Viewpoint

Space Matters!

By Group Captain (Ret'd) Ian Shields

"Space is a highly significant area of science policy and it is necessary for the Government to take a strategic approach to space activities… The Space sector has great economic potential. The UK space industry is ambitious and focused… The UK has world-leading space scientists and technologists. Space science both depends on technology and can drive technology developments… We suspect that unfortunately the public is still unaware of the ***variety, breadth and importance that space activities play in their everyday lives…****"*

The above quotes (with added emphasis) are from the Summary to the House of Commons' Select Committee on Science and Technology's Seventh Report, prepared on 17 July 2007 and titled "A Space Policy". This report correctly highlighted that space matters to the United Kingdom (and, indeed, to all developed and most developing nations). Since the report was primarily aimed at industry, it rightly concentrated on the economics of space as they impact the country, identifying the opportunities that exist and capturing those areas where the British still enjoy pre-eminence. The report also acknowledges that the UK does not fund launchers or participate in human spaceflight to any great extent, and warned that the country was trading heavily on past investments and that current financial commitment is limited.

The nub of the issue is that space has become a – arguably *the* – mainstay for the public, private, commercial and, crucially, defence sectors but in such an insidious way that our growing dependency on space has left us markedly vulnerable. This article will initially explore the potential economic benefits to the country of space, but will then highlight how we (and particularly defence) have become dependent on space to the extent that it represents a potential single point of failure. Key vulnerabilities are explored next, then threats to space security are considered before the article concludes by arguing that we need to take a more robust stance on space and that we, as airpower practioners, are best placed to take the lead.

First, from the wider perspective, some good news for the country. As the Science and Technology Select Committee discovered, there is every reason for the UK to invest in space. That little that has been invested so far has brought financial returns that are measured in multiples of five, seven and even ten: the country has benefited directly in a considerable manner from the small investment to date. The spin-offs are harder to quantify, but certainly exist in terms of transferred technology and Britain's place as a leading scientific and technological contributor. But the economic potentials of space are only just now beginning to be recognised. For example, a metal-rich asteroid of just two kilometres size (of which there are many) would yield ore priced at some $US 9 ***trillion*** at today's prices. Meanwhile, the moon is known to contain significant deposits of Helium 3, vital for nuclear fusion. One Space Shuttle load of Helium 3 would provide enough Helium that once converted into electricity through nuclear fusion could power the entire United States for one year. While neither are practical propositions yet, as resources continue to be depleted on Earth, such options will become increasingly attractive, and therefore financially viable; and where financial viability leads technical ability will soon follow. The Government is alive to the potential, and the creation of a full-blown United Kingdom Space Agency (UKSA) on 23 March 2010[1] was recognition that the UK still has a lead in certain aspects of space (for example, small satellites)[2] and the new Agency will seek to harness these advantages and boost this high-technology, high-return sector. What remains less clear is how UKSA will link with the European Space Agency, or, of more concern to the defence and security sector, how the MOD will interface with UKSA.

So much for good news, but in what ways have we become vulnerable as a society and as a military due to our reliance on space? Let us first examine societal dependency, before considering more carefully the military position. The Government has identified eight sectors (communications, emergency services, energy, finance, food, government, health, transport, water)[3] that are critical to the well-being and continued functioning of the country, and how they might protect them from attack or interference from any direction. Every one of these sectors depend on space to a greater or lesser extent. Consider for example both food and transport: your local supermarket does not have a vast warehouse full of food at the back of the store, and that stock it does carry is non-perishable. "Just in Time Logistics" has been embraced by the supermarkets to a very large extent, and they rely on satellite tracking (not to mention SatNav to guide their drivers, albeit sometimes with amusing consequences) of their goods. Those who recall the petrol strike of the year 2000 will recall how easily the country was put under threat by simple blockades of fuel depots, highlighting how little resilience our infrastructure has.[4] Communications is an obvious example, but it is the reliance on the timing signal from the Global Positioning System (GPS) that has become the most critical. For example, for mobile telephones to function without interference as we move around the country, the various radio masts that they utilise must be synchronised. That synchronisation is achieved from the GPS signals. For the banking sector, every electronic transaction is accurately time-stamped (important if you are trading millions of pounds around the globe) and GPS again provides that timing signal. Synchronisation of the alternating current output from power stations is again achieved by the timing signal from GPS. Since the very function of GPS relies on a highly accurate (<10 milli-seconds) and stable timing signal[5] that effectively offers atomic clock performance globally and is the most widely-used aspect of GPS.

If the wider community is reliant, then, on space what of the military, and particularly the Air Power user? Here the case is, if anything, more stark. The first Gulf War is commonly held as being the first conflict where space played a very significant role:

"For the first time in history, space systems were employed during the Persian Gulf War at not only the strategic level of war, but also at the operational and tactical levels as well. Space-borne assets had a dramatic effect on the ability of the operational level commander to successfully plan and prosecute a comprehensive warfighting campaign."[6]

Analysis of the coalition success in this conflict highlighted how networked information and significant situational awareness gave the Americans and their allies an overwhelming asymmetric advantage. But it also revealed how dependent we have become on space-based assets and how, therefore, space represents a potential single point of failure. Since then, our dependency has grown to what amounts now to an overwhelming reliance. Cleary expeditionary operations, and in particular our current operations in Afghanistan are reliant on space for functions such as satellite communications, data-links, surveillance, GPS (be that for navigation of a tank or as an element of the terminal guidance for a precision-guided munition), controlling at range an unmanned air vehicle and then distributing its data. More tellingly is the extent to which we, in the main unknowingly, have come to rely on space for every single sortie. Much of our meteorological data is now resourced from space, with increasingly sophisticated satellites providing far more than visible-band pictures, but wind, temperature and moisture content are now all primarily derived from satellite data[7] rather than reports from aircraft or the now defunct network of weather ships.[8] Our navigation systems are almost totally reliant, at least to bound Inertial Navigation System platforms, on GPS. An increasing part of our weaponry is GPS guided. And the ubiquitous GPS timing signal allows us to synchronise frequency-hopping secure radios. It is becoming doubtful not whether we could mount a training serial that is entirely devoid of space products, but whether it would be safe enough to do so.

Accepting that we have become reliant on space, how vulnerable is the space sector in reality? This article will next consider five key areas of brittleness (launch and control sites, communications links, the Electro-Magnetic Spectrum (EMS), the predictability of orbits, and the platforms themselves) before considering one particular threat.

Launch and control sites are large, fixed and in known locations. As such they are obvious targets and vulnerable to conventional, kinetic attack. While attacks against launch sites would have little immediate effect, destroying command and control hubs, or seizing them with the intent to cause mischief, could have immediate repercussions. Indeed, it is this latter point, the command and control aspects, that represents the greatest weakness. Satellites send and receive data almost constantly, including course correction data to avoid other satellites, the increasing quantity of man-made space debris and natural hazards such as meteorites. These signals are invariably encrypted, but while military satellites are protected to a very high degree the same cannot be said for commercial platforms, where the driver is data throughput (revenue earning) rather than security. Furthermore, to interfere with the guidance signals from a satellite would not require the full panoply of a state to engineer and therefore there is a significant vulnerability in these signals. Moreover, hostile organisations may not seek to take total control of a satellite, but to use it for their own purposes either as a broadcast or re-broadcast platform, or to task it for their own purposes if it was, say, a surveillance station.

Developing this issue further, the EMS is itself of only limited width and although developments such as low-power data-streams, directional antennae and technology allowing bandwidth utilisation have all increased its utility it is finite in width. This leads to a degree of predictability in its use and exposes a further weakness. And the satellites themselves have not only a limited number of useful orbits, many of which are already very crowded, but the orbits are highly predictable. Knowledge of when a particular satellite will be in view offers both defensive and offensive possibilities but it is increasingly true that despite its vastness it is remarkably hard to hide in orbital space.

Finally, what of the platforms themselves? Of the five key areas of vulnerability, this, counter-intuitively, may be the least. While the operating environment in space does represent a threat due to extreme radiation and the destructive energy of collision with even very minor particles[9] , direct man-made threats to objects once in orbit is limited. There are a variety of methods of initiating a kinetic attack on a satellite, be that from a ground-based launch site or from another satellite, but both require very advanced computing power to solve the targeting issue and is, at least for the present, the preserve of major state actors. The satellites themselves are, then, relatively immune from direct interference.

They may be, however, particularly vulnerable to one type of attack, which is the use of an Electro-Magnetic Pulse. From 1958 – 1962 both the US and the (then) USSR conducted a series of exo-atmospheric nuclear tests to test both their potential to defeat incoming Inter-Continental Ballistic Missiles, and to destroy satellites. They proved that the thinner atmosphere above about 50 km altitude had a significantly less attenuating impact on EMP than those closer to the ground. But the tests had unintended effects also. For example, on 9 July 1962 the US detonated a 1.4 Mega-Ton yield device 400 km above Johnson Atoll in the Pacific Ocean, codenamed Starfish Prime. This test damaged electronics in Honolulu and New Zealand (approximately 1,300 kilometers away), fused 300 street lights on Oahu (Hawaii), set off about 100 burglar alarms, and caused the failure of a microwave repeating station on Kauai, which cut off the telephone system from the other Hawaiian islands.[10] Starfish Prime also produced an artificial radiation belt in space which soon destroyed three satellites (Ariel, TRAAC, and Transit 4B) and minor degradation to three others (while Cosmos V, Injun I and, most famously, Telstar). Given how few satellites were then in orbit compared to today, it can be readily seen how significant the impact of an exo-atmospheric nuclear detonation would be. That said, any adversary undertaking such an action would themselves suffer the same significant damage to their capabilities, while it would be impossible for a state to deny their actions, such is the monitoring capability of both launch and nuclear capabilities. In 1963 the Partial Test Ban Treaty ended atmospheric and exo-atmospheric nuclear tests, while the Outer Space Treaty of 1967 bans the stationing and use of nuclear weapons in space.

Having established our dependence on space and explored some of the vulnerabilities, what should we do about it? There are, I would argue, two steps that we should take, all of which centre around the theme of resilience. First, we must acknowledge the extent to which we are reliant on space and seek to educate both broadly and, by investing in a cadre of space expertise, narrowly and deeply. Secondly, we should explore how we can maintain access to space in the event of disruption, be that from man-made interference or natural phenomena such as space weather.[11] While it may not be necessary for the UK to develop a totally indigenous satellite launch capability (although with the advent of the Virgin Galactic and the development of ultra-small satellites such an option might exist), having the ability to launch additional satellites to replace damaged ones or to create new capabilities at short notice (a programme known as Operationally Responsive Space) has attractions. Likewise, closer cooperation with potential partners (such as more collaboration with the European Space Agency) and more dual-use of commercial satellites would increase our resilience.

But why should Air Power proponents take a lead in such advances? Here are three reasons. First, the leading proponent of Space Power remains, and is likely to continue to be, the United States. There the USAF has the lead for the military applications of space, and we are well-placed to build on our traditional links to them. Second, with our space observation capability based around RAF Fylingdales we already have an understanding of space, and thus could provide the core of a space cadre. Third, space, like the air, is ubiquitous and although the laws of aerodynamics are replaced by Keplarian physics when it comes to orbitology, there is common understanding between Space Power and Air Power.

In conclusion, the UK is reliant on space to a degree that is hard to recognise, so pervasive has our use of the environment become. There are weaknesses and vulnerabilities in our present approach, but the first hurdle to be overcome is recognition of the threat that the loss of space would represent. This in turn would allow the development of resilience and plans to mitigate some the threats outlined here. Space matters, as an opportunity for the country, for the smooth-running of our infrastructure, and particularly for defence. Air Power proponent are well-placed to lead the debate on how to build space resilience, but it is a debate that is overdue and needs to be undertaken.

Notes

[1] See, for example, **http://news.bbc.co.uk/1/hi/8579270.stm**

[2] Surrey Satellite Technology Limited, based at Guilford, remains a world-leading company. See: **www.sstl.co.uk**.

[3] **www.cpni.gov.uk**.

[4] There is a good reminder of the effects at: **http://news.bbc.co.uk/1/hi/uk/921360.stm**.

[5] GPS functions on a ro-ro-ro time differential system. For an excellent introduction, see the US Government website **http://www.gps.gov**.

[6] Report by Lt Col S J Bruger USAF, US Naval War College, RI, Department of Operations: "Not Ready For the First Space War, What About the Second?" **http://oai.dtic.mil/oai/oai?verb=getRecord&metadataPrefix=html&identifier=ADA266557**. See also: "Joint Warfare and Military Dependency on Space", Maj J L Caton USAF, Joint Force Quarterly Winter 1995/6 (**http://www.fas.org/spp/eprint/1310.pdf**).

[7] **http://metoffice.com/research/nwp/satellite/**.

[8] The International Civil Aviation Organization (ICAO) established a global network of 13 weather ships in 1948. The agreement of the weather ships ended in 1990. The last weather ship was *Polarfront*, known as weather station M ("Mike") at 66°N, 02°E, run by the Norwegian Meteorological Institute. Polarfront was put out of operation 1 January 2010.

[9] The US Space Shuttle on its first flight suffered a cracked windscreen from a fleck of paint in orbit. Since then, the Shuttle has always been flown backwards so that the engines, not used for re-entry, act as a shield to protect the cockpit and its delicate human crew.

[10] **http://glasstone.blogspot.com/2006/03/emp-radiation-from-nuclear-space.html**

[11] We are overdue a significant solar flare. That of 2 September 1859 had a significant impact on the relatively primitive but robust telegraph system, with operators reporting electric shocks from the equipment as far apart as Philadelphia in America and Bergen in Norway (**http://www.thenakedscientists.com/HTML/articles/article/the-biggest-solar-storm-in-history**).