High-Resolution Imaging From

A World-Wide Survey (Part III - Europe & Part IV - ISS)

Until recently, Europe (outside Russia) has not been involved very much with high-resolution imaging from space. Much of Europe's efforts have been channeled through ESA - which, in the Earth observation area, appears to be dominated by those European scientists who are involved in global environmental monitoring.

By Gordon Petrie

The result has been an emphasis by ESA on the acquisition of wide-area, low-resolution imagery, as manifested in the image data acquired by the ERS-1, ERS-2 and Envisat satellites. In the area of medium-resolution imagery, the French SPOT satellites have been prominent. However the last satellite in the SPOT series has now been launched. Only the French Helios military reconnaissance satellites have delivered high-resolution imagery, but obviously this data does not reach civilian users. Now, however, the situation is about to change in a fairly dramatic fashion. This decade will see the advent of high-resolution imagery that will be generated through three large national programmes that are being implemented by France, Germany and Italy, together with a much smaller project being developed in the U.K. Although some of these high-resolution satellites are intended for "dual [civilian/military] use", as will be seen, the major driving force has been the requirements of military organizations in each of the countries concerned. In particular, the acquisition of high-resolution SAR imagery has now reached the top of the European space imaging agenda.

III.1 France

Without doubt, France has been the leader within Europe in developing terrain imaging from space. Much of this leadership has been based on the very successful SPOT series with SPOT-1 (1986), -2 (1990), -3 (1995-98) and -4 (1998-). These have all produced medium-resolution imagery with 10m (pan) and 20m (multi-spectral) ground pixel sizes over a 60km swath width. SPOT Image - a subsidiary of CNES, the French Space Agency - is a semi-commercial operation with reportedly an annual income of circa $45 million. This sum may go some way to recovering the costs of the SPOT ground segment, but certainly not the high investment costs of the space segment of the programme in the shape of the SPOT satellites and their imagers. Essentially the SPOT programme has been quite heavily subsidized by the French government and taxpayers.

SPOT-5

With SPOT-5, CNES has moved into the high-resolution imaging area. The satellite was launched in May 2002. Its HRG pushbroom scanners produce imagery with twice the ground resolution of the previous SPOT satellites. In the case of its pan imagery, it has a basic 5m ground pixel size; through the use of the "Supermode" procedure, the resolution of the resulting pan imagery is improved to give a 2.5 to 3m ground pixel. The multi-spectral images acquired from SPOT-5 have a 10m ground pixel size. In both cases, the swath width still remains at the 60km of the original imagery of the first four SPOT satellites. Besides the HRG scanner, SPOT-5 also has its HRS imager, which has been funded jointly by CNES and Astrium. This is an along-track stereo-imager featuring a rectangular 5m x 10m ground pixel and a swath width of 120km. It is designed specifically to produce DEMs. In particular, these DEMs are intended to meet the requirements of the French military forces now that France has acquired cruise missiles with a terrain following capacity. Up till now, it has not been possible for civilian customers to buy the HRS stereo-imagery from SPOT Image; only the processed and value-added DEM data can be purchased. However, inspection of the coverage map on the SPOT Image Web site shows that this DEM data has already been produced for much of North Africa, the Middle East and Western Asia. Within Europe, the coverage is concentrated on France, Italy, the Iberian Peninsula and Central Europe.

Helios-1 Satellites

Operated in parallel with the SPOT programme in recent years has been the Helios series of military reconnaissance satellites. Helios-1A was launched in July

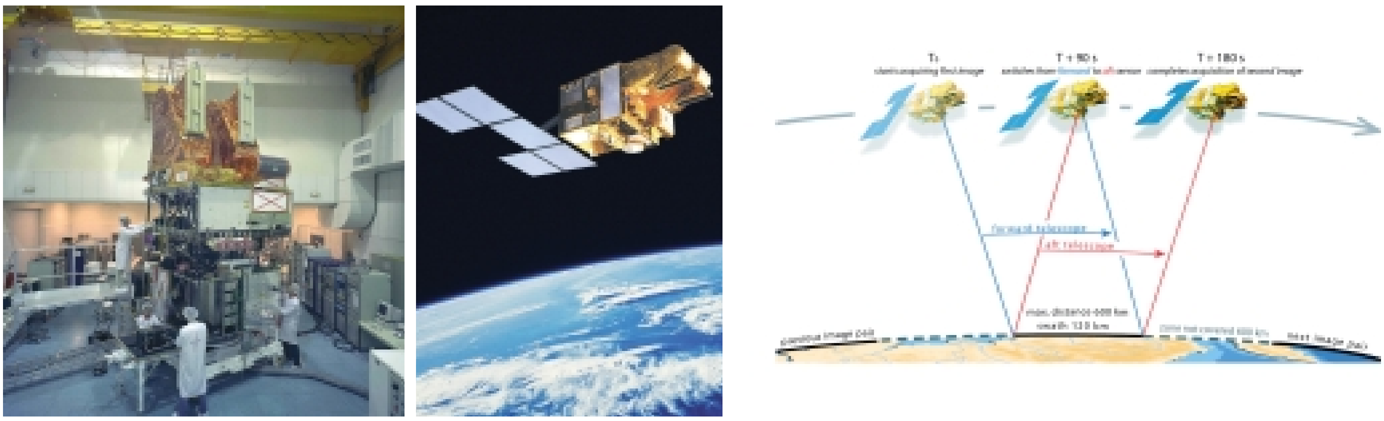


Figure 1 - (a) The SPOT-5 satellite seen during its assembly and ground testing. (Source: Astrium), (b) An artist's impression of the SPOT-5 satellite operating in its near-polar orbit in space. (Source: Astrium), (c) Diagram showing the collection of scanner image data for DEM production being carried out from the SPOT-5 satellite using its HRS along-track stereo-imager. (Source: SPOT Image)

Space

Figure 2 - An artist's impression of one of the forthcoming Helios-2 military high-resolution reconnaissance satellites. The similarities of the basic platform with that of the SPOT-5 satellite [in Fig. 1(b)] can be seen. (Source: Astrium)

1995 and Helios-1B in December 1999. These two Helios-1 satellites utilize the same basic satellite platform as the SPOT-1 to -4 satellites (built by Matra-Marconi Space), but they produce still higher-resolution imagery with a 1m ground pixel size using their EPV optical imagers. The Helios-1 satellites have been funded mainly by France (79%) with Italy (14%) and Spain (7%) as junior partners in the programme. Each country can use the satellites in proportion to their financial contribution. However some of the Helios-1 imagery has been supplied to and used by the WEU Satellite Centre in Spain during the Kosovo crisis in 1999.

Helios-2 Satellites

Currently the construction of two replacement satellites - Helios-2A and Helios-2B - is under way. These are much larger - 4.2 tons in weight v. 2.5 tons for the Helios-1A and -1B satellites - and will use the same basic platform bus as SPOT-5. The main contractors are Astrium for the satellites and Alcatel for the optical imagers. The resolution of the Helios-2 high-resolution imager is reported to be 0.5m in terms of its ground pixel size. Besides which, the Helios-2 satellites will carry a medium-resolution optical imager giving a wider field-of-view. Furthermore, there are several reports that the Helios-2 satellites will have an infra-red imaging capability to allow the production of imagery at night. France tried to attract Germany and Italy into the Helios-2 programme, but they did not join in. In this particular respect, the cost of the Helios-2 programme is very high - reports in journals quote a figure of around $1.5 billion for the two satellites. Thus Germany and Italy decided instead to invest in their own national programmes. So the Helios-2 programme is overwhelmingly French (95%) with only Belgium (2.5%) and Spain (2.5%) as very minor partners. The Helios-2 programme is run jointly by CNES and DGA (the French armaments supply agency). Currently the Helios-2A satellite is scheduled to be launched late in 2004; the Helios-2B satellite will follow later.

French/German Cooperation

Originally, another proposal was made by France to Germany for the construction of a satellite that would be complementary to the Helios-2 satellites and would produce high-resolution SAR imagery. This was to be implemented through a cooperative project between the two countries called OSIRIS (French) or Horus (German). Under this proposal, Germany would play the leading role in the project which would utilize the extensive SAR experience of the German Space Agency (DLR). The proposal was that France would pay 40% and Germany 60% of the overall cost, which was estimated to be in the order of $1 billion. However, once again, Germany turned the OSIRIS/Horus project down on financial grounds. Instead it decided to invest in its own national programme of high-resolution military radar satellites - the SAR-Lupe satellites.

Pleiades

In its place, France then turned to Italy and, in 2001, an agreement was signed in Turin for a cooperation between France and Italy. Under this agreement, France will build a pair of high-resolution (HR) optical satellites - called Pleiades - and Italy four high-resolution radar (RA) satellites equipped with X-band SAR imagers - called COSMO-SkyMed. The Pleiades HR-1 and -2 satellites will be much smaller (weighing 1 ton) than SPOT-5 (4 tons), but will produce much higher resolution imagery with ground pixel sizes of 0.7m (pan) and 2.5m (multi-spectral) respectively. The Pleiades HR satellites will be built by Astrium, while the high-resolution imager will be supplied by Alcatel Space. In fact, the formal contracts for the construction and supply of these items have only just been awarded by CNES in November 2003. The first Pleiades satellite is not scheduled to be launched till mid-2008, while the second is due to be launched in 2009. Presumably this will be the time period when the SPOT-5 and Helios-2 satellites will be reaching the end of their operational lives.

III.2 Italy

COSMO-SkyMed

The four Italian RA satellites of the COSMO-SkyMed programme will be built by Alenia Spazio with the Galileo and Laben companies acting as sub-contractors. Each of these radar satellites will weigh 1.7 tons and will be placed in a near-polar Sun-synchronous orbit with the four satellites

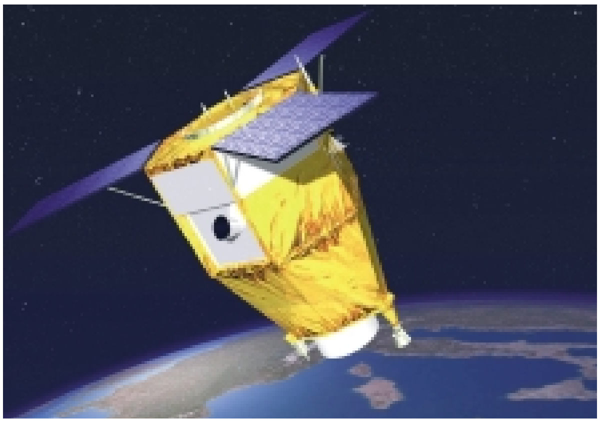


Figure 3 - Another artist's impression, this time, of a Pleiades HR (high-resolution) satellite. This satellite is designed for "dual [civilian/military] use" and is scheduled to be launched towards the end of the decade. (Source: CNES)

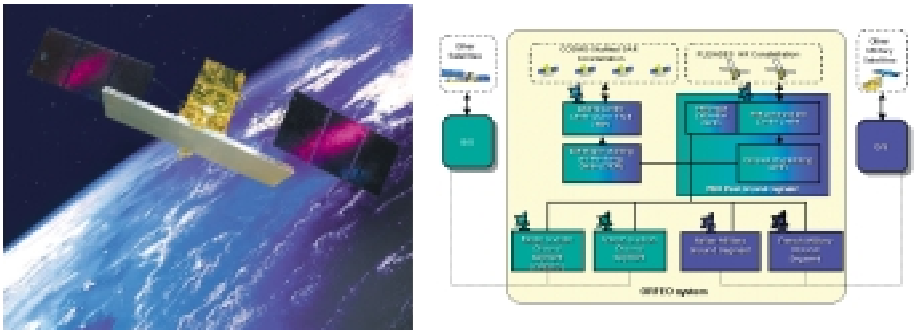


Figure 4 - (a) An artist's impression of a COSMO-SkyMed high-resolution satellite. The large radar antenna and the solar panels for power generation show up prominently. (Source: Alenia Spazio), (b) A diagram of the ORFEO system showing the relationship of the space and ground segments of the Italian COSMO-SkyMed and the French Pleiades satellite constellations producing complementary high-resolution SAR and optical imagery respectively. (Source: ASI)

placed 90° apart in longitude. The costs of developing the COSMO-SkyMed system are being shared between the Italian Ministry of Defence and the Italian Ministry of Research. The Italian Space Agency (ASI) is responsible for the management and execution of the programme. The first of these RA satellites is planned be launched in June 2005, with the whole constellation being completed and made operational in 2007. The satellites will produce SAR images with a 1m ground pixel over a 10km swath when operated in their high-resolution (spotlight) mode. As originally proposed (prior to the agreement with France), the COSMO-SkyMed satellites would have formed the basis of a purely civilian programme to generate imagery for use in scientific studies of the Mediterranean Basin, including disaster monitoring. In this respect, the COSMO part of the title was an acronym derived from the full title of the project - "COnstellation of Small Satellites for Mediterranean Basin Observation". Now, however, the high-resolution imagery that will be produced by the COSMO-SkyMed satellites is for "dual-use" - i.e. civilian and military applications.

ORFEO & SIASGE

The combination of the Pleiades-HR and COSMO-SkyMed RA satellites will form the so-called Orfeo system. Under this arrangement, the defence authorities of both countries will have priority in terms of mission planning and the image data acquired for these authorities will be classified. Furthermore the two defence ministries will also have access to the raw data of the civilian archives. Since the French Pleiades satellites will not be launched for several years, in the meantime, Italy will be given access to the high-resolution optical imagery from the Helios-2 satellites as part of the cooperative Orfeo agreement. However, during 2003, papers given by ASI staff at various conferences have revealed that the Italian Space Agency (ASI) is also considering a cooperation with its Argentinean counterpart, CONAE. Under this cooperative programme, entitled SIASGE, the X-band SAR data from the four COSMO-SkyMed satellites would be exchanged with the L-band SAR data from the two SACOM satellites being developed by CONAE in Argentina. The idea is to maximize the multi-polarization capabilities of the two SAR systems, besides utilizing the complementary image characteristics derived from their use of very different wavelengths. It would appear that this proposed Italian-Argentinean cooperative project is oriented mainly towards scientific applications and disaster management, including flood monitoring and oil spill detection.

III.3 Germany

Germany has also had a strong interest and successful record in undertaking imaging from space. In particular, DLR attracted much notice throughout the 1990s with the medium-resolution optical imagery derived from its MOMS-02 project. This utilized a three-line pushbroom scanner operating along-track to generate overlapping stereo-imagery, This MOMS-02 imager was flown both on the Space Shuttle and on the Russian MIR space station. However this pioneering work is not being followed up in Germany - though, as we have seen, the idea of generating along-track stereo-scanner imagery for mapping and DEM production from space has since been taken up in France (SPOT-5 HRS), India (IRS-P5 Cartosat) and Japan (ALOS/PRISM). Instead, German agencies have moved very firmly into the acquisition of high-resolution imagery with SARs (synthetic aperture radars) offering day/night and all-weather capabilities. In particular, two major spaceborne SAR programmes are currently under way in Germany - SAR-Lupe and TerraSAR.

German SAR Heritage

German agencies have, over a long period, shown a strong interest in spaceborne radar, especially X-band SAR (with Ï = 3cm). Past projects include participation in the two SIR-C/X-SAR missions carried out using the Space Shuttle in 1994 and the SRTM (Shuttle Radar Topography Mission) carried out jointly by NASA and the German (DLR) and Italian (ASI) Space Agencies in 2000. Besides which, further extensive experience had been gained through DLR's airborne SAR projects - including its own E-SAR and the SARs operated by the AeroSensing Radarsysteme spin-off company, which is now owned by the Canadian Intermap group.

SAR-Lupe

The SAR-Lupe project is now well under way to build five relatively small (770kg) satellites, each equipped with an X-band

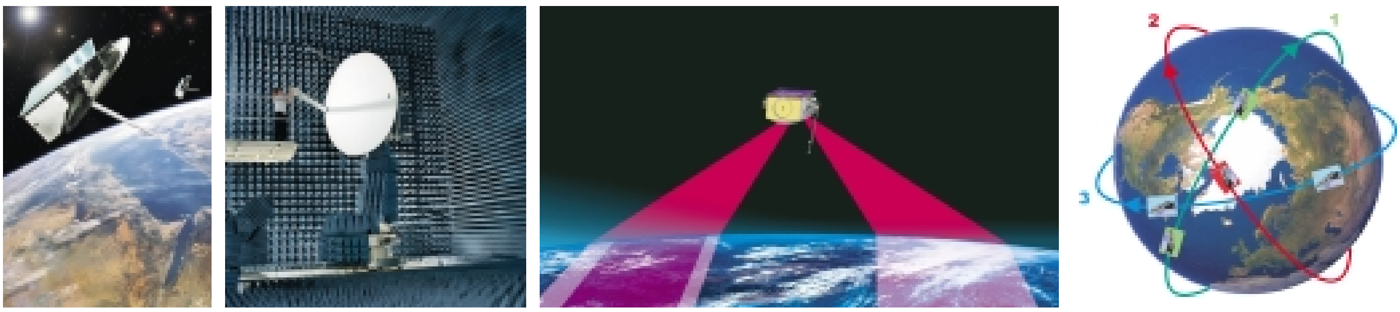


Figure 5 - (a) An artist's impression of a pair of SAR-Lupe satellites in orbit. (Source: OHB-System), (b) The SAR antenna for one of the SAR-Lupe satellites undergoing tests. (Source: Saab Ericsson), (c) A diagram showing the ground coverage that can be achieved from an individual SAR-Lupe radar satellite on either side of its flight path. (Source: OHB-System), (d) A diagram showing how the constellation of five SAR-Lupe satellites will be placed in three different orbital planes to ensure both world-wide coverage and a rapid response. Orbit-1 will contain two of the satellites; Orbit-2 will have a single satellite; while Orbit-3 will feature the remaining two satellites. (Source: OHB-System)

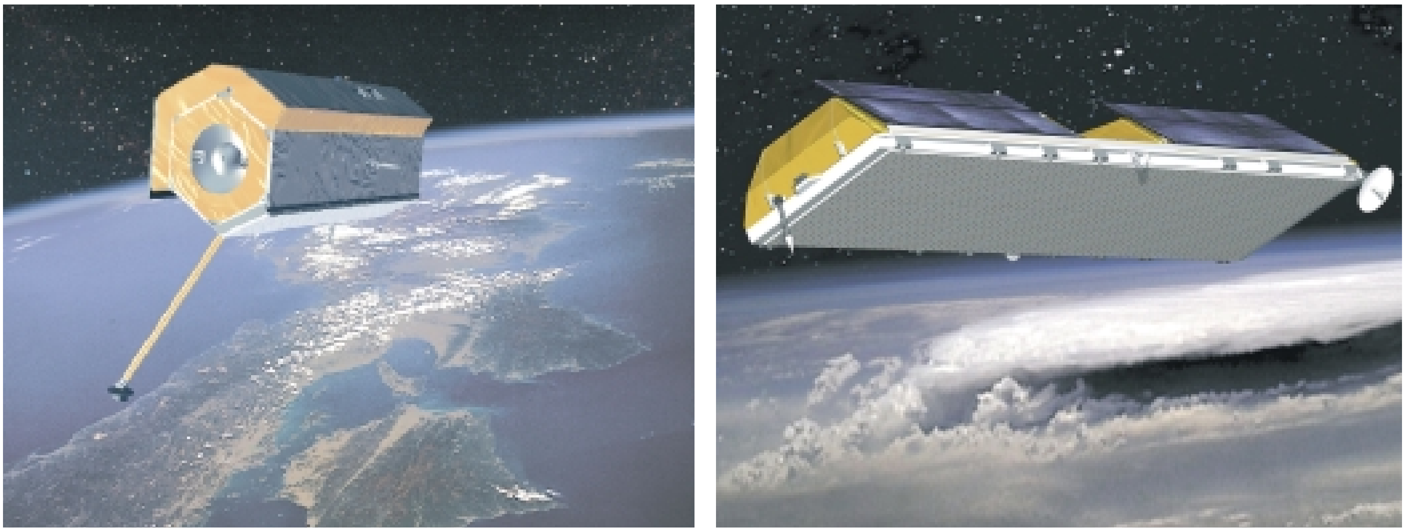


Figure 6 - These are artist's impressions of (a) the TerraSAR-X; and (b) the TerraSAR-L High-resolution radar satellites in orbit. (Source: Astrium)

SAR, for the German Ministry of Defence. These five satellites will be placed in three different near-polar orbital planes spaced out to ensure world-wide coverage. Orbit-1 will contain two satellites; Orbit-2, a single satellite; and Orbit-3, two satellites. The satellites are being built by the OHB-System company in Bremen with some help from various foreign suppliers of components - Alcatel, Tamex (France), Saab Ericsson (Sweden), Carlo Gavalli (Italy) and various American electronics companies (Integral Systems, EMS Tech, etc.). The ground resolution of the resulting imagery will be better than 1m ground pixel over an area of 5 x 5km on the ground when the SAR is used in its highest resolution mode. The launch of the first satellite will be carried out using a Russian Dnepr rocket in 2005. It is hoped that the launches of all five SAR-Lupe satellites will be completed by 2007. It will be a really remarkable success if this project is completed successfully within its budget. In this respect, the contract to OHB-System is for $283.6 million, whereas the Horus project involving a single large radar satellite was estimated to cost $1 billion. According to the American AFJI journal, the cost of the SAR-Lupe satellites has been kept down partly through the use of proven components from other space missions. Thus the antenna is derived from that supplied by Saab Ericsson for use on ESA's Rosetta interplanetary satellite; the SAR electronics are based on those developed by Alcatel for the radar altimeters mounted on the Poseidon and Jason satellites; the radar tubes are those developed for use on ESA's ERS satellites; etc. Currently France is negotiating to gain access to the SAR-Lupe radar imagery; in return, it is offering Germany access to the Helios-2 optical imagery.

TerraSAR

In parallel with the SAR-Lupe programme is another German project to produce high-resolution X-band SAR imagery from space called TerraSAR-X. This is a so-called public/private partnership with DLR contributing $90 million and the German arm of Astrium (formerly Dornier) contributing a further $25 million towards the costs - though in fact, both organizations had spent considerable sums on research and development prior to the start of the project. Like the SAR-Lupe satellites, TerraSAR-X is planned to be launched in 2005 using a Russian Dnepr rocket. The TerraSAR-X satellite will produce its high-resolution images with a 1m ground pixel size. Originally, during the late 1990s, the TerraSAR project was proposed by the U.K. (BNSC) and Germany (DLR) as part of ESA's Earth Watch programme. When the proposal was not accepted as an ESA project, the U.K. dropped out and Germany decided to adopt it as a national project. The original TerraSAR proposal also included a second satellite - TerraSAR-L - equipped with an L-band radar. This project is at present on hold, but may yet come to fruition.

III.4 - U.K.

Last and least of the Western European countries concerned with high-resolution imagery is the U.K. Up till now, the U.K. has taken no part in the construction of satellites generating high-resolution imagery of the Earth. Instead, the comparatively low level of government funding that has been made available for Earth Observation purposes has gone into the provision of wide-swath, low-resolution imagery for environmental science research and global monitoring purposes. Furthermore, most of the U.K. government's money has been spent on the support of ESA programmes, principally on instrumentation. This has included the ATSR optical scanner that has been operated on the ERS-1 & -2 satellites and the similar AASR mounted on Envisat (producing 1km ground pixel images). Also the U.K. has had a major share in the AMI and ASAR C-band SAR imagers, that have also been mounted on these satellites (producing images with 30 to 150m ground pixel sizes). Other than this, and quite independently of the U.K. government, the SSTL company - an off-shoot of the University of Surrey - has built

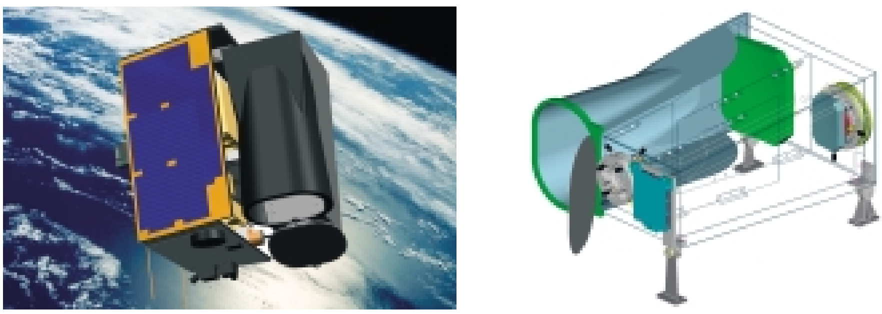


Figure 7 - (a) An artist's impression of TopSat in orbit, showing how the telescope of the high-resolution imager is mounted externally on top of the main body of the micro-satellite. (Source: SSTL)
(b) A perspective diagram showing the arrangement of the mirrors and the folded optical path within the telescope of the high-resolution scanner imager being built by the Rutherford-Appleton Laboratory for use on TopSat. (Source: RAL)

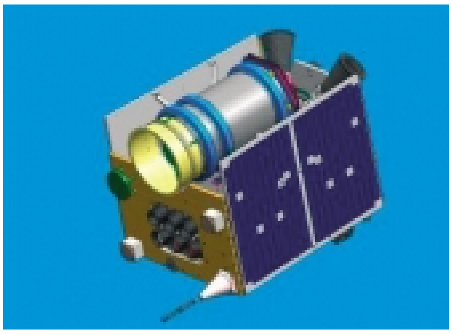


Figure 8 - (a) A CAD drawing providing an external view of the China DMC+4 micro-satellite, including its optical telescope, solar panels and antenna. (Source: SSTL), (b) A CAD drawing with the outer panels removed to show the internal arrangement of the power supply, electronics, etc. within the China DMC+4 micro-satellite. (Source: SSTL)

a large number of micro-satellites for those developing countries - South Korea, Portugal, Chile, Thailand, Malaysia, China, Algeria, Nigeria, Turkey, etc. - that wish to have their own space programme. The resulting imagery is mostly of a medium ground resolution.

TopSat

However TopSat, the first U.K. satellite with a high-resolution imaging capacity is now under construction. It is being funded jointly by BNSC (British National Space Centre) and the U.K. Ministry of Defence. The enhanced micro-satellite platform is being built by SSTL, while the Rutherford Appleton Laboratory is building the pushbroom scanner imager. DERA (now QinetiQ), which is a military research agency, is carrying out both the overall management of the project and the development of its ground segment, which will include the use of a RAPIDS transportable ground receiving station. TopSat will generate pan images with a 2.5m ground pixel size over a 15km swath width and multi-spectral images with a 5m ground pixel size over a 10km swath width. The satellite is scheduled to be launched using a Russian Cosmos rocket late in 2004. Once again, it is a "dual-use" (military/civilian) project; the civilian commercial aspects are being handled by the Infoterra company (owned by Astrium), which will also be handling the TerraSAR imagery.

China DMC+4

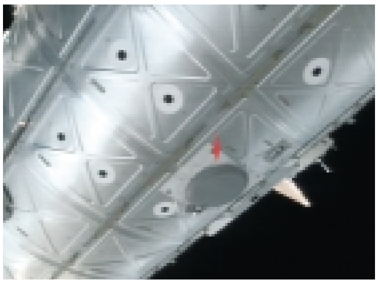
The most recently launched micro-satellites built by SSTL for remote sensing purposes are the AlSat-1 (Algeria), NigeriaSat (Nigeria), Bilsat (Turkey) and UK-DMC (UK) satellites. These form the first part of the so-called Disaster Management Constellation (DMC) that is being operated as a group by SSTL and its overseas partners. All of these DMC micro-satellites generate multi-spectral imagery having a ground pixel size of around 30m. Bilsat also produces pan imagery having a 12m ground pixel size. However the next micro-satellite in the DMC series that is now being built by SSTL is the China DMC+4. This satellite is being constructed for the Beijing Landview Mapping Information Technology (BLMIT) company. It will include a new high-resolution imager generating pan imagery with a 4m ground pixel size, as well as the standard 30m multi-spectral imager used in the other DMC micro-satellites. This new high-resolution optical imager is being developed by SIRA Electro-Optics Ltd., which had previously designed and built the hyperspectral imager being operated on ESA's PROBA micro-satellite.

III.5 Russia

I have accumulated a fairly large folder of material on Russian high-resolution space imagery. However, since quite a lot of it is contradictory and cannot be verified, I have decided not to discuss it in any detail in this overview. Still, in passing, it may be worth noting the planned Resurs DK-1, DK-2 and DK-3 series, which, if they come to fruition, will generate optical imagery with a ground pixel of 0.4m (pan) and 2 to 3m (multi-spectral). Other proposed high-resolution space imaging systems that have been reported are the SOKOL series, that would generate pan imagery with a 0.5 to 1m ground pixel size, and the Condor-E satellite which would generate SAR imagery with a 1m ground pixel size.

Summary - European High-Resolution Imagery

In terms of high-resolution imaging technology, France has remained with optical imagers in the shape of the imagers mounted on SPOT-5 and on the Helios and Pleiades satellites. In this, it has also been joined by the U.K. with its TopSat demonstration micro-satellite. Whereas Germany has largely left the optical imaging field and, for the future, has gone for high-resolution SAR imagery in a really major way with its SAR-Lupe and TerraSAR-X satellites. In this respect, it has been joined by Italy with its COSMO-SkyMed SAR project. When these German and Italian projects have been completed, then Europe will have no less than ten high-resolution SAR satellites and imagers in orbit. It can be seen that the military intelligence gathering and mapping requirements of European countries are playing just as dominant a role in defining the types of high-resolution imagery that will be acquired as is the case with the U.S.A. and the Asiatic countries. Furthermore, for all the talk of a European strategic reconnaissance capability backing up a European Rapid Reaction Force, one notes that, so far, each of the three countries - France, Germany and Italy - mainly



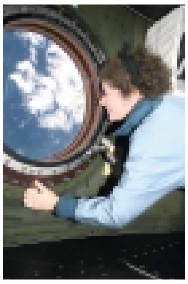


Figure 9 - (a) Dr. Karen Scott of the Aerospace Corporation - leader of the team that developed and built the 20 inch (50.8cm) diameter optical glass window fitted to the Destiny module of the ISS - looking through the window together with astronaut Mario Runco and Dr. Dean Eppler of SAIC. (Source: The Aerospace Corporation)
(b) A close-up view of the underside of the Destiny module, showing the WORF window port with its external protective cover in position. (Source: NASA-JSC)
(c) American astronaut, Susan Helms, viewing the Earth through the crystal-clear WORF window. (Source: NASA-JSC)
(d) Russian cosmonaut, Sergei Krikalev, operating a camera to acquire images of the Earth through the high-quality WORF window. (Source: NASA-JSC)

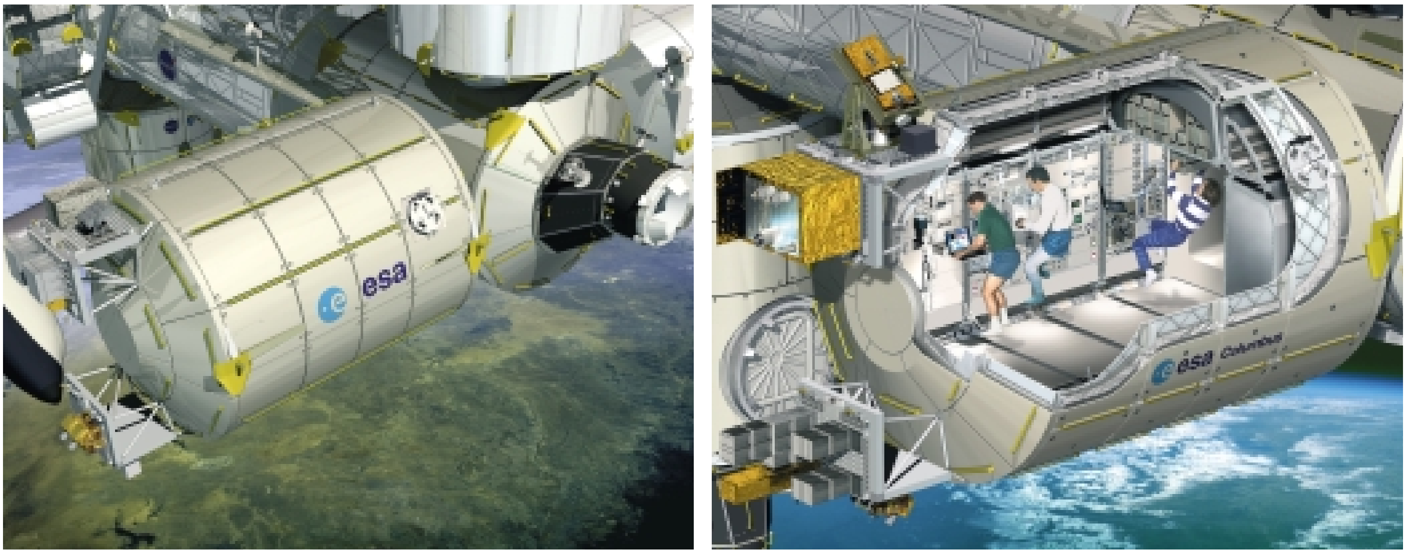


Figure 10 - (a) The Columbus laboratory module, costing $1.4 billion - which is ESA's major contribution to the ISS. The Columbus module is fitted with an external framework on which research payloads such as cameras and imaging scanners can be mounted. The framework is provided with power, data and command links to allow connections to the control, power, recording and other equipment mounted inside the module. (Source: ESA), (b) A cut-away drawing showing the interior of the Columbus module with some of the ISS crew operating the equipment. (Source: ESA)

involved in these discussions have chosen to retain national control of its own satellites acquiring high-resolution imagery from space. However barter arrangements are being made for the exchange of this high-resolution imagery between the countries involved in this activity. Thus, for example, France proposes to make the optical imagery from its Helios-2 and, later, its Pleiades satellites available in exchange for access to the Italian and German SAR imagery. Unfortunately, as elsewhere, much of this imagery will not be available to civilian users.

Part IV - International Space Station

Finally there are a number of proposals to produce high-resolution imagery from space from the International Space Station (ISS). The ISS has been placed in an orbit that is similar to that of the Russian MIR space station, having an orbital inclination of i = 51.6° and an orbital altitude of 350 to 470km. Thus, like MIR did with the MOMS-2P imager, any imager placed on the ISS platform would cover those areas of the Earth lying between latitudes 52°N and S. A number of facilities are being provided on the Station from which high-resolution imaging can be carried out, for example;-

(i) Window Observational Research Facility (WORF) - an internal facility provided within the U.S. Destiny laboratory module.
(ii) U.S. Express Palette - an external platform on which payloads can be mounted.
(iii) Columbus Module - a laboratory fitted with an external platform for payloads that is being provided by ESA.
(iv) Japanese Experiment Module - Exposed Facility (JEM-EF) - yet another external platform to be provided by JAXA.

WORF

NASA has provided the WORF facility on the U.S. Destiny lab that was attached to the ISS in February 2001. This consists of a very high-quality optical window built into the floor of the Destiny module to allow nadir viewing. The window was built by the Aerospace Corporation in Houston and comprises a 20 inch (50cm) diameter window with four layers of fused silica glass, plus an external cover. The window offers a very high optical transmission of 98.5% in the visible and near-IR parts of the spectrum. Appropriate power supplies, support racks, cooling and data handling facilities have all been provided as well. Astronauts on the ISS have already taken tens of thousands of images through this window using small- and medium-format digital and film cameras. Using long focal length lenses, the image resolution is 5 to 6m ground pixel size. However, there has been considerable criticism of NASA's Office of Earth Science which has done little or nothing about installing remote sensing imagers on a long-term basis - even though a number of proposals have been made for such projects using the WORF facility.

Columbus Module External Platform

In February 2000, ESA gave its approval for the German RapidEye company and DLR to place a multi-spectral pushbroom scanner on one of the nadir-pointing external platforms being attached to its Columbus module. This is the same imager as will be used on the proposed RapidEye constellation of four satellites designed mainly for agricultural applications. The imager is a 5-channel multi-spectral pushbroom scanner being built by Jena Optonic and DLR using 12,000 pixel linear arrays. From the ISS, it will produce images with a 4m ground pixel over a 48km swath width.

Conclusion

As this overview has tried to show, there has been a big increase in the number of Earth-orbiting satellites that can acquire high-resolution imagery from space. What is really striking is that more countries, especially in Asia and Western Europe, have been able to develop or acquire the technology that allows them to carry out high-resolution imaging operations from space. However most of these new developments have taken place because of concerns over national security by the countries involved in this activity and their need for high-resolution imagery from space for intelligence gathering and military mapping requirements. So it does seem likely that only a little of the resulting imagery will reach civilian users. Furthermore it appears that commercial high-resolution imaging operations are not really viable at this stage of their development without extensive government support, especially from their military mapping and intelligence gathering agencies.

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