Imagery for surveillance and intelligence over Afghanistan

By Professor Gordon Petrie

Much speculation has taken place in the press regarding the capabilities and possible use of imagery for reconnaissance, intelligence gathering and mapping over Afghanistan. Not all of this discussion is based on the actual capabilities of the platforms and imagers likely to be involved. ***Professor Gordon Petrie*** *assesses what is known about these capabilities.*

Figure 1: The General Atomics Predator propeller-driven unmanned aircraft with the image turret and control antenna fitted to the underside of the aircraft. (Source: General Atomics)

SPACEBORNE IMAGERY

Based on the experience gained from other recent conflicts such as the Gulf War, Bosnia, and Kosovo, we can be sure that every possible source of imagery that can be obtained from space – whether commercial or otherwise – is being exploited for intelligence purposes in connection with the conflict in Afghanistan.

Medium resolution/wide area coverage

In particular, the images from the SPOT and IRS optical satellites and from the ERS-2 and Radarsat radar satellites have been used extensively for general surveillance in the past. Almost certainly, they are again being used in this role. While the ground resolution of the images being acquired by the two series of optical satellites (with 5 to 10-metre ground pixel size) is limited, their wide coverage – 60 x 60 kilometres for SPOT and 70 x 70 kilometres for IRS-1C/D – is decidedly useful for overall surveillance and military planning. In the case of the ERS-2 and Radarsat-1 satellites, the most obvious advantages are their all-weather and day/night capabilities. On the debit side, the limitations of the dead areas, layover and clutter of synthetic aperture radar (SAR) imagery are well known. So is the variability in the detection of the ground objects being imaged depending on their orientation with respect to the direction of the SAR imaging beam. Furthermore, although Radarsat-1 can achieve an 8-metre ground pixel size (over a 50-kilometre swath) when operated in its fine beam mode, both ERS-2 and Radarsat-1 are more usually operated at much coarser

ground resolutions, typically with ground pixel sizes of 25 to 30 metres and having a much wider swath.

Moreover, it should also be noted that some of the satellites mentioned above are not in the best of health. The recording and storage devices on the older SPOT-1 and -2 satellites failed a long time ago. Only SPOT-4 has an operational recorder. Thus, images of Afghanistan can only be received from the SPOT-1 and -2 satellites by ground receiving stations that are located within sight of the satellite while it is passing over the country. In the case of the IRS-1C and -1D satellites, launched in 1995 and 1997 respectively, their remaining fuel load is very limited. This means that they cannot be manoeuvred to point cross-track to image targets that do not lie directly along their orbital tracks and within the swath width of the imager when operated in a vertical (nadir) orientation. In the case of the ERS-2 satellite, all the on-board gyroscopes have failed. Thus the satellite attitude is now being measured by its horizon sensors to provide signals to the satellite's reaction wheels to try to maintain the correct orientation for imaging. Still, in spite of these various deficiencies and limitations, we can be sure that, wherever possible, all of these different satellites are being used to their fullest capacity.

High-resolution/small area coverage

Given the failures of the EarlyBird, EROS-A, IKONOS-1, QuickBird-1 and OrbView-4 satellites, commercial optical observation satellites having a higher resolution of one to two metres and a comparatively narrow swath width of 10 to 15 kilometres are rather scarce. In fact, currently there are only two commercial high-resolution satellites – IKONOS-2 and EROS-A1 – that are operational. While this article is being written, the news has just come through that the QuickBird-2 satellite has been launched successfully. However, 90 days will be needed to check out and bring the satellite to an operational condition.

Furthermore, EROS-A1, with its 2-metre ground pixel size imagery, has only just come into service. Its main limitation is that it has no on-board facility for storing images. So, once again, a ground receiving station needs to be within sight of the satellite to allow the images to be recorded over the target areas. However, so far, only a very few ground stations – in Israel, Taiwan, Japan, Sweden and Argentina – have been equipped with suitable facilities and can receive EROS-A1 images. Of these, only the Israeli station is remotely relevant within the present context and, even then, only the farthest western part of Afghanistan lies at the extreme edge of the station's receiving cone.

By contrast, IKONOS (see figure 2) is likely to be in very heavy use. Afghanistan lies well within the direct receiving cone of the ground station of Space Imaging Middle East (SIME) located in the United Arab Emirates. Besides the direct reception of the imagery using this facility, the IKONOS satellite has a considerable on-board capacity to record and store images. These can then be downlinked later to the ground receiving station of the Space Imaging company located at its headquarters in Thornton, Colorado. According to press reports, the US Department of Defense has bought the exclusive rights to all IKONOS images of Afghanistan acquired from 7 October onwards. This prevents the Afghan authorities or their sympathisers acquiring IKONOS imagery for their own purposes. Moreover, it also means that the media cannot acquire images which, if published or broadcast, could potentially compromise Coalition military operations in the war zone. Of course, some of the media have suggested that this also means that they cannot monitor and report on the manner in which these military operations are being conducted, especially with regard to the civilian population and its property.

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Figure 2: The IKONOS satellite being fitted to its Athena rocket prior to launch. (Source: Space Imaging)

On the radar imaging side, within this high-resolution category, it is highly likely that considerable use is being made of the SAR images acquired by the Lacrosse military satellites (also known as the Onyx or Vega satellites) that are operated by the US National Reconnaissance Office (NRO). Reputedly, they can be operated in a variety of imaging modes. With the finest of these, the resulting images have a ground pixel size of one to two metres, albeit then with a restricted area coverage. At least two of these satellites were operational prior to the terrorist attacks of 11 September in the USA. Furthermore (and wholly fortuitously, since it had been planned and started being built quite some time ago), it is thought that the large satellite launched by NRO on 17 August this year is another in the Lacrosse series. The image data acquired by the Lacrosse satellites is normally relayed back to a ground receiving station at White Sands, New Mexico, using NASA's Tracking and Data Relay Satellite (TDRS) network. A distinctive feature of these satellites when you see them at night is their orange-red hue. This is almost certainly created by the gold foil or orange-coloured kapok thermal insulation material in which they

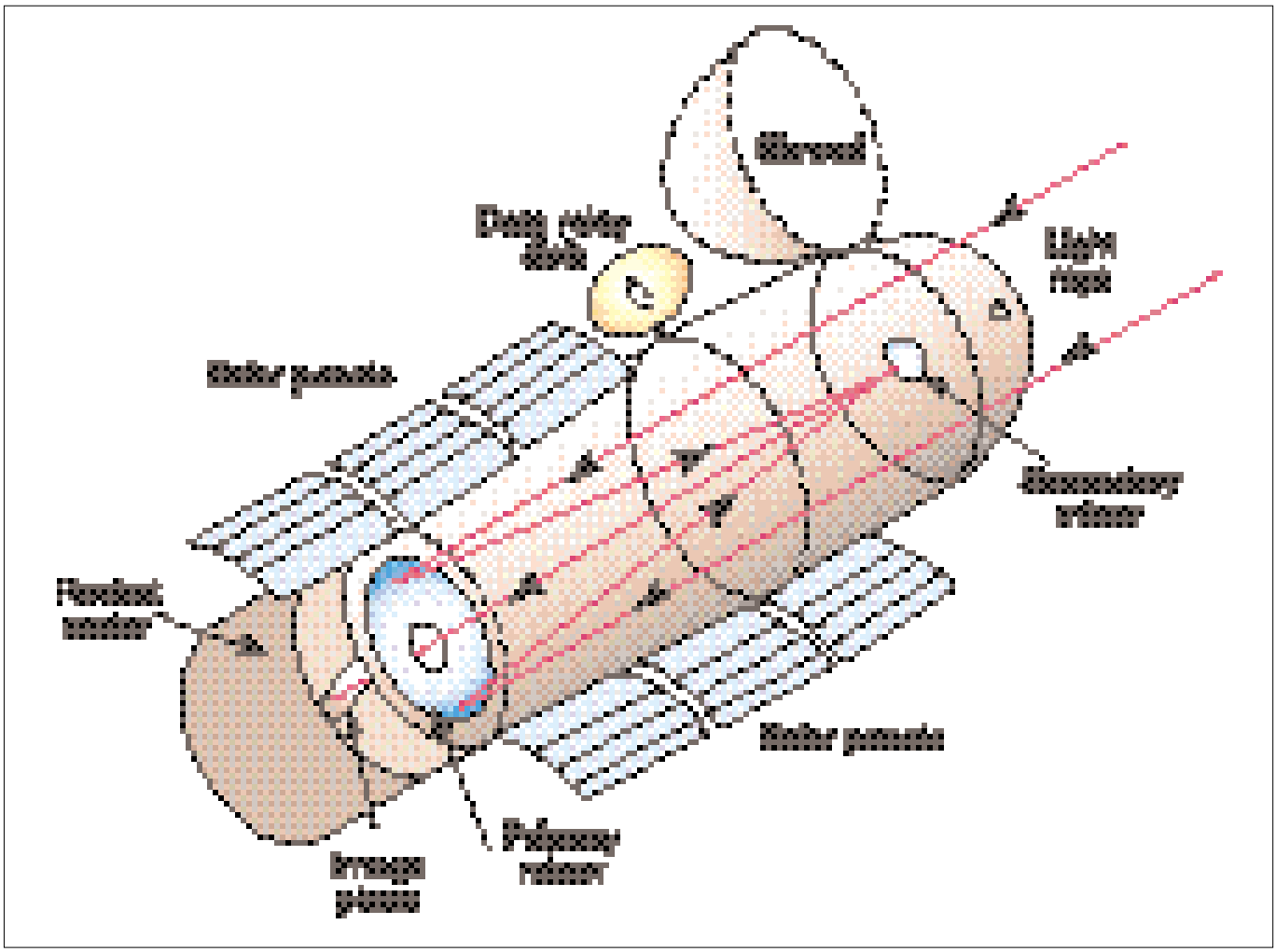
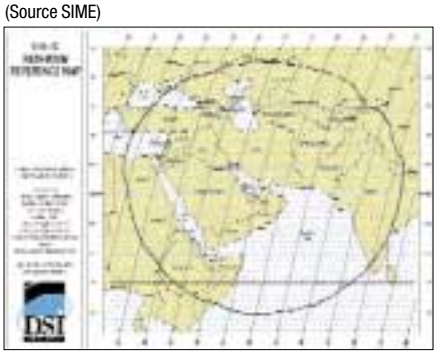


Figure 3(a): A sketch of the KH-12 satellite with its mirror-based telescope.

are wrapped.

It is also worth mentioning that the Russian KFA-3000 and KVR-1000 film cameras return imagery with similar ground resolutions (two to three metres) to those already mentioned. In recent years, non-governmental organisations such as relief organisations and private disarmament and nuclear monitoring organisations have made much use of these images. Reputedly the Russians also have a high-resolution reconnaissance satellite, Cosmos 2344 or Arkon-1, launched in 1997 that produces purely digital imagery. It is an open question as to whether this Russian film or digital imagery is available and is being used by Coalition agencies over Afghanistan.

Figure 4: The ground footprint of the Space Imaging Middle East receiving station located in the United Arab Emirates. (Source SIME)



Very high resolution/very limited area coverage

Within this category, we are dealing with very high resolution optical imagery: ground pixel values in the range 0.5 to 0.15 metres have been suggested. In turn, this means that only a very narrow area of the ground can be covered at this resolution. The main American reconnaissance satellites with this capability are the KH-12 series (see figures 3a and b), also known as the KH-11B or Improved Crystal satellites, operated by the NRO. The best single source of information on these satellites is the relevant pages on the website of the Federation of American Scientists (www.fas.org/spp/military/program/imint/kh-12.htm). These pages, and also those on many other military satellites, have been compiled under the direction of John Pike with detailed drawings of the satellites and their imagers produced by Charles Vick.

The KH-12 satellites have been placed in highly elliptical near-polar orbits having perigee values as low as 160 kilometres and apogee values of 330 kilometres. Essentially the KH-12 satellites resemble the Hubble Space Telescope but are pointed towards the earth instead of into space. The satellites feature a powerful rocket motor with a large fuel load which is used to manoeuvre the satellite and to point the imager's telescope in the desired direction to image the target area. The images acquired by the KH-12 are then transmitted in real time via the Milstar relay satellites to the appropriate ground stations. From their orbital and imager characteristics, it can be deduced that the KH-12 satellites are being used to produce very high resolution images of specific point targets or sites occupying a comparatively limited ground area. Again, quite fortuitously, another new satellite that was launched by NRO on 5 October is thought to be yet another in the KH-12 series.

Ground receiving stations

It is also instructive to review the situation regarding the ground stations that are capable of receiving in real time the imagery acquired by satellites over Afghanistan. Of these, two are located in the Arabian Peninsula. The longest established is the Saudi Center for Remote

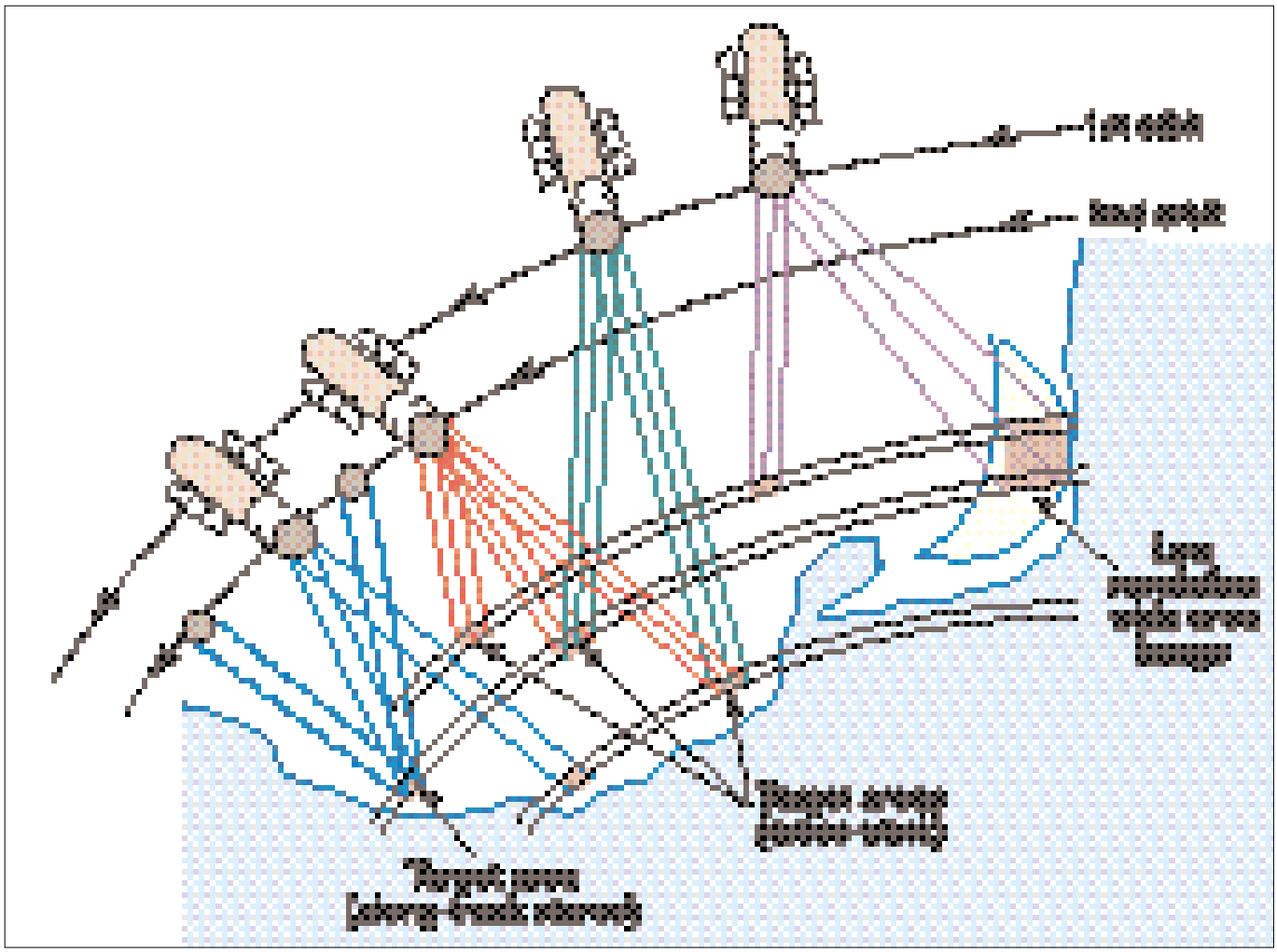


Figure 3(b): The different operational modes of the KH-12 satellites. (Drawn by M. Shand; adapted from diagrams by C.A. Vick of the Federation of American Scientists)

Sensing (SCRS) forming part of the King Abdul Aziz City for Science and Technology, which is located in Riyadh. Primarily this station acquires SPOT and Landsat imagery. The second station is that operated by Space Imaging Middle East (SIME) in the UAE (see figure 4). The original station was a transportable station supplied by Datron that has been used to acquire imagery from the IRS and Landsat-5 satellites. However, with Landsat-5 having been taken out of service and given the present limitations of the IRS satellites, the station has been mothballed. It has been replaced by the much larger station supplied by Raytheon E-Systems that is performing the crucial role of taking down in real time the IKONOS imagery of Afghanistan. A third Middle Eastern station located in Israel receives SPOT imagery. Its receiving cone also reaches Afghanistan. In the Indian sub-continent, two more stations may also be relevant in terms of acquiring real-time imagery of Afghanistan. One is the SPOT receiving station in Islamabad in Pakistan. The other is the main ground receiving station of the Indian Space Research Organisation in Hyderabad that is being used to acquire IRS-1C and -1D imagery.

Transportable ground receiving stations

In view of the small number of fixed ground stations in the region bordering Afghanistan and the delays before the space images reach the command staff and units operating within the Afghan theatre of operations, this brings to the fore the matter of transportable ground receiving stations. Almost certainly, consideration will have been give to the deployment of the Eagle Vision stations operated by the American military forces. Each of these comprises a large expansible van

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Figure 5: The trailer-mounted antenna of the RAPIDS transportable ground receiving station with its 2.6 metre diameter dish antenna. (Source: NRI)

containing the receiving and processing equipment together with a trailer-mounted tracking antenna. The two units can be transported either as two separate loads in a C130 Hercules military transport aircraft or as a single load in the larger C141 aircraft. The two existing Eagle Vision units are stationed at Ramstein Air Force Base in Germany (operated by the USAF) and at Fort Belvoir, Virginia (operated by the US Army). Over the last two or three years, these stations have been set up and used operationally in the Far East, Europe and the Middle East. Two more stations, Eagle Vision III and IV, are under construction and are scheduled to be delivered by this December, when they were to be allocated to units of the Air National Guard. Mostly Eagle Vision I and II have been used to acquire imagery from the medium resolution satellites – SPOT, Landsat, IRS, ERS and Radarsat.

However, Eagle Vision II had also been upgraded to receive image data from the OrbView-4 satellite, but unfortunately this suffered a failure at launch in September. It is not clear whether the two new units will also be able to download other high resolution imagery.

Besides the American units, the French military forces also possess transportable stations, mainly for use with the French Helios military reconnaissance satellite. These units have been constructed by the Matra company, which has also played a substantial part in the construction of the Eagle Vision series. In the UK, DERA has also purchased and is operating a RAPIDS transportable station built by BURS Ltd (see figure 5). This can download image data from the SPOT and ERS satellites. Finally, a most intriguing unit is one of the German mobile stations in operation based in Bishkek in Kyrgyzstan, located just north of Afghanistan. Until now, it has been used mainly to take down SAR imagery from

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The Pentagon and the World Trade Centre, September 11th 2001: A turnin

the ERS and Radarsat satellites in connection with a geotectonic study of the region. However, it also has the capability to receive medium resolution optical imagery. Obviously all of these units can be considered for operations involving the acquisition of space imagery over Afghanistan.

AIRBORNE IMAGERY

When discussing reconnaissance activities over Afghanistan, most analysts and commentators give the impression that this is mostly carried out using earth orbiting satellites. In my personal opinion, this appears unlikely. The difficulties with all the satellites discussed above is that they can only visit and observe an area for 10 to 15 minutes each day and, in many cases, only once every few days. This has been a source of complaint for some time.

Manned Aircraft

By contrast, reconnaissance aircraft are much more flexible in terms of being able to take advantage of breaks in the cloud cover and of being able to remain over an area of interest for a considerable period. This is particularly the case in Afghanistan, where the Taliban forces do not possess anti-aircraft weapons capable of reaching aircraft flying even at medium altitudes. It is even less likely that they have this capability given the concentrated attacks made on these weapon systems in the initial Coalition air attacks on Afghanistan. This situation is really tailor-made for reconnaissance aircraft. In particular, part of the US Air Force's substantial inventory of more than 30 U-2 aircraft seem certain to have been deployed to acquire imagery of Afghanistan. To do this, they can enter its air space either from the Central Asian countries to the north or through Pakistan from the south or east. Indeed, Lockheed U-2 aircraft are known to have used Pakistan air space on previous occasions – including an overflight of the Pokharan nuclear test site in West India in August 1998, which drew loud protests from the Indian government. It is also well known that U-2 aircraft have been stationed at Taif air base in Saudi Arabia for some time to monitor events in Iraq. These aircraft can easily be deployed and used over Afghanistan.

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The modern U-2 aircraft, which can fly at altitudes up to 70,000 feet, can be equipped with electro-optical (EO) and infrared (IR) imagers – the so-called Senior Year Electro-optical Reconnaissance System (SYERS) – as well as several different types of film camera. However, many U-2s are now fitted with the Advanced Synthetic Aperture Radar System (ASARS-2) using a new type of antenna that scans in azimuth electronically and features an enhanced moving target indicator capability. This provides an all-weather imaging capability. The U-2 aircraft can also transmit its EO and IR image data in real time to a ground station, either through a direct radio link or via a communications satellite. According to press reports, the Royal Air Force has also sent a pair of its venerable Canberra PR9 high altitude reconnaissance aircraft to the Persian Gulf area for possible deployment over Afghanistan. Of course, further reconnaissance capabilities can also be provided by the tactical fighter and attack aircraft being used by the Coalition air forces. These can be equipped with EO/IR and SAR imagers and film cameras that are contained in pods hung under the aircraft.

ng point leading to the declared war on terrorism by the Coalition forces.

Unmanned aircraft

What does seems certain is that the use of manned aircraft is being supplemented by the extensive deployment of unmanned aerial vehicles designed specifically for reconnaissance and surveillance work. Many of the newer unmanned craft feature ultra high-altitude operation, extreme long range and an endurance that lies beyond the capabilities of human aircrew. Like the U-2, unmanned aircraft can transmit their images in real time to local ground stations. Since, as discussed above, the need for flights at ultra high altitudes is unlikely over Afghanistan, the obvious candidate for use over the country is the General Atomics Predator (see figure 1). This propeller-driven aircraft has an operational ceiling of 25,000 feet but it also has an endurance of 24 hours at a range of 400 nautical miles (800 kilometres), which makes it ideal for loitering over a target area for surveillance purposes. Its imagers normally comprise an electro-optical/infrared combination. However, it can also be fitted with a high-resolution SAR imager, either the Northrop Grumman TESAR or General Atomics' own Lynx SAR. Again both of these imagers have a moving target indicator capability. The images acquired by the Predator can also be sent direct via a radio link or relayed via a communications satellite to the appropriate ground station.

Besides the Predator, another candidate unmanned aircraft for use over Afghanistan is the still more capable Global Hawk. This is a much larger jet-powered aircraft capable of being operated at altitudes of 65,000 feet with a range of 2,200 kilometres and an on-station endurance of 24 hours (three times that of the U-2 manned aircraft). So far, five of these Global Hawks have been delivered to the USAF; more are being built.

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CONCLUSION

Clearly, a formidable array of platforms and imagers exist that can provide imagery of Afghanistan for surveillance, intelligence gathering and mapping purposes by the Coalition forces.

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Figure 6: The Global Hawk high-altitude, long endurance unmanned craft during its recent deployment to Australia. (Source: Northrop Grumman)