Radio frequency spectrum congestion – Emerging headache for NCW

Dr Carlo Kopp

A problem gaining increasing attention in the US is the progressively worsening impact over time of radio spectrum congestion. Operations in Iraq have already been impacted, to the extent that operational planning now must consider what radio based systems can be used where and when.

Iraq has exposed what analysts and planners in the US have been predicting for some years, which is that the explosive growth of commercial wireless radio frequency technologies will severely impact operations by reducing available radio spectrum for military use. This itself is exacerbated by the increasing pressures within the military domain for networked capabilities running over radio channels.

Put simply, radio spectrum is a finite resource and subject to competing demands from civilian and military operators.

What is often less understood is the extent to which the radio spectrum is constrained by the physics of radio propagation. For military applications, the bands between 100 MHz and 18 GHz are of most interest.

Below 10 GHz radio waves generally penetrate atmospheric moisture, rain, fog, cloud, smog aerosols and dust clouds with very little loss. This all changes above 10 GHz into the centimetre bands where increasing water vapour in the atmosphere causes the microwave signal to be absorbed. Absorption peaks around 22 GHz but losses resulting from oxygen molecule resonances at 60 GHz then come into play. In practical terms, clear sky conditions provide a 'propagation window' below 18 GHz and another between 28 and 35 GHz.

Satellite communications, broadcast usage, mobile telephony and networking, plus dedicated commercial radio-frequency link usage all account for these physics by crowding especially into the bands below 18 GHz. Commercial operators have little interest in spending more shareholders' cash to operate in the upper centimetric and millimetric bands.

Satellite operators are understandably obsessed with maintaining their service despite cloud cover and rain, and have crowded the bands below 10 GHz. Terrestial microwave link operators, especially Telcos, have done much the same. Mobile telephony has firmly occupied the bands between 450 and 960 MHz and increasingly is appearing in the 1.8-1.9 GHz bands.

The 2.45 GHz and 5.8 GHz unlicenced Industrial Scientific Medical (ISM) bands are now heavily congested in most urban areas with WiFi networking signals, as business and consumers increasingly invest in wireless computer and appliance networking using 802.11 and Bluetooth. The new WiMax broadband standard and 3G telephony will push this envelope up well toward the centimetre bands.

A soldier loads radio frequencies on the communications systems in a Bradley Fighting Vehicle before a mission in Baqubah, Iraq.

Radio communications are critical to operations in combat operations. (US Defense photos)

The long term outlook is thus for increasing congestion below 18 GHz, as competing commercial services eat up available bands and push further up the frequency scale.

For users of military networking this presents two problems. The first is in maintaining reserved spectrum for military networks and radars, to ensure that these can be operated in peacetime and training environments without mutual interference. The second is that in wartime contingencies globally expeditionary forces are not confronted with similar spectral congestion across bands reserved for military use in developed nations but not elsewhere. Wireless has become the technology of choice for commercial operators in developing and industrialising nations, as it avoids the expense of laying cables to subscribers.

Another emerging problem is that of spectral purity in transmission equipment. For instance a radio transmitter operating at 450 MHz is apt to produce some harmonic components, at a lower power level, at 900, 1350 and 1800 MHz. In developing nations without strong regulation of equipment standards, cheaply built hardware with strong harmonic emissions can present a real problem.

There are two emerging byproducts of the spectral congestion problem. The first is the need to relocate specific military datalinks and radars out of bands firmly occupied by commercial service.

A good example is the replacement of the APQ-181 Ku-band radar on the B-2A bomber with an X-band design, as the spectrum used by this radar was reallocated for commercial use. Existing US datalink equipment for the AGM-130 standoff missile and the EGBU-15 glidebomb will also have to be replaced due to the loss of L-band spectrum used by this equipment.

The other problem is the need to design future datalinks not only for 'local frequency agility' to maintain jam resistance, but also for frequency agility between bands. The latter might mean that a datalink or network built for 1.2 GHz might have to be built to operate in other bands, say above 2 GHz or 6 GHz simply to stay out of locally congested bands. While the latter may appear to be a simple problem it is not – new radiofrequency hardware from antennas through to the transmitter and receiver hardware is typically required, including complete electromagnetic compatibility requalification for the carrying platforms.

In summary, advocates of NCW need to think long and carefully about this problem, since it will only get worse over time.