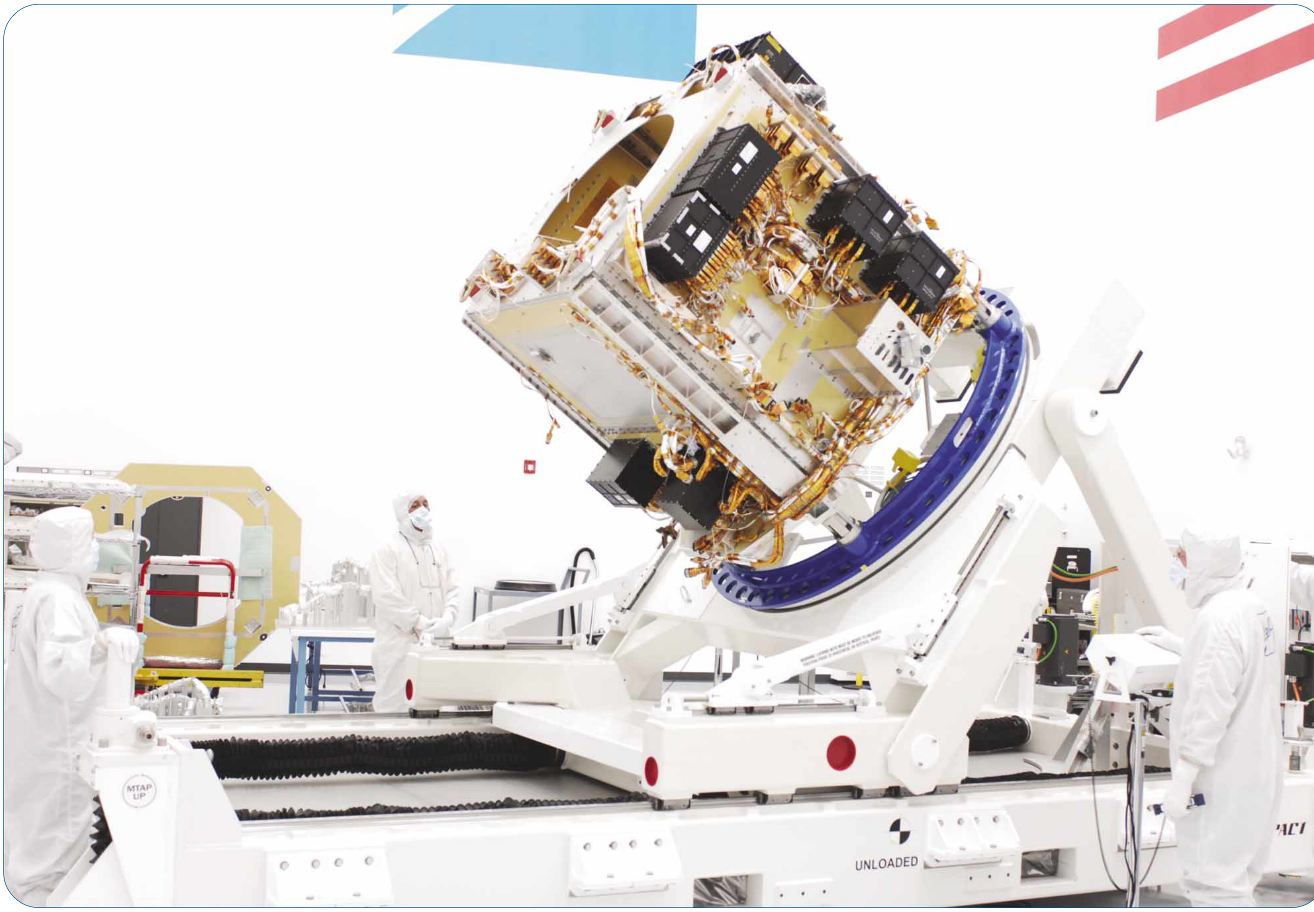


Earth Observation, Worldview 2, photo courtesy Ball Aerospace.

A unique viewpoint

The use of earth observation satellites for military and governmental use is expected to increase further in the future for countries all over the world. Global Military Communications looks at the major earth observation programmes.

The way in which we look at the earth has changed in a big way over the past 50 years. The advent of satellite communications has seen to that. They provide our governments and various other different agencies with a unique view of the entire planet and can provide images of almost any territory giving commanders incredibly detailed intelligence on infrastructure, terrain and monitoring of human activity without infringing on national sovereignty. During the Cold War, the United States and the Soviet Union used earth observation satellites extensively to spy on each other and to help intercept missiles. Now, satellites are used on a day-to-day basis to help assimilate intelligence and surveillance techniques, plan operations and give accurate and real-time information about exactly what is going on in the battlefield. Earth observation is a key part of any military's intelligence systems.

The primary purpose of satellites used in the defence sector is to monitor visible ground activity. Resolution and clarity have improved to a great extent over the years. For example, 3D maps can now be generated for use in operations and missile guidance systems. They can also monitor invisible information such as the growth of a country's crops (e.g. poppies in Afghanistan) or the heat given off by certain buildings.

As we have seen, EO's characteristics enable the viewer to see images of the earth in all kinds of resolution and for all kinds of purposes. The military are principal users of earth observation techniques and it has proved to be an invaluable tool. EO improves the military's spatial awareness – an absolutely crucial factor that enables commanding officers to make informed decisions. Manoeuvres may be planned down to the tiniest detail – even down to the terrain of the land. High-resolution satellite instrumentation can lend intelligence through target detection, location of troops and resources available to them. EO can also provide surveillance of borders and shorelines, it can monitor the impact of a crisis area and the damage that has been done.

As part of network centric operations, EO is a major decision-making tool for strategic and tactical operations. The combination of satellite surveillance and intelligence plus real-time communications build-up a detailed picture, layer on layer. Switching between high, medium and low resolutions means that the complete picture can be assessed. However, it is not just optical earth observation that is valuable in defence circles.

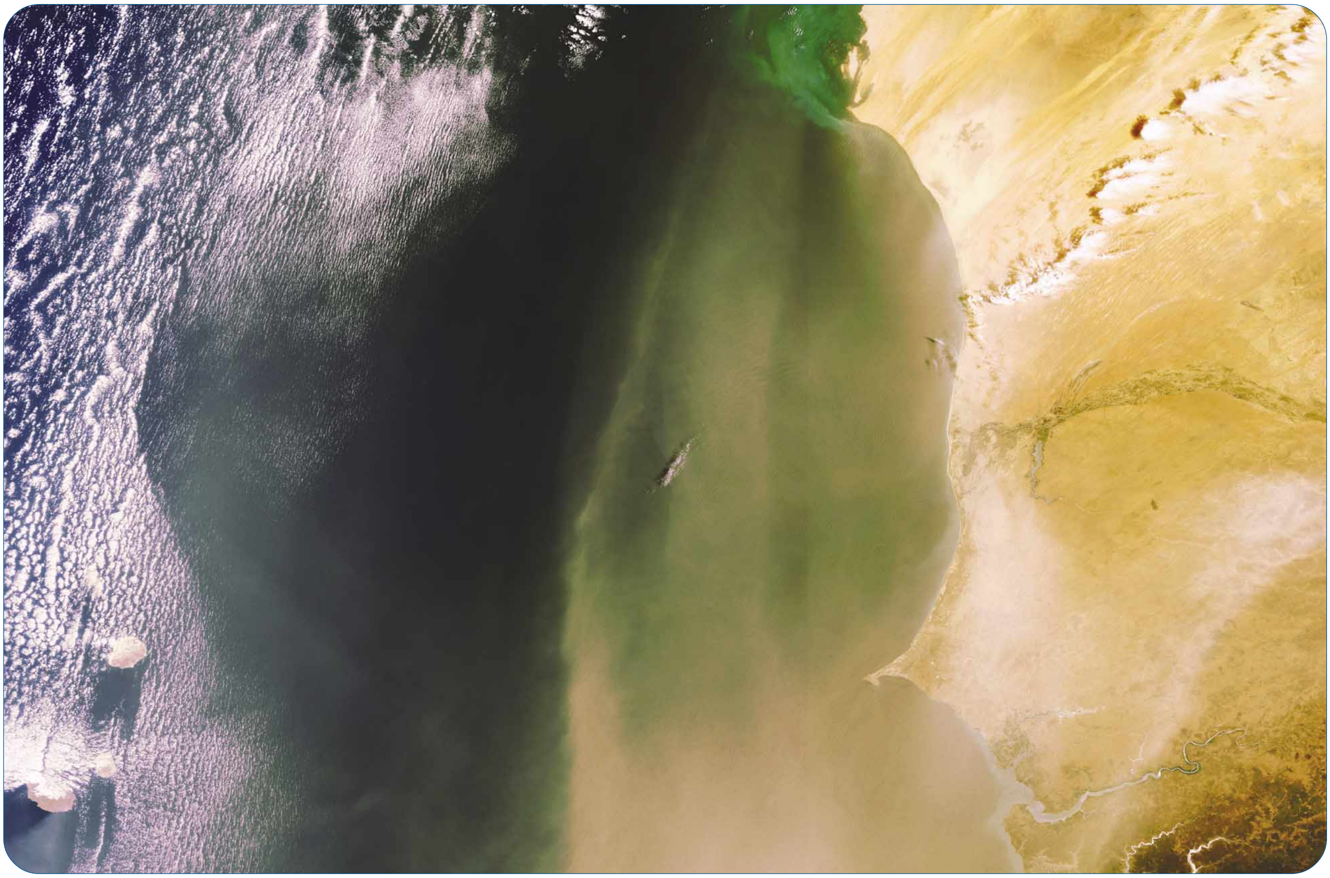
The earth observation family of satellites is growing at a quite remarkable pace. Now that countries have discovered the benefits open to them by launching such satellites (at a relatively low cost compared to communications satellites), they are an ideal way in which to begin a satellite programme and many countries who have not launched satellites before are beginning with EO programmes. It is forecast that over the next ten years a total of 200 satellites will be launched by 29 countries across the world. That is a quite impressive number and the capabilities of these satellites are evolving all the time enabling data to be gathered on all kinds of different issues such as sea and climate change, de-forestation and monitoring of coastal erosion. It is not just the military that is benefiting nowadays. There are so many uses for earth observation techniques it would be too time consuming to list them all here.

There are various EO instruments that have different objectives:

- **Optical:** Each day, when the sun rises, the earth is bathed in solar energy. Some of this energy is absorbed into the earth but some is reflected back into space. Optical earth observation instruments record this reflected energy across various wavelengths including visible light and invisible infrared bands. The amount of bands available to an optical instrument is known as its spectral resolution. The higher the resolution, the more detailed the image;
- **Radar:** Radar instruments direct microwave pulses to the earth and then record how they are reflected back into space. They measure surface roughness and are not affected by cloud cover or adverse weather conditions making them very reliable. A combination of different radar images can even show even the smallest amounts of motion on the ground. This technique is called interferometry;
- **Altimeter:** An altimeter can record the time it takes for a microwave or laser pulse bounce back to the satellite. This enables a record of land and sea height to be made with great accuracy; and
- **Atmospheric:** These instruments work by detecting how the air around our planet affects heat, light and radio energy that passes through it.

The amount of detail visible in a satellite image is dependent on the spatial resolution of the instrumentation. This relates to the minimum size of detail visible within an image. Low spatial resolution instruments are used for the study of regional vegetation coverage, for example and for wide area weather and cloud patterns. Intermediate resolution sensors are used for agriculture and resource mapping but can also be used to evaluate the damage caused by natural and man-made disasters. High- resolution sensors are able to pick up minute details such as particular buildings, roads or even cars.

The US Department of Defense runs a Defense Meteorological Satellite Programme. The DMSP designs, builds, launches and maintains its satellites that are used to monitor meteorological, oceanographic, and the solar-terrestrial environment. Each satellite has a 101-minute, sun synchronous near-polar orbit at an altitude of around 830km above the earth's surface. The visible and infrared sensors collect images across a 3000km swath, providing global coverage twice a day. The combination of day/night and dawn/dusk satellites allows monitoring of global information such as clouds every six hours. The microwave imagers and sounders cover one half of the width of the visible and infrared swath. These instruments cover polar-regions at least twice and the equatorial region once a day. Data from DMSP satellites is received and used at operational centres continuously. In Europe, the European Satellite Centre provides geo-spatial prod-



Sand and dust from the Sahara Desert. Photo courtesy of ESA.

CMOS is the military centre for observing Helios images.Photo courtesy of EADS Astrium / MINISTERE DEFENSE.

ucts from analysis of satellite imagery for EU operations. For example, the data gained from the satellite imagery has assisted EU operations in Bosnia and Herzegovina, the Democratic Republic of Congo and in Indonesia.

The Helios Constellation

Helios I was the first European military reconnaissance system and is jointly funded by France, Italy and Spain. The next generation of the Helios family, Helios II will ensure continuity of service when the Helio I satellite expire and will also offer enhanced features such as enhanced resolution, infrared capability, expanded image capability and shorter image transmission time. The system will also be used for guidance, mission planning and combat damage verification purposes. The Helios IIA was launched in December 2004 and the next edition of the constellation, Helios IIB will be added in the final quarter of 2009. The two satellites are identical and build on the foundations of the Helios I satellites.

Helios II will operate in the visible and infrared portions of the spectrum to deliver imagery to the French military day and night. France has also agreed with its partner that some of Helios II's optical observing capacity will be exchanged for new and improved radar capacity that is under development. The satellites have been designed to accommodate any upgrades that are required in the future.

SAR-Lupe

Germany's first reconnaissance satellite system, SAR-Lupe has been developed by OHB-System and comprises five individual satellites, each weighing 770kg each. The first satellite was launched in December 2006. This was followed by three further launches, two in 2007 and one so far in 2008. The final satellite is slated for launch anytime now when the entire system will become operational.

The constellation will be controlled by the ground station at Gelsdorf. The satellites are equipped with Synthetic Aperture Radar (SAR) enabling high resolution images to be captured day or night, whatever the weather. The satellites will operate in 3,500km orbits in planes that are roughly 60 degrees apart. They will use X-band radar with a 3m dish and response time for imaging of a given area will be 10 hours or less. The program is based on sophisticated technologies in SAR radar field, able to get images under any weather or light conditions (day or night).

The fourth German SAR-Lupe reconnaissance satellite was launched at 18:15 hours on 27 March 2008 from the Russian space centre Plesetsk, south of Archangelsk. The Cosmos 3M launch vehicle which was carrying the radar satellite released it into its intended orbit around half an hour later. After roughly 90 minutes, a direct contact was established between the control centre and the satellite. Preliminary tests confirmed that the fourth SAR-Lupe satellite is also working properly.

Satellite control was initially in the hands of the German Space Agency DLR in Oberpfaffenhofen. The ground station of the German Armed Forces in Gelsdorf is tracking the satellite at the same time and assumed operative responsibility for it at which point in time the radar payload went into use. The German Federal Armed Forces have been utilising the system since December 2007 and are extremely pleased with the image quality.

In orbit since December 2006 and July and November 2007, respectively, the first three SAR-Lupe satellites are supplying outstanding high-resolution images and operating very successfully and reliably. SAR-Lupe 4 is identical in construction to the previous satellites. As they are operating perfectly, not even minor adjustments were necessary.

COSMO-SkyMed

Cosmo-SkyMed is an Italian-funded constellation of satellites that provide earth observation facilities for the Mediterranean Basin. The dual-use system comprises four medium-sized satellites with SAR sensors providing global coverage. They are used for defence and security purposes but are also providing vital images necessary to carry out agricultural mapping, seismic hazard analysis and environmental disaster monitoring.

With a lifespan of five years, the spacecraft are in sun-synchronous orbits phased at 90 degrees and at 619km with an orbit time of 97 minutes. The United Launch Alliance provided the launch service for the first two satellites that were launched in June 2007 and December 2007 respectively. Both satellites were launched on a Delta II launch vehicle. A Delta II will also be taking the third satellite into orbit later this year. The final satellite will be launched at a later date, still to be confirmed.

The Cosmo-SkyMed satellites carry, and will continue to carry SAR technology. The Cosmo SAR is a multimode sensor, a programmable system that is able to operate providing different performance in terms of swath dimension, spatial resolution and polarisation. The radar's transmitter and receiver operate through an electronically steerable, multi-beam antenna that concentrates the transmitted energy in a narrow beam, along a direction normal to the satellite track, whilst the characteristics of the transmitted pulses and of the reception timing determine spatial resolution and coverage.

Cosmo SAR provides the user with a set of standard operational modes; nevertheless the operation is fully flexible and all the parameters that are necessary in order to define a beam are selectable by means of ground commands. During the Farnborough Airshow this year, it was announced that e-geos, a joint-venture between the Italian Space Agency and Telespazio formed to develop the commercial side of COSMO-SkyMed, will be providing the data received from the satellite for the global market. e-geos, which has sites in Rome and Matera, aims to become a global leader in the sector of geospatial information, with an integrated range of application solutions, content and services, based on synthetic aperture radar (SAR) data and very high resolution (VHR) optical data. The company will operate along the whole of the value chain in earth observation, from data acquisition and processing to the provision of services and applications.

The system's unique and innovative characteristics and the data acquired from the radar satellites of the Italian COSMO-SkyMed constellation will enable the company to offer operational monitoring services that up to now were impossible. By 2009, COSMO-SkyMed will have four satellites in orbit, equipped with radar sensors capable of operating day and night in all atmospheric conditions, and with frequent revisitation times. They will thus be able to provide rapid and effective application services for the management of emergencies (e.g. earthquakes, fires and floods), for territorial and environmental protection (e.g. landslides, subsidence, oil spills and pollution) and for the monitoring and management of natural resources.

The COSMO-SkyMed system has already demonstrated its effectiveness, following the devastating earthquake that hit China's Szechuan province on 12 May. On 13 May, at the request of the Chinese government, the COSMO-SkyMed satellites took the first radar pictures of the region around the city of Guan Xian, one of the closest to the earthquake's epicentre, showing (as they did with the floods in Myanmar) the system's extraordinarily quick response times in the event of a crisis. Furthermore, the particular weather conditions, with heavy cloud cover and precipitation, highlighted the capabilities of Italian radar satellites in comparison with those of optical satellites.

The captured images were processed in a few hours at ASI's Matera Space Centre, which is managed by Telespazio, and allowed observers to assess the earthquake damage caused to buildings, bridges and dams in the region.

GeoEye

The National Geospatial-Intelligence Agency (NGA) and GeoEye launched their GeoEye-1 satellite on 6 September 2008. Since then, the satellite has undergone calibration and testing. The Company will begin selling GeoEye-1 imagery products later this fall. The company released the first image from the satellite on October 8 2008.

Matthew O'Connell, GeoEye's Chief Executive officer, said, "We are pleased to release the first GeoEye-1 image, bringing us even closer to the start of the satellite's commercial operations and sales to our customers. This is a remarkable achievement, and I want to thank all of our employees, customers, especially the National Geospatial-Intelligence Agency, strategic partners, vendors and investors for their support."

GeoEye-1 simultaneously collects 0.41-metre ground resolution black-and-white imagery in the panchromatic mode and 1.65-metre colour (multispectral). This first image showing Kutztown University located midway between Reading and Allentown, Pennylvania was produced by fusing the satellite's panchromatic and multispectral data to produce a high-quality, true-colour half-metre resolution image. Though the satellite collects imagery at 0.41-metre ground resolution, due to US licensing restrictions, commercial customers will only get access to imagery that has been processed to half-metre ground resolution.

Bill Schuster, GeoEye's chief operating officer, said, "We are bringing GeoEye-1 into service within four years of our contract award with no contract cost overruns.

"The entire programme which includes the satellite, launch, insurance, financing and four ground stations was less than $502 million. That's the amount established and agreed to four years ago." He further noted, "GeoEye-1 is an excellent fit to meet the US Government's important requirements for mapping and broad area space-based imagery collection over the next decade."

Brad Peterson, GeoEye's Vice President of Operations, said, "This image captures what is in fact the very first location the satellite saw when we opened the camera door and started imaging. We expect the quality of the imagery to be even better as we continue the calibration activity."

The Kutztown University image shows the campus, which includes academic buildings, parking lots, roads, athletic fields and the track-and-field facility. The image was collected at 12:00 p.m. EDT on Oct. 7, 2008 while GeoEye-1 was moving north to south in a 423-mile-high (681 km) orbit over the eastern seaboard of the US at a speed of four-and-one-half miles per second. GeoEye-1 was built by General Dynamics Advanced Information Systems in Gilbert, Arizona. The imaging system was built by ITT.

The future? more satellites

Earth observation will always play a critical role in defence. There is simply no other way in which to obtain such detailed and informative views of virtually anywhere on the planet. Governments are likely to remain EO's most constant customer and with the anticipated launch of so many satellites dedicated to EO the sector, it is guaranteed growth in the long term. Satellites are certain to play an integral role in the world's government agency's efforts to combat climate change and environmental issues and also disaster mitigation and management.

The introduction of private companies such as GeoEye will be an interesting thread to follow as they will make the data access much more commercial and improve the distribution of EO imagery and data to many different users such as business and industry.

The EO sector is going from strength to strength and will continue to be a lynchpin of intelligence for defence but also for many other purposes. The value of these spacecraft cannot be underestimated. ■