ONE METER AND BELOW HIGH RESOLUTION SATELLITES IN PRODUCTION

A. Demirel, I. Bayir

Inta Space Turk (Space Imaging Eurasia), Haymana Yolu 12.Km 06830 Golbasi Ankara, TURKEY
(ibayir@spaceturk.com.tr, ademirel@spaceturk.com.tr)

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ABSTRACT:

Satellite remote sensing involves gathering information about features on the Earth's surface from orbiting satellites. These satellites have two types of sensor systems known as "active" and "passive". A "passive" system generally consists of an array of small sensors or detectors which store (as digital numbers) the amount of electro-magnetic radiation reflected and/or emitted from the Earth's surface. A multispectral scanner is an example of a passive system. An "active" system propagates its own electro-magnetic radiation and measures (as digital numbers) the intensity of the return signal. Synthetic Aperture Radar (SAR) is an example of an active system. The digital data acquired by the satellites is transmitted to ground stations and can be used to reconstitute an image of the Earth's surface similar to an aerial photograph. Commercial high resolution satellites now under development can detect objects smaller than one meter. In this article high resolution satellites which are being produced will be presented based on their web sites. The objective of the paper is to provide information about airborne sensors and upcoming missions.

1. ORBVIEW-5

1.1 Orbimage

ORBIMAGE is a global provider of Earth imagery products and services, with digital remote sensing satellites and an integrated worldwide image receiving, processing and distribution network. In addition to the high-resolution OrbView-3 satellite, ORBIMAGE operates the OrbView-2 ocean and land multispectral imaging satellite and the SeaStar Fisheries Information Service, which provides maps derived from essential oceanographic information to aid in commercial fishing. ORBIMAGE also produces value-added imagery products and advanced photogrammetric engineering services at its St. Louis facility. The company distributes its products directly to the U.S. government for national security and related mapping applications. Commercial sales are handled through a worldwide network of value-added resellers, regional distributors, sales agents, and select strategic partners.

1.2 Orbview-5

ORBIMAGE's next-generation OrbView-5 satellite will be at 660 km above the Earth in a sun-synchronous orbit and it will collect imagery at 0.41 meter resolution in the panchromatic (black and white) mode, and 1.64 meter resolution in the multispectral (color) mode. When OrbView-5 joins the company's OrbView-3 satellite in early 2007, the constellation will collect more than 1.2 million square kilometer of imagery per day with a combined revisit period of less than 1.5 days for any geographic target.

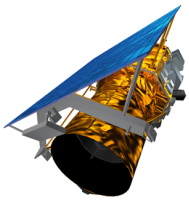

Figure 1. Orbview-5

2. WORLDVIEW

2.1 Digital Globe

DigitalGlobe is the provider of spatial imaging and information products worldwide. In fact, launching the QuickBird satellite in 2001, made DigitalGlobe the world's highest resolution commercial satellite imagery provider in the world. With a focus on advanced image resolution and customer service — and through its unmatched commitment to quality, fairness and customer satisfaction — DigitalGlobe makes it easier to use spatial information to improve decisions in a variety of commercial and government market areas.

DigitalGlobe will continue this legacy of providing superior products with the construction and launch of WorldView — the industry's next-generation commercial satellite imaging system.

2.2 Worldview

DigitalGlobe expects to launch the satellite by mid-2006. Ball Aerospace is building the spacecraft while Eastman Kodak Company is building the sensor. The Delta 2 launch vehicle will be built by Boeing.

WorldView will offer:

- higher than half-meter resolution
- substantially improved agility
- daily revisit capability at one-meter resolution or better
- improved geo-locational accuracy
- substantially improved collection capacity with greater on-board storage and a higher data downlink rate
- 8-band multispectral imagery

In addition, DigitalGlobe satellite controllers will be able to task the satellite more quickly – enabling image turnaround within a few hours rather than a few days.

Figure 2. Worldview

3. PLEIADES

3.1 CNES

CNES (Centre National d'Etudes Spatiales) is the French space agency. It is a state-owned industrial and commercial organization, currently under the joint responsibility of the Ministry of Research and the Ministry of Defence. Created in 1961, CNES is responsible for shaping France's space policy, presenting it to the government and implementing it.

3.2 Pleiades

In addition to the platform, the satellite will be in two parts. The first part will consist of an instrument performing the imaging function, composed of a telescope, a detection unit and all the associated electronics.

The second part will combine the other functional elements of the satellite: the data processing, storage and transmission elements, mechanical support, thermal control, attitude and orbit control facilities, power units, etc.

The Pleiades High Resolution satellite will weigh less than 1000 kg to ensure its compatibility with launchers such as Rockot, Soyouz, Vega, etc.

The Pleiades-HR instrument should have the following characteristics :

Image characteristics	
Panchromatic mode resolution	0.7 m at nadir [PAN : 480 - 830 nm]
Swath	20 km at nadir
Spectral bandwidths [Resolution : 4 times	B0 (blue) : 430 - 550 nm B1 (green) : 490 - 610
the resolution of the panchromatic mode]	nm B2 (red) : 600 - 720 nm B3 (PIR) : 750 - 950 nm
Agility	
Roll 60°	25 secondes
Pitch 60°	25 secondes
Acquisition capability	
Up to 450 images per day and per satellite	
Location accuracy	
With a ground control point	1 m
With no ground control point	better than 20 m

The Pleiades satellites will be placed on a sun-synchronous, phased and almost circular orbit at an altitude of 694 km, with a descending node at 10H15. The orbital cycle will be 26 days. With a roll "dispointing" capability of 30° with respect to the track, world access can be achieved in 5 days with one satellite, and in 4 days with the system's 2 satellites.

The great agility of Pleiades-HR satellites, with their motion capability in roll, pitch, and winding, will allow new acquisition modes, impossible with SPOT series satellites for example. These modes are :

- the "one pass" acquisition mode,
- the simultaneous stereoscopic or tri-stereoscopic acquisitions mode,
- the multi-spot acquisition mode.

Figure 3. Pleiades

4. KOMPSAT-2

4.1 Korea Aerospace Research Institute

Korea Aerospace Research Institute develops and tests of new designs of airplanes, supports national development projects and conducts research & development and launching of satellites.

4.2 Kompsat-2

KOMPSAT-2's main mission is to be able to launch into the region of the Korean peninsula to monitor natural disasters on a large scale and utilize each resource to grasp a sound understanding of its actual conditions, and to offer high-resolution earth observation images through the application of Geographic Information Systems (GIS). For the accomplishment of such a mission, KOMPSAT-2 is scheduled to board a Multi-Spectral Camera (MSC) that will capture 1m resolution panchromatic images and 4m resolution multiple band images. KOMPSAT-2 does not only have the ability to observe images of the Korean peninsula, but also of the lands worldwide. High-resolution digital maps and color images similar to maps which are spread over a diverse range of bands being of high quality and giving added value to the image, can be produced with the use of KOMPSAT-2. Because KOMPSAT-2 is being developed with the foundations of KOMPSAT-1's developmental experiences, through KOMPSAT-1's development industry, the accumulated techniques and manpower is being applied for maximization. Also, following behind KOMPSAT-1, it will continue to conduct Earth observations, the images accumulated will be applied afterwards as being of high added value.

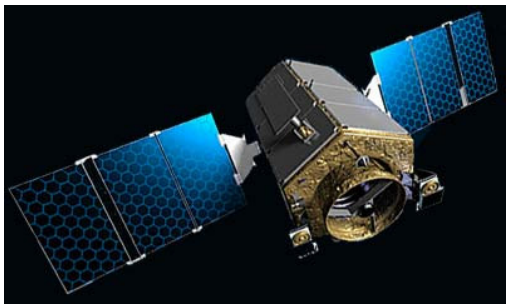

Figure 4. Kompsat-2

The KOMPSAT-2 system consists of the satellite, launcher, and the ground station. The satellite consists of a multi-spectral camera (MSC) payload and a satellite bus. The satellite's mission is for the smooth execution of payload that supports the bus. The payload was developed in collaboration with ELOP (Electro Optics Industries LTD) and KARI (Korea Aerospace Research Institute), while KARI and KAI (Korea Aerospace Industry) is in charge of monitoring the bus. As the launcher that will raise the satellite into mission orbit has yet to be confirmed, plans are underway to select an appropriate launcher for the satellite.

KOMPSAT-2 will be applied to the two locations currently being used by KOMPSAT-1. These will be KGS (KOMPSAT Ground Station) that controls and utilizes data receiving and the User Ground Station. KGS complements the modification of the existing equipment of KARI and Electronics and Telecommunications Research Institute (ETRI), while the User Ground Station is being developed in collaboration with ETRI and the company. These two ground stations that monitor the movements of the satellite, will be installed with a control system that gives commands to the satellite, and a processing system for distribution and image reception.

KGS, which is positioned in KARI, Daejeon, is setting up KOMPSAT-2's mission plans and has the functions that will allow satellite control, and will be able to execute the processing of the payload's image data received through the X-Band. KGS satellite control is attained by the use of the S-Band. The ground station's user group will have the main role of the execution of image data reception and processing, while KGS will execute the role of satellite control.

5. TERRA-SAR-X

5.1 EADS Astrium

EADS Astrium is a world leader in the design and manufacture of satellite systems, with business activities covering civil and military telecommunications and Earth observation, science and navigation, space equipment and associated ground infrastructure. EADS Astrium designs and manufactures a wide range of highly versatile platforms, optical and radar instruments and ground segment equipment for the complete scope of remote-sensing applications, operations and services: end-to-end systems for Earth observation, control and data centres, as well as data services direct to customers or via subsidiaries.

5.2 DLR German Space Agency

As Germany's space agency DLR manages the country's space activities on behalf of and under the instructions of the federal entities responsible for those activities. On the basis of the policy objectives of the German government, and in collaboration and coordination with its German partners

- DLR plans the german space activities;
- DLR carries out the german space-flight programs and activities;
- DLR represents the interests of the German space-community in the international sphere.

5.3 Terra-SAR-X

The TerraSAR System comprises two radar satellites which operate in different frequencies and thereby optimally complement each other.

The TerraSAR mission has its origin in an industrial initiative to provide market-derived X- and L-band SAR products from a

pair of spacecraft operating in tandem in a sun-synchronous orbit. From 2006, the new 1 metre resolution radar satellite TerraSAR-X will be delivering Earth observation data for scientific, institutional and commercial users. TerraSAR-X will be the first satellite realized in a Public/Private Partnership in Germany, as EADS Astrium GmbH and the German Aerospace Centre (DLR) share the costs for construction and implementation of the satellite

The TerraSAR-X Basic Image Products are described by the following characteristics:

Spotlight (up to 1 m resolution)

StripMap (up to 3 m resolution)

ScanSAR (up to 16 m resolution)

TerraSAR-X is a new generation, high resolution satellite operating in the X-band at 9.65 GHz. The launch of the 1-ton satellite into a 500-km orbit is planned on a Russian/Ukrainian rocket for April 2006. TerraSAR-X is to be operated for a period of at least 5 years. TerraSAR-X will carry an active X-band instrument. "Formerly it would have been necessary to turn the whole satellite in order to obtain a different viewing angle, TerraSAR-X, however, is capable of moving "the eyes" - i.e. the scanning swath - by active antenna. The extensive data streams will be transmitted to Earth via broadband technology. TerraSAR-X will fly on a polar orbit in an altitude of approx. 500 kilometres. As the Earth rotates below this orbit, the satellite will scan all regions of the Earth swath by swath. Priority observations of any site can be performed within three days or even in a shorter time.

Height:	5.0m
Diameter:	2.3m
of which payload:	394 kg
SAR Antenna:	4.8m X 0.80 X 0.15m
Resolution:	1 m for 5 X 10 km scene
Power consumption:	605 W
Data storage:	256 Gbit
Data transmission:	300 Mbit/s X-Band downlink
Orbit:	514 km / 98º inclination sun-synch.
Revisit interval:	11 day
Life time:	5 years

5.4 SAR Technology

The Synthetic Aperture Radar (SAR) scans the Earth's surface by radar wave pulses. The reflected radar signals - the so called radar echo - is received by the satellite antenna and recorded. The distance between the Satellite antenna and different reflecting points on the Earth's surface can be calculated from runtime measurements, as the time the radar echo needs to be received is proportional to the distance of the reflecting point. For achieving a high spatial resolution, a technical trick is used: The satellite moving at very high speed along its ground track keeps receiving and accumulating the echo of a great number of emitted radar pulses. This simulates a very large radar antenna depending on the distance the satellite meanwhile moves forward. This trick is what synthetic aperture means. Thus the spatial resolution is increased as it is a function of the antenna size.

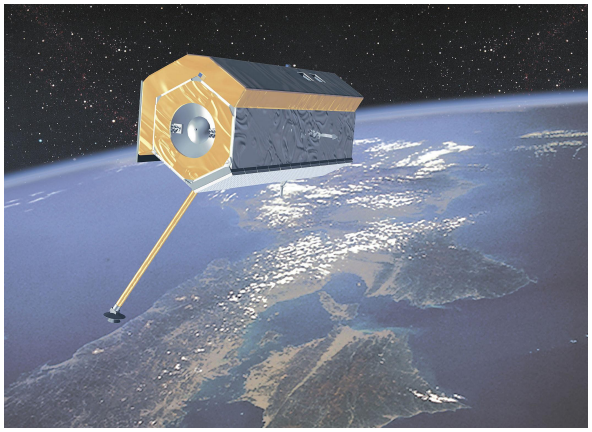

Figure 5. Terra-SAR

6. COSMO-SKYMED

6.1 ASI (Italian Space Agency)

The Italian Space Agency (L'Agenzia Spaziale Italiana or ASI) was founded in 1988 to promote, co-ordinate and conduct space activities in Italy. Operating under the Ministry of the Universities and of Scientific and Technological Research, the Agency cooperates with numerous entities active in space technology and with the President of the Council of Ministers.

6.2 Cosmo-SkyMed

COSMO-SkyMed (Constellation of Small Satellites for Mediterranean basin Observation) is a 4-spacecraft constellation of ASI (Agenzia Spaziale Italiana), Rome, Italy. Each of the four satellites is equipped with a SAR (Synthetic Aperture Radar) instrument and is capable of operating in all visibility conditions at high resolution and in real time. The overall objective of this program is global Earth observation and the relevant data exploitation for the needs of the military community as well as for the civil (institutional, commercial) community. Sample applications of COSMO-SkyMed data are seen the following fields:

· Defense and security applications: Surveillance, intelligence, mapping, damage assessment, vulnerability assessment, target detection/localization

· Risk management applications: Floods, droughts, landslides, volcanic/seismic, forest fire, industrial hazards, water pollution

· Other applications: Marine and coastal environments, agriculture, forestry, cartography, environment, geology and exploration, telecommunication, utilities and planning

· Provision of commercial imaging services

· The high revisit frequency offered by the four X-band SAR spacecraft is also expected to provide a unique potential to the operational meteorological user community through provision of ancillary data and/or data on atmospherical phenomena, in particular as regards sea ice monitoring and study of ocean wave patterns.

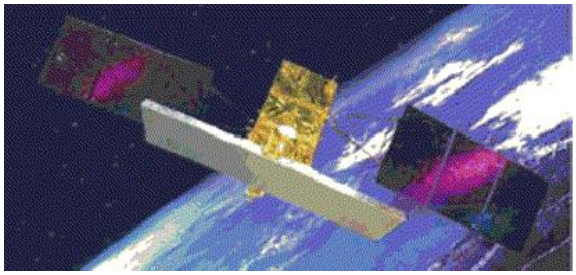

Figure 6. Cosmo-SkyMed

Applications

Disaster Monitoring

The constellation's observation capabilities in the optical and radar bands, combined with the short revisiting intervals, will prove to be a formidable asset for disaster monitoring and damage assessment such as earthquakes, floods and fires as well as man-caused disasters.

Urban Monitoring

High ground geometrical resolution and stereo capabilities will allow an almost permanent control of urban and rural areas.

Law Infringment

The day-night and all-weather observation capabilities will make it possible to implement new forms of control from space of violations of international codes and infringements of national laws.

Coastal Monitoring

The hyperspectral I.R. and the VIS/NIR cameras can provide a better insight into the state of the coasts.

Environmental Monitoring

The fully ground commandable, multispectral and the hyperspectral I.R. images will contribute most to the determination of pollutants.

Agricultural Monitoring

Certain analysis bands have proven to be inadequate in distinguishing different crop types. The I.R. and VIS/NIR data can dramatically improve the quality of the end user products.

Cartography and Mapping

COSMO SkyMed high resolution images will facilitate making new maps and updating older ones.

7. CONCLUSION

As satellite imaging provides enormous amounts of geographical data covering very large areas in a cost-effective manner, it is very important. Satellite imagery is usually less expensive and easily convenient compared to aerial photographic coverage, and it comes in a digital format for immediate ingest into computer database systems, such as GIS.

SAR systems obviously have the advantage of collecting imagery in all weather conditions. So, this kind of sensors will be very useful in case of natural disasters and for security especially if the imaging system is a constellation. Besides, passive remote sensing will be in progress as long as optical sensor technology is developed.

Another criteria for an imaging satellite is the collection efficiency which can be described as the ratio of total continuous area collected with a particular resolution to the time spent for collecting the area. The less time spent for slew manoeuvres or the faster scanning, the better efficiency we have. Thus, not only the sensor technology but also manoeuvring time with pointing accuracy is very important in design.

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