraint — not only finding the correct direction but maintaining it in a high wind — limits the size, gain and beamwidth of antennas for field use.

Corner reflector and dipole arrays have been used in these frequency bands but CSA have has preferred the ruggedness of a slot fed panel for 225-400MHz and the simplicity of front-fed grid paraboloid for the higher bands. By using a single design of reflector with two interchangeable feeds they have produced a compact and economical package to cover the 830-960MHz and 1300-1500MHz bands.

As well as the reduced probability of interception provided by the clean radiation patterns of these antennas and the rapid fall in field strength beyond the line-of-sight, the user can adopt frequency hopping or spread-spectrum techniques to protect his circuit. The bands provide wide high-capacity channels for large data rates.

For fixed circuits the greatest information capacity and security are always obtained in the microwave bands. Large fixed antennas can then be used; these have very narrow beamwidths and very low levels of radiation outside the main beam.

Satellite Links

These play a major role in every aspect of world communications, especially now the on-board power at the satellite may be made large enough to allow the use of very small portable ground stations with low-gain antennas. Satellites offer poor security against signal interception by others—so systems must carry a large overhead (in terminal equipment and system capacity or speed) to achieve information security. It is now very clear that the physical security of a satellite is in doubt if an adversary has sufficient resources.

Intelligence Gathering

Obtaining an understanding of the form and content of the communications of other powers is often useful, even in peace-time. This activity represents an information gathering exercise of great complexity. Antennas for this purpose will include high-gain low-noise arrays directed at known areas where interesting signals originate. On the whole these must be placed as close as possible to the signal source — except perhaps in the HF band where a more discreet distance may be just as effective.

Multiple-element phased arrays are frequently used for their ability to form a number of high-directivity independently-steerable beams which can search large volumes of space and track moving signal sources.

The planning of such activities is quite different from the planning of regular communications facilities as advantage must be taken of any adventitious improvement in propagation conditions which may occur, even for a short time. Every loophole must be exploited.

Future Developments

Improvements in materials allow the construction of more convenient forms of existing hardware. These will be lighter, quicker to erect and more durable in field conditions.

The introduction of intelligence into field hardware is reducing the demand for specialist manpower at the point of use. As long as these improvements are accompanied by a sufficiently hard-headed view of reliability and serviceability the result should be even better communications.

The 225-400 MHz antenna ready for deployment.