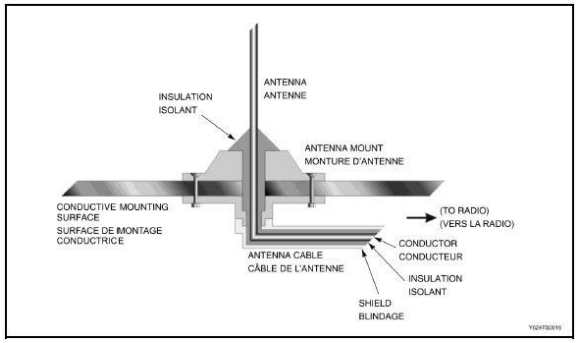
Optimal Placement of Antennas for Maximum Radio Frequency Safety

Long since passed are the days of Marconi and his ground-breaking work on long distance radio transmissions. The pace of technological change now more than ever before offers many more options in the use of wireless and communication devices for Canadian Army (CA) land equipment. The perpetual growth in the use of mobile radios for diverse applications, environments and into higher frequencies, creates more stringent parameters on the design, construction and subsequent placement of antennas. Antenna placement, while crucial to system performance, is not the only requirement in the placement strategy. Often antennas are mounted within a location that is easy to accommodate for installation, but antennas should always be located and positioned for optimal performance and operator safety, as radiation hazards may pose risks to nearby personnel, equipment and/or infrastructure.

Integrating an antenna onto a land vehicle platform poses many challenges. Platform motion and environmental factors such as terrain and building or structure location may reduce system effectiveness in operational conditions. Furthermore, military vehicles commonly incorporate several antenna systems in close proximity.

The performance of an antenna's radiated electromagnetic field is often affected by conductive objects located nearby. Antennas best radiate on the center of the vehicle's roof because the conductive metal surface acts as a ground plane on the vehicle to reflect the transmitted signal. The vehicle's roof also provides Radio Frequency shielding for the safe and effective operation of most commercial transmitters. There must be continuous electrical contact between a coaxial cable's outer shield, the metallic mounting, and the vehicle's roof. Antennas that are not properly grounded can radiate on the outside of the coax and introduce Radio Frequency (RF) radiation into areas and devices within vehicles.



Recommended Installation for DND/CAF Vehicle Antennas

There are a number of critical issues to consider when integrating an antenna on a land vehicle platform. Military vehicles commonly incorporate several antenna systems in close proximity, and interference between these systems can cause problems with simultaneous system operation. When alternative systems and locations for mounting system antennas are being considered, it is important to conduct a RF safety survey. The primary purpose of the survey ensures personnel are not exposed to RF radiation beyond the limits imposed by Health Canada's Safety Code 6 (SC6) and it verifies that the equipment is correctly functioning as installed.

Radio Frequency safety surveys are performed by the Quality Engineering Test Establishment (QETE) within DGLEPM. Their aim, on behalf of DND and the CAF's Radio Frequency Safety Program (RFSP), is to prevent incidents, injuries and losses that may occur as a result of exposure to electromagnetic radio frequency emissions.

All RF devices within DND and the CAF, including newly acquired or recently modified equipment, must be surveyed every three years to ensure they remain compliant with SC6. Vehicle surveys must be done on at least one vehicle for all vehicles of the same configuration, as the previous control measures may no longer be valid. If

however, the configuration of an antenna is altered, a re-survey will be required to ensure compliance. Due to the wide variety of configurations, a single survey representing the "worst case" configuration of each installation or equipment type can be surveyed, however this may impose higher limits on the entire fleet type. Because antenna configuration greatly affects overall equipment compliance, it is important not to alter the configuration of antennas without the appropriate discussions involving the Life Cycle Material Manager and QETE. Any identified risks can then be addressed with alternative configurations or approaches for limiting exposure to personnel.

Once a survey has been completed, QETE will provide exposure limits for the equipment that must be followed during daily activities. Personnel who work within Controlled Environments can be exposed to limits ten times lower than the threshold for potential adverse health effects but are required to meet the following three conditions: (1) the area must be one where the RF field intensities have been adequately characterized by means of measurement or calculation or modelling; (2) the RF exposure is incurred by persons who are aware of the potential RF exposure and are cognizant of the intensity of the RF fields in their environment; and (3) the RF exposure is incurred by persons who are aware of the potential risks associated with RF exposures and whom can control their risk using mitigation strategies. If personnel have not met the three conditions and have not received training on the

hazards associated with the RF equipment, they cannot work within a Controlled Environment.

The general public areas known as Uncontrolled Environments are areas where the criteria defining the Controlled Environment are not met. Personnel who do not work with or near RF equipment or do not have adequate RF Safety training are considered to be within an Uncontrolled Environment. No precautions, apart from respecting warning signs (i.e. Do Not Enter), are required as these areas have a exposure limit of fifty times lower than the threshold for potential adverse health effects.

Adverse health effects may occur if a person is over-exposed to RF radiation. Hazards that personnel may experience due to over-exposure to RF electromagnetic energy may include:

(1) Tissue heating. (Thermal effects): This can occur at frequencies from 100 kHz to 300 GHz. Over-exposure to these frequencies may cause an increase in the core body temperature above normal levels if excessive heat cannot be carried away by the body's normal thermo-regulatory process, leading to adverse health effects. As with other tissue heating conditions such as sunstroke and heatstroke, symptoms due to RF over-exposure at not immediately apparent and take time to develop. Symptoms include: tingling sensation, headache, lethargy, nausea or pain in body joints, and may last 2-3 days in severe cases. The eye is also known to be vulnerable to RF thermal effects since unlike other parts of the body, there is no surrounding tissue such as skin, bone, fat or muscle to offer protection, and minimal blood circulation to remove the excess heat.

(2) Nerve stimulation. SC6 limits for internal electric field strength are intended to prevent occurrences of nerve stimulation at frequencies between 3 kHz and 10 MHz. At this frequency range, electric charge can build up on surfaces such as the skin and cause a tingling sensation at the peripheral nerve endings of the body.

(3) Induced currents. Induced currents occur at frequencies below 1 MHz. The body acts as a receiving antenna and induced electrical current flows through the body exposed to RF energy. Adverse health effects can include tissue heating and burns, as well as altered chemical responses in human tissue and cells.

The body relies on internal electric potentials to communicate information from the brain to muscles, organs, and other tissues within the body. These electric potentials are created at the cellular level where the internal cell has a different electric potential than the external cell environment. When an induced current is high enough, it can affect a cell's ability to respond to communication from the brain. For example, if the induced currents are high enough, then muscle control such as the ability to open and close a hand may be affected.

(4) Contact currents. Contact currents occur around HF antennas designed for use between 3 MHz to 30 MHz. High frequency radiation induces voltages on metal structures such as antenna wires, cables, and metal railings. A person in contact with RF-energized metal structures will have electrical current flow through the body as though they are touching a live wire. As with touching a live wire, the adverse health effect of contact currents is electric shock and tissue heating at the point of contact. Depending on the intensity, it may cause a stinging sensation at the point of contact, involuntary reactions that pose a safety hazard to the person, and pain or visible skin damage due to an RF burn.

The requirements of the Radio Frequency Safety Program are in place to protect personnel and equipment. What may seem like an inconsequential change when altering the location of an antenna may result in an inadvertent over-exposure to personnel. Refer to CFTO C-55-040-001/TS-002, *Radio Frequency Safety Standards and Requirements*, when working with or near RF equipment, device or systems to ensure that all Department of National Defence (DND) and CAF personnel are protected by the federally mandated Health Canada Safety Code 6. The local Radio Frequency Safety Officer (RFSO) should be contacted with any questions regarding DND and CAF RF Safety Program requirements, as well as when reporting any accidents, incidents or near misses, to ensure appropriate reporting and investigating is conducted.

"Training is arguably the most important aspect of what we do as technicians and what and how we train is continuously changing."

Sources:

- CFTO C-55-040-001/TS-002, *Radio Frequency Safety Standards and Requirements;*
- Health Canada Web Site (Safety Code 6); and
- IWCE's Urgent Communication Web Site.