Article

Another Giant Leap: 50 Years of UK Military Satcom

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Abstract: The story of human exploration of space tends to capture the imagination but there has been a distinct lack of study into the Royal Air Force's own history of space operations. This article reflects upon another 'giant leap' that occurred shortly after the 1969 moon landings, when UK Defence took its initial steps into space operations, with the launch of the first of a series of Skynet communications satellites. The article introduces the principles of satellite communications, recounts the history of Skynet and highlights the operational importance of satellite communications throughout half of the RAF's first century of history. It concludes with a look forward into what the future might look like for the next generation of satellite communications and the RAF's broader role in space.

Introduction

In one of his first speeches as Chief of the Air Staff, Air Chief Marshal Mike Wigston reaffirmed the leading role that the Royal Air Force plays in space, announcing that the Service had 'initiated ground-breaking programmes that underpin the Royal Air Force's lead of the command and control of space operations for the UK MOD.'[1] With a renewed focus on space that sets it alongside air power as part of the RAF vision, it is appropriate to reflect that the UK Ministry of Defence (MOD) and specifically the RAF has a history of over half a century of conducting space operations. As Neil Armstrong took his 'giant leap for mankind' by stepping onto the surface of the moon on 20 July 1969, another giant leap into space was being planned by the UK MOD: the launch of its first communications satellite. Just four months after man first stood on the moon, on 21 November 1969, a Delta rocket was launched from Cape Kennedy in the US, carrying Skynet 1A into orbit.[2] The launch of Skynet 1A marked the start of UK sovereign military space operations and a leading role for the RAF in space. It is worthy of note that for half of the RAF's century of delivering air power, it has also operated in space.

This article will recount the history of UK military satellite communications (satcom), from high risk nascent technology through to the absolute reliance upon space-based support by all forms of military operation, an ever-present feature of recent conflict. Satcom and other space-based services have become unseen omnipresent utilities. Manned space travel and to a large extent scientific exploration of the solar system and beyond, captures our childhood imaginations and this is often sustained into adulthood. However, despite our reliance on space, our achievements in the seemingly more mundane space support activities, without astronauts as heroes, can pass us by. As a consequence, we tend to forget the ground-breaking human endeavour in science and engineering that created them. This article aims to remind the reader of some of those little-known achievements and highlight the continuing criticality of satcom to military operations. First, the underpinning principles of satcom will be examined, from the initial proposal for the creation of artificial satellites orbiting the earth, to a non-technical discussion of some of the orbital principles, and characteristics of communications transmission via space. Second, the article will examine the history of the Skynet programme and more broadly the UK's development of space as a military communications medium. Third, the operational impact of satcom will be considered with a few examples of its contribution to UK military operations. Fourth, the article will offer a brief view on the future of satcom before summarising the vital role satcom has played in supporting defence over the last half a century.

Satcom Principles

The idea of placing communications satellites in space is credited to the scientist and science fiction writer, Arthur C Clarke. Clarke served in the RAF during World War II and after reaching the rank of corporal, was commissioned in the Technical Branch of the RAF on 27 May 1943.[3] He is perhaps best known for writing the screenplay for the 1968 film *2001: A Space Odyssey* and his television series *Arthur C. Clarke's Mysterious World* and *Arthur C. Clarke's Mysterious*

Universe, but earlier he had proposed the general principle that underpins satellite communications. Writing a short article in *Wireless World* magazine in 1945, Clarke noted the possibilities presented by the World War II German V2 rocket, stating that if a rocket could reach sufficient speed parallel to the surface of the earth, it 'would continue to circle forever in a closed orbit; it would become an "artificial satellite"'.[4] He concluded that 'an "artificial satellite" at the correct distance from the earth would make one revolution every 24 hours; i.e. it would remain stationary above the same spot and would be within optical range of nearly half the earth's surface'.[5] Clarke's proposal described what became known as the Geostationary Orbit (GEO), with orbital positions along the earth's equatorial plane at a nominal altitude of 35,800km.[6] GEO is particularly useful for communications, as it places the satellite in a stable position that remains within constant line of sight from ground stations.[7]

Geostationary orbits, in theory, maintain the satellite in exactly the same position over the equator. However, in practice the orbit is not only influenced by the earth's gravitational pull, but also by gravitational effects of the Moon and Sun, that tend to pull it north and then south.[8] These movements away from the equatorial plane would require 'station-keeping' to maintain the satellite in its orbital plane, i.e. short 'boosts' of its station-keeping jets.[9] Repeated station-keeping manoeuvres expend valuable and finite fuel resources. As a consequence, the satellite is generally permitted to move a few degrees either side of the equatorial plane in a defined 'box'.[10] Fixed ground station antennas have complex tracking systems that maintain the received signal strength by 'following' the satellite as it moves around its 'GEO orbit box'. From the point of view of the ground station, as the satellite moves north and south during its orbit, it appears to follow a figure of eight pattern.[11] Although nominally described as geostationary, 'in practice, therefore, satellites in "GEO" orbit are thus more or less "geosynchronous" but not really "geostationary" because of these small excursions off the equatorial plane'.[12]

In addition to the GEO orbits, other orbit types provide useful military applications. Low earth orbits (LEO) use an altitude of up to approximately 1,600 km and have an orbital period of approximately 100 minutes.[13] This makes them particularly useful for remote sensing applications, such as Intelligence Surveillance and Reconnaissance (ISR) satellites. Medium Earth Orbits (MEO) sit at altitudes between 1,600 to 19,300 km, corresponding to orbital periods between 100 minutes and 12 hours. MEO provides greater coverage of the earth's surface than LEO and the longer orbital periods provide greater dwell time. MEO is suitable for positioning, navigation and timing (PNT) services, such as those provided by the Global Positioning System (GPS).[14]

Since the first launches into space in 1957 mankind has made 5,560 successful rocket launches, placing around 9,600 satellites into orbit.[15] Tracking the increasing number of space objects has become a significant task for both the scientific and defence communities. The US Secretary of the Air Force, Heather Wilson stressed that the US and its allies need 'near real-time situational awareness of the entire space realm out to [geosynchronous orbit]. It is a real part of what it will take to defend this domain'.[16] Despite the apparent vastness of space, European Space

Agency statistical modelling suggests that satellites share their orbits with: 34,000 objects larger than 10 cm; 900,000 objects between 1 cm and 10 cm; and 128 million pieces of debris between 1 mm and 1 cm.[17] The amount of debris in orbit contributes to making space a particularly harsh operating environment.

In addition to the man-made hazards in space, space operations including satcom must deal with the naturally occurring hazards in the environment. There are numerous naturally occurring phenomena that contribute to what is generically called 'space-weather', with the biggest impacts coming from the sun. The sun constantly emits radiation including in the frequency bands used by satcom. This creates a constant need for signals to and from the satellite to be able to overcome the 'background noise' caused by the sun's emanations.[18] In addition to the constant presence of radiation, the sun periodically and randomly emits massive increases in radiation, primarily through solar flares and coronal mass ejections. These huge surges in sun activity degrade both terrestrial and space-based radio systems.[19] One of the largest coronal mass ejections on record occurred at the end of October 2003, known as the Halloween Storm.[20] A coronal mass ejection on 28 October caused significant impact on earth and was at its most intense on 29 and 31 October, causing auroras, normally only observed in the high extremes of latitude to be visible as far south as Florida and Texas. Perhaps more importantly, it was responsible for the degradation of satcom and GPS and caused disruption to military operations.[21]

The simplicity of Clarke's proposal for the geostationary orbit masks significant technical challenges, both in terms of getting a spacecraft into the correct orbit and in creating, and maintaining, a reliable communications relay platform. Satcom continues to provide one important solution to the problem of communicating between distant locations across the globe. Communications satellites fundamentally act as repeaters for radio signals. Signals are transmitted from a highly directional antenna on the earth towards the satellite via the *uplink*. The satellite *transponder* translates the signals to a different band of frequencies, amplifies them and retransmits them back to earth via the *downlink*.[22] As proposed by Clarke, theoretically '…three repeater stations, 120 degrees apart in the correct orbit, could give… coverage to the entire planet'.[23]

Before the advent of satcom, the UK armed forces had relied upon a world-wide network of terrestrial High Frequency (HF) radio transmitters and receivers. HF radio propagation relies upon the principle of ionospheric refraction, where signals in the HF band are refracted from an ionized layer in the upper atmosphere and therefore can effectively be 'bounced' thousands of kilometres around the earth's surface.[24] Whilst HF radio endures in some important military and civil applications, its use has largely been replaced by fibre optic and satcom, principally because transmission quality is variable at different frequencies, time of day and season.[25] The lower frequency range of HF also means that less data can be transmitted than is possible using satcom. The introduction of Skynet offered the potential to supplant 40 years of HF as 'the Service's thin long haul communications bearer',[26] with the promise that satcom could be 'free from the atmospheric effects which interrupt the high-frequency radio circuits on which most of the long distance communications depend at present'.[27]

Although the development of satcom overcame some of the limitations and challenges of HF, it brought with it a new set of technical and operational problems. The most suitable frequency bands for satellite transmission are the Ultra High Frequency (UHF) and microwave bands; the higher the frequency, the higher the rate of data transmission. In any radio system, the signal is attenuated over distance, with the signal loss due to attenuation being proportional to the square of the distance from the antenna.[28] Antennas for microwave transmission are designed to minimise attenuation by focussing as much transmitted power as possible in a very narrow beam in the direction of the receiver. This is the reason for the now ubiquitous parabolic reflective antenna, or 'dish', being chosen for satcom. The parabolic reflector focuses all the transmitted energy to a focal point, 'in theory this effect causes a parallel beam without dispersion'.[29] The larger the antenna, the more 'tightly directional is the beam',[30] hence the large 12.2m and 6.4m antennas that have populated the skyline at satellite ground stations. These enormous dishes are not static, rather they require the ability to move in both azimuth and elevation with an accuracy of fractions of a degree to remain 'locked' onto the signal of the distant spacecraft in geosynchronous orbit. Smaller antenna size for deployed mobile ground stations comes at the cost of lower capacity links, such as those used by so-called 'small aperture terminals'.[31]

UK Satcom History

The history of UK satcom started with collaboration with the UK's closest ally, the US. Prior to the Skynet programme, the UK participated in joint trials with the US as part of the Interim Defence Communication Satellite Programme (IDCSP), which launched 26 satellites and provided an early network for the two transatlantic partners and their NATO allies.[32] Building upon IDCSP, the UK purchased 2 geostationary satellites, Skynet 1A and 1B, manufactured in the US by Philco Ford. Skynet was designed to be interoperable with the IDCSP system.[33] With the launch of Skynet 1A in November 1969, the UK gained its first independent space network.[34] Ten months later, Skynet 1B was launched as an 'in-orbit spare', but failed to survive launch.[35]

From the launch of Skynet 1A, the centre of RAF satcom operations was No. 1001 Signals Unit (1001 SU) based at RAF Oakhanger, near Bordon in Hampshire. 1001 SU, whose motto *Ultra Tellurem Dico*, can be translated as 'I speak beyond the earth',[36] was charged with the responsibility of operating the United Kingdom Military Satellite Communications System (UKMSCS). This role was twofold: managing the communications traffic and networks between the UK and fixed and deployable overseas locations on land and sea, and the in-orbit management and control of the Skynet series satellites and those of NATO.[37] The establishment of RAF Oakhanger as the hub of UK satcom included a £1 million contract with the Marconi company to supply and install a complete satellite communications terminal.[38] Oakhanger, and later its sister station at RAF Colerne and the control centre at RAF Rudloe Manor were manned by RAF engineer officers and technicians round the clock for several decades, assuring the delivery of communications services within UKMSCS. In addition, highly trained officers and senior non-commissioned officers at the Enhanced Spacecraft Operations Facility (ESOF), based at a separate site at Oakhanger were responsible for 'flying' Skynet. This little-known function placed the responsibility for controlling 'the equivalent (in replacement cost terms) of several squadrons of front-line aircraft' in the hands of a small crew of specialist controllers.[39]

Perhaps as a result of the surge of public interest in the year of the Apollo 11 moon landings, the RAF's nascent role in space did attract some media attention. The RAF was invited onto the BBC children's programme *Blue Peter* in November 1969 with a Skynet satellite mock-up.[40] BBC News also visited RAF Oakhanger and conducted an interview with the Station Commander, Group Captain Frank Padfield.[41] Group Captain (later Air Commodore) Padfield is credited with planning the introduction of Skynet and overcoming significant resistance within the MOD.[42] Air Commodore Padfield had originally joined the RAF as a radar mechanic during World War II, serving alongside Arthur C. Clarke, before being commissioned in 1946.[43] Reflecting on the first 25 Years of Skynet, Dennis Cummings marks three individuals as the 'pioneers and visionaries' of UK Satcom: Air Commodore Padfield, Lord Mountbatten who secured funding and Cabinet approval, and Peter Whicher, project director at the then Ministry of Technology.[44]

Skynet 1A interconnected fixed ground stations at Oakhanger, Singapore, Cyprus, Bahrain and Gan, and two air-transportable stations were held for contingency operations.[45] The next UK satcom breakthrough came when the Royal Navy demonstrated shipborne satcom capability on board *HMS Intrepid* in June 1970.[46] The requirements of the maritime domain for global communications went on to become particularly important as the general withdrawal of UK armed forces from the 'East of Suez' led to the Army and RAF becoming largely fixed in Europe.[47] Unlike the static ground stations, maritime satcom presented some additional challenges to the engineers. In particular, the antenna system did not merely need to cope with the slight adjustments in the orbit of the satellite, it also had to account for the 3-axis movement of the maritime platform, including ensuring the system remained locked to the satellite whilst the ship rolled up to 30° in either direction.[48]

The next phase in the Skynet programme, Skynet 2, marked the point where 'UK military satcoms unquestionably came of age'.[49] Unlike the Skynet 1 spacecraft which were manufactured in the US, the Marconi Company produced the Skynet 2 space vehicles in the UK. In the early 1970s, launching a satellite into orbit remained an extremely high-risk endeavour. Skynet 2A failed after launch in January 1974, due to 'sub-standard coatings' and was destroyed upon re-entry into the earth's atmosphere.[50] However, its sister satellite Skynet 2B successfully entered service and functioned well beyond its planned service life.[51] Skynet 2B became an increasingly important part of UK military communications, with the development of mobile terminals for use on land and the increased deployment of shipborne terminals.[52]

One of the characteristics of orbital space is that man-made satellites placed in orbit remain there, theoretically indefinitely. However, in practice, without periodic manoeuvring the orbit degrades over time, hence precious rocket fuel resources are carefully managed to carry out small in-orbit manoeuvres throughout the satellite's operational life. Once the fuel used to manoeuvre the satellite is expended, it is often moved to a 'graveyard orbit'. Although it may no longer have operational utility, the communications payload, powered through solar energy, continues to function far longer than the planned life of the satellite. Indeed, Skynet 1A remained in space in a graveyard orbit, 50 years after its launch, one of the ever-increasing numbers of trackable objects in space.[53] Writing to mark the 25th Anniversary of UK satcom, Dennis Cummings remarked that the payload of Skynet 2B 'has proven to function satisfactorily throughout the past 19 years whenever it has been tested in its uncontrolled orbital meanderings'.[54]

The development of satellite communications amounted to a significant investment for the UK, with 1972 Cabinet papers citing the cost of Defence Satellite Communications at £10.1m and the nation's total space expenditure at £31.19m.[55] The expensive launch failures of Skynet 1B and 2A were followed by a period of significant financial austerity in the mid-1970s, leading to the cancellation of the Skynet 3 programme in favour of leasing communications satellite capacity from the US and NATO.[56] Cummings argues that internal detractors with the Ministry of Defence and the 'traditional conservatism of the military community' were in part to blame for the cancellation of Skynet 3, citing a senior officer dismissing 'the new medium as a "triumph of improbability over common sense"'.[57]

The Skynet 3 hiatus was finally overcome to satisfy the requirements of the Royal Navy, who unlike the RAF and Army in the late 1970s retained the need for global communications, a requirement that was to be starkly underlined by the Falklands conflict.[58] 11 December 1982 marked the start of the operational life of Skynet 4, when the first in a series of six GEO satellites was launched in an Ariane rocket.[59] Skynet 4 heralded a significant increase in capacity to meet the military's demand for communications services. The programme also satisfied the increasing need for small mobile terminals, including developing a terminal to be flown on the Nimrod aircraft.[60] From the perspective of the UK space industry, the success of the Skynet 4 constellation was recognised by NATO procuring satellites built to the same design as Skynet 4 for its NATO IV series, launched in 1991 and 1993.[61]

Although central to the UK satcom story, Skynet has not been the only solution to the military demand for global fixed and mobile communication services. The history of UK satcom has increasingly included a blend of commercial satcom services to complement the core military capabilities. The additional capacity and flexibility of using commercial services is balanced against some of the benefits of government ownership, such as security, physical hardening of the space and ground segments, resilience against electronic warfare, and the ability of commercial providers to support austere and dangerous operating locations. UK Defence has also made extensive use of satcom services provided by INMARSAT, which was founded in

1979 by the Inter-Governmental Maritime Consultative Organisation.[62] INMARSAT has been particularly useful for maritime use, but with the development of its Broadband Global Area Network (BGAN), INMARSAT has helped satisfy the requirement for small lightweight terminals on land, filling a vital role for 'early-entry' communications.[63]

The transition from the Skynet 4 series ended the era of wholly owned and operated communications satellites within the UK MOD, with the successor, Skynet 5, delivered through a partnership with industry under a Private Finance Initiative (PFI) program.[64] The Government's deliberations regarding another huge investment in satcom came at a time when greater involvement of the private sector was becoming a preferred method of delivering asset-intensive services.[65] The advantages of PFI, from the government perspective, were that it would: 'obtain better value for money from existing budget allocations; improve the quality of service it receives; [and] reduce risk to MOD'.[66] In the late 1990s PFI was the chosen route for many capital investment projects that might not otherwise be affordable. The Skynet 5 Programme handed over ownership and responsibility to Paradigm Secure Communications Ltd, now a subsidiary of Airbus Defence and Space. In doing so, the MOD moved from a model of ownership of space assets to one that is designed as a 'service-based approach'.[67] This approach has enabled a mix of protected military capacity and long-term commercial leases.[68]

The transition to Skynet 5 also marked a turning point for the RAF. Ownership of RAF Oakhanger and the other ground elements transferred to the contract partner and the direct role of uniformed personnel operating, maintaining and 'flying' Skynet came to an end. RAF personnel continue to be employed alongside their colleagues from the other services, civil service and contractors, within Joint Forces Command.[69] The uniformed RAF presence at Oakhanger continued a little longer in the guise of the RAF-manned NATO Satellite Ground Terminal, which opened in 1971, just a few years after its neighbour, RAF Oakhanger. The Skynet 5 partnership provides the MOD not just with the space segment and the fixed satellite ground stations, but includes mobile terminals including the Reacher series of equipment.[70] Reacher is one of the latest in a long line of mobile and deployable satellite terminals operated by the RAF's communications and information system specialists at No. 90 Signals Unit, who have continued to be RAF satcom operators long after commercialisation under Skynet 5.[71]

The Skynet 5 partnership took ownership of the legacy Skynet 4 spacecraft before launching replacement satellites Skynet 5A, 5B and 5C between 2007 and 2008.[72] Paradigm expanded upon its support to the UK MOD by agreeing contracts to provide services for the Portuguese, Canadian, Dutch and US Forces and took contracts to deliver part of the NATO requirement for satcom services.[73]

This brief review of the epochs of UK military satcom, marked by the successive numbered generations of Skynet, captures only a snapshot of major milestones. It cannot adequately reflect the effort and engineering expertise of a huge number of personnel, military, MOD civilian and industry partner, who have underpinned the generations of satcom. The paper now turns to the reason for military satcom's existence: supporting military operations.

Operational use of satcom

Military artificial satellites do not, of course, exist for their own ends. Each satellite has a payload, which coupled with the relative merits of its orbital position allow it to carry out a particular function or operational mission. This section, by no means exhaustive, highlights just a few examples of the impact space and particularly satcom has had on the conduct of operations.

The 1982 Falklands War was the first conflict where the UK had relied heavily upon the use of satcom for command and control.[74] The remoteness of the Islands and the decision to deploy a military task force some 8,000 miles to retake them from the occupying Argentinian forces, meant that satcom became an important tool. At this time, the UK military had been largely postured for Cold War conflict centred on North-West Europe, and was not well equipped to be operating over extremely long lines of communication.

A satellite rear-link was landed at San Carlos and established at Ajax Bay on 25 May 1982, providing a means of command and control over the deployed Land forces for Admiral Sir John Fieldhouse in Northwood.[75] The presence of the satellite link enabled the explicit direction of Land Forces from Northwood and Whitehall that shaped the campaign. One of the most well-known decisions of the campaign, was initiated when Brigadier Julian Thompson, Commander of 3 Commando Brigade 'found himself summoned to the satellite terminal at Ajax Bay'.[76] After the lengthy transit of the Task Force from the UK, the landing at San Carlos and a number of losses of shipping, the Government, led by Prime Minister Margaret Thatcher, was desperate to demonstrate some quick success to the British public. As a result, Thompson was ordered to engage the Argentinians at Goose Green, an isolated settlement, that he 'regarded as strategically irrelevant'.[77] Despite the presence of satcom, Hastings and Jenkins' history of the conflict argues that 'for all the marvels of modern technology there were remarkable lapses in liaison'.[78] A failure to communicate led to intelligence that was known to those in Whitehall not being shared with the South Atlantic.[79]

The fairly nascent use of satcom during the Falklands conflict may have had other unintended consequences. Some post conflict analyses argue that use of satcom may have contributed to the loss of *HMS Sheffield*, the destroyer sunk by an air-launched Exocet missile. It is argued that at the time of the attack the ship had her search radar switched off as her satellite terminal was in use, and that this was a contributing factor.[80] However, analysis carried out by Ganley and Ganley argues the more likely explanation that the radar was turned off as part of normal emission control measures and also cite weaknesses in the ship's electronic countermeasures.[81]

The 1991 Persian Gulf War is often described as the first space war, or the first 'high technology-satellite war'.[82] The build-up to the Gulf War, under the UK Operation Granby marked a significant increase in demand for satellite communications services. This was the first time that the UK, the US and their allies had a large number of satellites at their disposal for communications, PNT, and intelligence gathering, with all of these services proving invaluable in supporting operations.[83] Interoperability between UK, US and NATO satcom systems as a result of years of mutual collaboration throughout their space programmes played a role in the successful use of space during the conflict.[84] The use of satcom in the 1991 Gulf War was not limited to military systems, Skynet, NATO and the US Defense Satellite Communications System (DSCS). During the conflict, commercial systems were also employed, particularly the use of INMARSAT for mobile communications.[85] The demand for satcom services for the US forces led to them being authorised to use UK Skynet and to lease commercial services.[86]

Retrospective analyses of the 1991 Gulf War claimed it was a 'Revolution in Military Affairs (RMA)', succinctly defined by Sir Lawrence Freedman as 'the strategic consequences of the marriage of systems that collect, process and communicate information with those that apply military force'.[87] Much of the debate around the RMA has focused on the precision effects of guided munitions, something which, since 1991 has been a characteristic of the UK means of employing air power. However, the enablement of effects through the 'marriage of systems', the combination of a range of technologies and processes, is perhaps the more important Gulf War legacy. Clearly, space played a highly significant role, with a combination of PNT, ISR and satcom as enablers of military activity. Taken in the context of the gradual evolution of space-based capabilities since the 1960s, the 1991 RMA seems more evolutionary, than revolutionary. Freedman's excellent balanced article on the subject, published in 1997, is illustrated by an early example of those now-ubiquitous diagrams showing 'warfighters' as part of a network of land, maritime, air and space platforms interconnected by undefined 'lightning bolt' connections.[88] The use of these diagrams, loved by Defence contractors and senior officers alike, can be useful abstractions of complexity, but can also lead to over-simplification and risky assumption.

The post-Cold War, post-1991 Gulf War world saw a shift in UK military operations from fixed operations, predominately in North-West Europe, to a more globally deployed posture. The increased demand on satcom services at 1001 SU, reflects this change. During the 1990s the requirement for UK Military Satcom for 'fixed' strategic communications remained relatively constant.[89] However, during and after Op Granby satellite traffic for deployed operations grew significantly throughout the 1990s as the UK military conducted operations in the former Yugoslavia, Exercise Purple Star[90] in the US in 1996 and the Op Ocean Wave deployment to Hong Kong in 1997.[91] The changing operational context of simultaneous operations in Bosnia, Kosovo and the Middle East also led to much greater use of commercial satcom carriers.[92] Operations in the former Yugoslavia led to the development of a complex network of nationally-provided and NATO communications systems, using satcom as 'rear-link' connectivity. By the turn of the century, the Kosovo campaign with its deployed presence under NATO KFOR had benefitted from several years of development of communications systems in Bosnia.[93] Satcom had become a feature of all British military deployments and, in the words of the then Commanding Officer of 1001 SU: 'In essence, wherever British forces are required to operate and communicate, either together or back to the UK base, there you will find a military satellite communications service provided by 1001 SU'.[94]

The Armed Forces were not the only important consumers of Skynet services during its history. One of the biggest customers of the early Skynet programme was the UK Signals Intelligence SIGINT) agency, Government Communications Headquarters (GCHQ). GCHQ's demand for satcom came from the need to exchange SIGINT data with the US National Security Agency (NSA), with the additional concern that in time of conflict the Soviet Union would use submarines to cut transatlantic cables.[95] This point has wider relevance for the need to invest in resilience for communications systems. The threat to communications during conflict, or even 'sub-threshold', is not just something that military planners of the 1960s and 1970s had to contend with; increasingly the resilience of the underpinning architecture of cyberspace, including undersea cables is a present-day concern for the UK and its allies.[96]

More recent conflicts in Iraq and Afghanistan, and over Libya and Syria have firmly embedded satcom as an essential service for all UK military operations. Widely dispersed locations in countries with extremely poor communications infrastructure led to an increased demand for satcom services for command and control, the dissemination of ISR data and increasingly in supporting the control of Remotely Piloted Air Systems (RPAS).[97]

Future of satcom

Each successive series of Skynet constellations has been launched with a predetermined expectation of their service life. The finite resources of rocket fuel that enable station-keeping, the risk of component damage through exposure to high energy particles in space, and general technology failure and obsolescence, require the custodians of the satcom mission to have one eye on the future. In September 2019, making his first keynote speech, the Defence Secretary Ben Wallace announced the competition for Skynet 6, the contract to deliver and operate the next generation of UK satcom.[98] Initially, it will take the form of the Skynet 6 Service Delivery Wrap (SDW), a contract to operate and maintain the constellation of spacecraft and the ground station infrastructure. In addition to SDW, negotiations are ongoing with Airbus to provide a single new generation spacecraft, Skynet 6A, with further work required to develop the remainder of Skynet 6, known as Enduring Capability.[99]

So, what might the future of satcom look like? The demand of the military customer for ever more quantity and quality of information grows unabated. Delivering that information in a timely manner to globally deployed forces will continue to require satcom, particularly for aircraft, ships and mobile units and those locations not well served by terrestrial fixed communications infrastructure. Despite the inability of military planners to predict the future, analysing the broader trends in the future operating environment indicates an ever-growing need for space services, including satcom. However, those trends also indicate that the space environment is itself changing, due to man's increasing use of it.[100] The large number of trackable objects and smaller debris in orbit, discussed earlier in this article, is only set to increase still further. The ever-growing congestion of space, mainly driven by a commercial space-race, adds to the risk of accidental collision. This risk is not merely a theoretical concern; in 2009 an inactive COSMOS satellite collided in orbit with an operational Iridium-33 satellite, 'creating thousands of pieces of debris in low-Earth orbit'.[101] The increased need to manage congested space is reflected in the expansion of the RAF's space control capability and the creation of a National Air & Space Operations Centre.[102]

In addition to space becoming ever more congested, it is also becoming contested. The desire to counter the advantages gained from space capabilities has led to many nations developing counter-space capabilities, including Anti-Satellite (ASAT) weapons.[103] In response to these threats, the UK has joined a US-led initiative, known as Operation Olympic Defender: 'a multinational coalition formed to strengthen deterrence against hostile actors in space and reduce the spread of debris in orbit'.[104] Physical destruction of in-orbit spacecraft is only one threat to space operations; the ground segment infrastructure is also vulnerable to physical attack. All aspects of the system, the space, ground and link segments are also vulnerable to attacks through cyberspace and the electromagnetic spectrum.[105] Most of these threats, with perhaps the exception of in-orbit ASAT weapons, are nothing new. Designers and operators of the early generations of Skynet were attuned to ground segment-physical and electromagnetic spectrum threats and designed and operated the systems accordingly. However, as the threat from the former Soviet Union waned, greater risk could be taken and greater use of commercialisation enabled more cost-effective solutions, without some of the resilience measures. The Skynet 6 generation will certainly need to be built with the full array of threats – environmental, operational, intentional and accidental – in mind.

It is possible that Skynet 6 may include more than the large reliable and resilient GEO satellites that directly replace their predecessors in providing a range of military and commercial services. Increasingly, it is likely that smaller scale, more operationally responsive, spacecraft may form part of a future solution. Outside of Skynet, the RAF may choose to build upon the Carbonite-2 concept demonstrator, delivered in partnership with Surrey Satellite Technology Limited.[106] Carbonite-2 successfully demonstrated a high-definition video capability, but in principle this type of space vehicle could carry other payloads. Under Project Artemis, the RAF has also reached an agreement with Virgin Orbit for the provision of responsive launch capabilities to short-cut the long lead times that have been a feature of previous space launches.[107] It is also possible that so-called 'pseudo satellites' are likely to be part of the solution for beyond-line-of-sight communications. High Altitude Pseudo-Satellites (HAPS), fixed-wing air vehicles and balloons, typically operate at altitudes of 60,000 feet, sitting between regulated airspace and the accepted defined boundaries of space.[108]

The possible solutions described in the paragraph above are alternative air and space vehicles, rather than specifically satcom payloads. However, in addition to the well tested, but extremely costly, GEO satellites delivered in typically 15-year epochs that have characterised the history of

Skynet, it is possible that any of the above solutions could be part of an overall suite to deliver beyond-line-of-sight communications solutions.

Summary

This article has provided a very brief overview of half a century of UK space support operations, specifically the history of UK military satcom. It has touched on some of the core principles of satcom, but deliberately simplified what is a complex mix of applied physics and multidisciplinary engineering. In describing the history of the generations of Skynet, the article has been necessarily scant on detail, not just in the interest of brevity, but as a reflection of the apparent lack of study into the topic of military satcom and in particular the RAF's role in that history. The history of UK satcom is not just one of technical achievement and the article has attempted to capture a sense of how it has enabled and directly contributed to military operations. Inevitably there are numerous stories from the operators and users of satcom that are yet to be written down. Despite the enormous expense and technical challenge of delivering satcom services, our dependence upon satcom is highly likely to assure its future, despite the difficulty in predicting what that future might precisely look like.

In writing to mark the 25th Anniversary of Skynet, Dennis Cummings concluded: 'Happy Birthday, Skynet, and congratulations to British pioneers who began it, and to those members of the UK forces who have fostered and operated it'.[109] As we have passed the 50th Anniversary, with a far greater role for commercial partners in current Skynet operations, we should perhaps add congratulations to the Whole Force Skynet operators, and all uniformed military, civil servants and contractor partners who have delivered satcom services for the UK Armed Forces. The high-risk pioneering endeavour of the 1960s has become almost an unseen utility, that has underpinned all military operations for half of the lifetime of the RAF. Satcom, like so many supporting capabilities in warfare, is a little-discussed 'unsung hero', yet its importance to the delivery and sustainment of operations is enormous. The visionaries like Lord Mountbatten and Air Commodore Frank Padfield, who took Arthur C. Clarke's idea and, during the space race of the 1960s, turned it into operational reality, were truly making a giant leap. This other giant leap, and the 50 years that followed it, merits further study and discussion to develop the historical record, which today's RAF space operators can reflect upon with pride.

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