A soldier of The King's Royal Hussars on patrol during Operation Zmaray Luma near Lashkar Gah in Afghanistan, equipped with Personal Role Radio. Photo courtesy of MoD

Is the future of personal role radios quantum?

The battlefield has changed forever since personal role radios (PRRs) were introduced. No longer are communications limited to shouted orders, notes, hand signals or other rudimentary techniques; today, the battlefield is truly digital. Defence force operations have become streamlined, more efficient, and more secure than ever before.

We've come a long way in recent years. Gone are the days when orders were shouted across the battlefield by commanding officers, or essential intelligence was delivered by note or messenger. Moving on from these un-secured communications, today the battlefield has become largely digitised, particularly where communications are concerned.

Personal role radios (PRRs) have changed everything for the warfighter in the field. Military units can operate with greater stealth, enhanced efficiency, and can react to changing situations more rapidly and with more up-to-date information. Highly portable, compact, and extremely reliable, PRRs operate smoothly in harsh environments, and are rugged enough to withstand degradation from abrasive elements such as a sand and smoke, as well as physical impacts.

In the UK, PRRs are used by all the British Armed Forces, including the British Army, the Royal Marines, the Royal Air Force and the Navy. The devices are now also used by the Canadian Army, the Swedish Defence Materiel Administration (FMV), some US defence forces and even selected United Nations (UN) peace-keeping forces, among others. Beyond military applications, PRRs are also used for blue-light coordination, medical services coordination, wireless intercom, logistic support and inter-agency communications.

Today's technology

Regardless of geography, there's one PRR that stands out for its popularity amongst users. The ultra-high frequency (UHF) transmitter-receiver module from Selex (formerly Marconi-Selenia Communications) was developed in 1999 for use by the British Armed Forces. Initially development took place as part of the Bowman Programme, but the PRR was later spun off to enable implementation more quickly. It was brought into widespread military use in 2002.

Selex's PRR weighs 1.5kg, has a continuous-use battery life of 20 hours powered by two AA batteries, and operates on the 2.4GHz band. It has 500m of range on open terrain, and while it does transmit though thick walls and in enclosed spaces, under these circumstances its range is reduced. The PRR can be reconfigured in the field to operate on 16 of the 256 available channels using a selector dial on the device, while the remaining 240 channels can be accessed using an additional tool.

While the original H4855 PRR did not feature encryption capabilities, AES128 encryption was later added when Selex upgraded the model to the EZPRR (Enhanced & Encrypted Personal Role Radio), also known as the PRC-43. The PRR was designed with a low probability of interception (LPI), ensuring secure communications. Another improvement from the original model included a wireless press to talk (PTT) fob; the short-range (2m) encoded switch can be installed on weapons or military vehicles to enable communications without the soldier removing their hands from their weapon. Each PRR can work with as many as four codes, which can be easily

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updated in the field; this is an especially useful feature for soldiers sharing vehicles.

The upgrade also included re-broadcast units, which feature two inter-linked PRRs and filters in a saddlebag for easy manoeuvrability. The re-broadcast units are used when the team is spread over extended distances or when operations take place under demanding circumstances, i.e. in enclosed spaces like tunnels, or in high-humidity environments like at sea or in the jungle. In these cases, the re-broadcast unit allows the communication range to be doubled.

Additionally, a chain of re-broadcast units can also be established to enable communications over much greater distances.

The PRR comes with multiple headset options in acknowledgement of the varied needs of the defence sector. A lightweight headset that fits comfortably beneath most nuclear, biological and chemical (NBC) suit helmets and allows an ear defender to be worn on top is fitted with a noise-cancelling microphone and works with any secondary radio. Alternatively, a lower profile daylight headset is also available in left-hand or right-hand versions.

The PRR can be configured for single user or dual user modes using the appropriate PTT Switch Pack. With the Dual PTT switch pack, the Commander can connect to the PRR and Combat Net Radio (CNR). The Switch Packs include an audio ancillaries socket in which the lightweight headset or alternative ancillaries can be connected. The dual switch interface means that audio from the CNR and PBR are heard from the same earphone, but not at the same time, thanks to a 'call waiting' audible tone. Second radio interfaces can be provided for MBITR, Harris, SINCGARS, PR4G, Bowman, TETRA, ICOM, Motorola and other professional radios.

One of the most notable upgraded features is the incorporation of data transfer capabilities. Information from small, low-power GPS and other sensors and target designators can be delivered to the desired personnel rapidly.

But what about tomorrow?

Industry rumours tell us that PRR sales have slowed this decade as defence sector budgets have been constrained, although sales are expected to spike at the end of the decade as demand for short-range communications devices grows.

And while traditional radio communications have delivered truly life-changing benefits to millions of people around the world in defence, government, and emergency services settings, the benefits are limited. Range is vastly reduced in many situations since radio waves do not propagate through walls efficiently, which means that usage in cities, indoors, underground or subsea is either extremely limited or impossible.

It all comes down to frequency. The higher the radio frequency, the worse the signal is at penetrating matter such as walls; this is the reason mobile phone signals cut out when you're in a tunnel. On the other hand, the very low radio frequencies, including magnetic radio, suffer from poor receiver sensitivity and extremely limited bandwidth of existing transmitters and receivers. Researchers have been duly exploring new solutions to enable radio communications under more hostile or enclosed environments and have recently reported a breakthrough.

Is the future quantum?

We've been hearing about quantum more and more in everyday life in the last twelve months; quantum computing is becoming increasingly advanced, while China's Micius satellite recently successfully enabled a video call between China and Austria one million times more securely than what's possible with today's standard encryption techniques, using quantum entanglement.

As of January 2018, quantum has now come to radio communications. Researchers at the National Institute of Standards and Technology (NIST) have developed a proof-of-concept for 'quantum radio,' wherein the magnetic field of Rubidium atoms is manipulated to send digital signals, as detailed in the *Review of Scientific Instruments.* Although very low frequency (VLF) radio is already used for submarine communications, data transfer is limited and one-way, and submarines must first rise to periscope depth, reduce travelling speed, and carry antenna cables to enable communication. All that is set to change with quantum radio.

But how does it work? The spin of the Rubidium atoms is modulated vertically and horizontally via a magnetic field sensor, allowing the researchers to create 'zero' and 'one' positions which can be transmitted to, and read by, a direct current magnetometer. The Rubidium atoms are situated in a small glass container, and the changes in their spin creates alternating current electric signals. The voltages are read by a light detector, which can be made at low cost and small form factor.

"The best magnetic field sensitivity is obtained using quantum sensors. The increased sensitivity leads in principle to longer communications range. The quantum approach also offers the possibility to get high bandwidth communications like a cell-phone has," said NIST project Leader Dave Howe.

A signal processing technique which reduces environmental noise has also been developed by the researchers to increase the range of communication. The next step is to develop ways to boost the signal and increase bandwidth. The researchers are also looking to improve the ability to pinpoint the location of a receiver, which they hope to achieve using better algorithms and noise suppression.

The researchers have gone on record saying that the aim is not to replace existing radios, but to provide a solution in situations where existing radio does not work. Firefighters, for example, who operate in life-threatening environments where traditional radio often fails, could use the quantum radio to safely exit a dangerous building, effectively coordinating with a team outside to ensure avoidance of new hazards. Quantum radio might also prove useful for first responders to natural disaster events, defence forces in urban terrain or disaster areas, or naval military groups operating beneath the surface. **GMC**

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