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High Resolution Satellite Imaging Systems – an Overview*

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Abstract: More and more high and very high resolution optical space sensors are available. Not in every case the systems are well known and the images are distributed over popular distributing channels or are accessible for any user. Several imaging satellites are announced for the near future. In the following, mainly the characteristics of systems usable for topographic mapping are shown, limiting it to sensors with a ground sampling distance (GSD) of approximately 15 m and better.

Not only the GSD of the imaging system is important, also the type of imaging with a transfer delay and integration sensor (TDI) or by reducing the angular speed with a permanent rotation of the satellite during imaging should be mentioned, like the accuracy of the attitude control and determination unit. The radiometric and spectral resolution has to be taken into account. For operational use the swath width, viewing flexibility and imaging capacity has to be respected. Stereo combinations taken from neighboured paths are affected by changes in the object space, atmospheric conditions or different length of shadows. With Cartosat-1 we do have a stereo systems like the existing, but restricted SPOT 5 HRS sensor, generating a stereoscopic coverage within some seconds by viewing forward and afterward in the orbit direction.

Synthetic Aperture Radar (SAR) sensors with up to 1m GSD are announced for the near future, allowing an imaging independent upon cloud coverage. Of course the information contents of SAR-images are not the same like for optical images with the same GSD, but nevertheless we are coming into the range of interest for mapping applications.

Zusammenfassung: *Hoch auflösende bildgebende Satellitensysteme – ein Überblick*. Immer mehr hoch auflösende optische Weltraumsensoren sind verfügbar. Nicht in jedem Fall sind die Systeme gut bekannt und die Bilder über etablierte Vertreiber zu beziehen. Einige Systeme sind für die nahe Zukunft angekündigt. Im Folgenden werden die Charakteristika der Systeme vorgestellt, die für topographische Datenerfassung nutzbar sind, womit die Bodenauflösung auf 15 m oder besser beschränkt ist.

Nicht nur die Bodenauflösung ist von Bedeutung, auch die Art der Vorwärtsbewegungskompensation durch Time Delay Integration (TDI) oder mittels Verringerung der Winkelgeschwindigkeit des Satelliten durch permanente Rotation während der Aufnahme, ebenso wie die Genauigkeit der äußeren Orientierung. Die radiometrische und die spektrale Auflösung sind wichtig wie auch die Streifenbreite und die Flexibilität der Bilderfassung. Die hoch auflösenden optischen Satelliten können die Blickrichtung sehr schnell ändern und ermöglichen damit eine stereoskopische Aufnahme in ein und demselben Orbit, allerdings auf Kosten der Anzahl Szenen, die in dem Orbit aufgenommen werden können. Auf der anderen Seite werden Stereoaufnahmen aus verschiedenen Orbits durch Änderungen des Objekts, der Atmosphäre sowie der Schattenlängen beeinträchtigt.

Synthetische Apertur Radar (SAR) Sensoren mit bis zu 1 m Bodenauflösung, die eine Bilderfassung unabhängig von der Wolkenbedeckung zulassen, sind für die nahe Zukunft angekündigt. Natürlich ist der Informationsgehalt von SAR Bilddaten nicht derselbe, wie der einer optischen Aufnahme gleicher Bodenauflösung, trotzdem kommen wir damit in für topographische Anwendungen sehr interessante Bereiche.

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1 Introduction

With the higher resolution and unrestricted access to images taken by satellites, a competition between aerial images and space data exists, starting for a map scale 1: 5000. Based on experiences, optical images should have approximately a ground sampling distance (GSD) of 0.05 mm up to 0.1 mm in the map scale corresponding to a map scale of 1: 20 000 up to 1:10 000 for a GSD of 1 m. GSD is the distance of the centre of neighboured pixels projected on the ground. Because of over- or under-sampling, the GSD is not identical to the projected size of a pixel, but for the user, the GSD appears as pixel size on the ground. An over- or under-sampling is only influencing the image contrast, which also may be caused by the atmosphere.

Mapping today is a data acquisition for geoinformation systems (GIS). In a GIS the positions are available with their national coordinates, so by simple theory a GIS is independent upon the map scale, but the information contents corresponds to a publishing scale. In no case the full information is available in a GIS, for a large presentation scale the generalisation starts with the size of building extensions which are included, while for small scales the full effect of generalisation is required. So for large presentation scales more details have to be identified in the images while for smaller scales a larger GSD may be sufficient. If the GSD exceeds 5 m, not all details, usually shown in the corresponding publishing scale can be identified.

Not only optical images have to be taken into account, in the near future high resolution synthetic aperture radar (SAR) images will be available. Radar has the advantage of penetrating clouds, so a mapping is possible also in rain-forest areas.

Within few years there will be an alternative between the satellite images and aerial images coming from high altitude long endurance (HALE) unmanned aerial vehicles (UAV) with an operating altitude in the range of 20 km.

Not from all systems images are accessible, they may not be classified, but sometimes no distribution system exists and it is difficult to order images.

2 Details of Imaging Sensors

2.1 *View Direction*

The first imaging satellites have had a fixed view direction in relation to the orbit. Only by panoramic cameras, scanning from one side to the other, the swath width was enlarged. For a stereoscopic coverage a combination of cameras with different longitudinal view directions was used, like for the CORONA 4 serious and later MOMS, ASTER, SPOT 5 HRS and Cartosat-1. With SPOT by a steer able mirror the change of the view direction across the orbit came. IRS-1C and -1D have the possibility to rotate the whole panchromatic camera in relation to the satellite. This requires fuel and so it has not been used very often. IKONOS launched in 1999 was the first civilian reconnaissance satellite with flexible view direction. Such satellites are equipped with high torque reaction wheels for all axes. If these reaction wheels are slowed down or accelerated, a moment will go to the satellite and it is rotating. No fuel is required for this, only electric energy coming from the solar paddles.

2.2 *TDI-sensors*

The optical space sensors are located in a flying altitude corresponding to a speed of approximately 7 km/sec for the nadir point. So for a GSD of 1 m only 1.4 msec exposure time is available, this is a not sufficient integration time for the generation of an acceptable image quality, by this reason, some of the very high resolution space sensors are equipped with time delay and integration (TDI) sensors. The TDI-sensors used in space are CCD-arrays with a small dimension in flight direction. The charge generated by the energy reflected from the ground is shifted with the speed of the image motion to the next CCD-element and more charge can be added to the charge collected by the first CCD-element. So a larger charge can

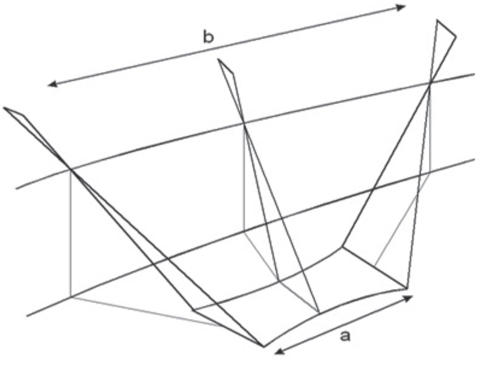

Fig. 1: Enlargement of integration time with factor b/a by continuous change of view direction.

be summed up over several CCD-elements. There are some limits for inclined view directions and vibrations, so in most cases the energy is summed up over 13 CCD-elements. IKONOS, QuickBird and OrbView-3 are equipped with TDI-sensors while EROS-A and the Indian TES do not have it. They have to enlarge the integration time by a permanent rotation of the satellite during imaging (see Fig. 1). Also QuickBird is using this because the sensor originally was planned for the same flying altitude like IKONOS, but with the allowance of a smaller GSD, the flying height was reduced, resulting in a smaller pixel size. The sampling rate of 6900 lines/sec could not be enlarged and this has to be compensated by the change of the view direction during imaging, but with a quite smaller factor like for EROS-A and TES.

2.3 *CCD-configuration*

Most of the sensors do not have just one CCD-line but a combination of shorter CCD-lines or small CCD-arrays. The CCD-lines are shifted against each other – see Fig. 2.

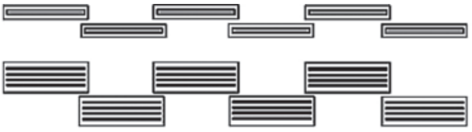

Fig. 2: Arrangement of CCD-lines in focal plane, above: panchromatic, below: multi-spectral.

The merging of sub-images achieved by the panchromatic CCD-lines belongs to the inner orientation and the user will not see something about it. Usually the matching accuracy of the corresponding sub-images is in the lower sub-pixel range so that the geometry of the mosaiced image does not show any influence. This may be different for the larger offset of the colour CCD-lines. Not moving objects are fused without any problems during the pan-sharpening process. By theory only in extreme mountainous areas unimportant effects can be seen. This is different for moving objects – the time delay of the colour against the panchromatic image is causing different locations of the intensity and the colour. The different colour bands are following the intensity. This effect is unimportant for mapping because only not moving objects are used.

2.4 *Staggered CCD-lines*

The ground resolution can be improved by staggered CCD-lines (Fig. 3). They do include 2 CCD-lines shifted half a pixel against each other, so more details can be seen in the generated images. Because of the over-sampling, the information content is not corresponding to the linear double information. For SPOT 5 the physical pixel size projected to the ground is 5m, while based on staggered CCD-lines the supermode has 2.5 m GSD. By theory this corresponds to the information contents of an image with 3 m GSD.

2.5 *Multi Spectral Information*

Sensors usable for topographic mapping are sensitive for the visible and near infrared (NIR) spectral range. The blue range with a wavelength of 420–520 nm is not used by all sensors because of the higher atmosphe-

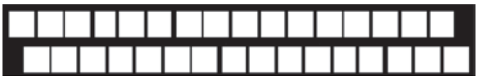

Fig. 3: Staggered CCD-lines.

ric scatter effect, reducing the contrast. In most cases the multispectral information is collected with a larger GSD like the panchromatic. With the so called pan-sharpening, the lower resolution multispectral information can be merged with the higher resolution panchromatic to a higher resolution colour image. This pan-sharpening is using the character of the human eye which is more sensitive to grey values like for colour. A linear relation of 4 between panchromatic and colour GSD is common.

The panchromatic range does not correspond to the original definition – the visible spectral range. Often the blue range is cut of and the NIR is added to the spectral range of approximately 500 to 900 nm.

2.6 *Imaging Problems*

Modern CCD-sensors used in space do have a radiometric resolution up to 11 bit, corresponding to 2048 different grey values. Usually there is not a good distribution of grey values over the whole histogram, so the important part can be optimised for the presentation with the 8 bit grey values of a computer screen. The higher radiometric resolution includes the advantage of an optimal use of the grey values also in extreme cases like bright roofs just beside shadow part. Also for 11 bit-sensors, there are some limits. If the sun light will be reflected by a glass roof directly to the sensor, an oversaturation will occur and the generated electrons will flow to the neighboured CCD-elements and the read-out will be influenced over short time. The oversaturation (Fig. 4) is not causing problems, but the human operator should know about it to avoid a misinterpretation of the objects.

2.7 *Direct Sensor Orientation*

The satellites are equipped with a positioning system like GPS, gyroscopes and star sensors. So without control points the geolocation can be determined. For example IKONOS can determine the imaged positions with a standard deviation of approximately 4m. Often more problems do exist with not well known national datum.

3 Imaging Satellites

Imaging satellites at first have been used for military reconnaissance. So 20 month after the launch of SPUTNIK in October 1957 the US tests with the CORONA system started in 1959. For reconnaissance the USA used film up to 1963 while the Soviet Union and later Russia made the last satellite photo flight in 2000. The historical images have been declassified by the USA in 1995; also Russia is selling now the old images.

For civilian or dual use (use for military and civilian applications) the digital imaging

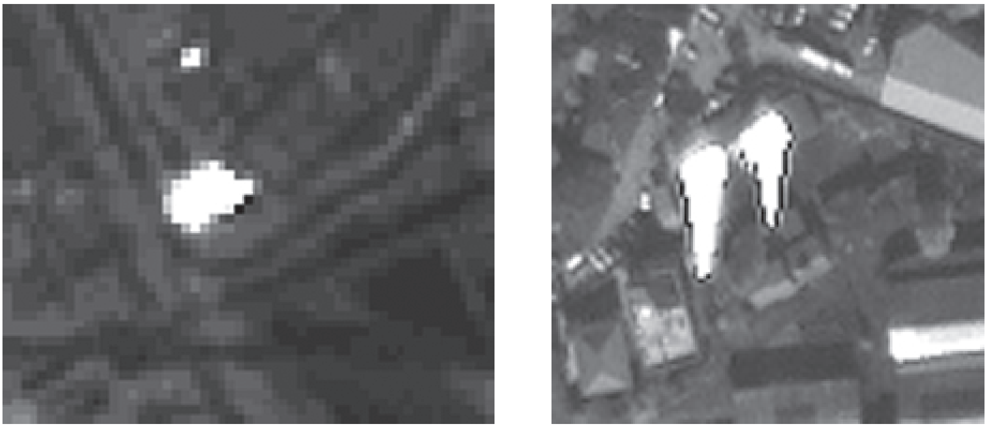

Fig. 4: Oversaturation; left: ASTER, right: IKONOS.

from space started with Landsat 1 in 1972, but the GSD was not sufficient for mapping purposes. This changed with the French SPOT satellite, at first launched in 1986. With the stereoscopic possibilities and 10 m GSD this system was used for the generation and updating of topographic maps up to a scale 1: 50 000 but not with the same information contents of traditional maps in this scale. This has been improved with the Indian IRS-1C in 1995 having a GSD of 5.7 m. The next big step came with the very high resolution IKONOS in 1999. Today there is a large variety of imaging sensors in space including not so expensive small satellite systems operated by a growing number of countries.

With the synthetic aperture radar (SAR) imaging radar systems are available which are independent upon the cloud coverage.

Tab. 1: Larger optical space sensors.
MS = multispectral fore = view forward in orbit direction
aft = backward in orbit direction

System	launch	GSD [m] pan/MS	swath [km]	remarks
SPOT 1 France SPOT 2 SPOT 3 SPOT 4	1986 1990 1993 1998	10/20	60	+/−27° across orbit
SPOT 5 France	2002	5/10 2.5 HRS 5*10	60 120	+/−27° staggered 23° fore 23° after
JERS-1 Japan	1992	OPS 18	75	+ SAR
MOMS 02 Germany	1993	4.5/13.5	37/78	nadir + 21.5° fore + 21.5° after
MOMS-2P Germany	1996	6/18	48/100	like MOMS 02
IRS-1C + 1D India	1995 1997	5.7/23	70/142	+/−26° across
IRS P6 India Resourcesat	2003	5.7 MS	23/70	+/−26° across
KOMPSAT-1 South Korea	1999	6.6 pan	17	+/−45° across
CBERS-1 + 2 China + Brazil	1999 2003	20	113	+/−31° across
Terra USA / ASTER Japan	1999	15, 30, 90 all MS	60	nadir + 24° aft
IKONOS-2 USA SpaceImage	1999	0.82/3.24	11	free view direction, TDI
EROS A1 Israel Imagesat	2000	1.8 pan	12.6	free view direction
TES India	2001	1 pan	15	free view direction
QuickBird-2 USA DigitalGlobe	2002	0.62/2.48	17	free view direction, TDI
OrbView-2 USA OrbImage	2003	1/4	8	free view dir., TDI
FORMOSAT-2 Taiwan	2004	2/8	24	free view dir., TDI
IRS-P5 Cartosat-1 India	2005	2.5 pan	30	−5°, +26° in orbit

Because of the speckle and quite different imaging conditions, the SAR images cannot be compared directly with optical images having the same GSD. So up to now only in tropical rainforest areas SAR has been used for the generation of topographic maps but this may change with the coming very high resolution SAR satellites.

Especially in the beginning several space missions failed. So from the 10 launches of CORONA KH-1 only one was successful while for the CORONA KH-4A only 3 of 52 missions failed. The highest ground resolution was possible with panoramic cameras like the CORONA serious without KH-5 and the similar Russian KVR-1000. Also for military reconnaissance a stereoscopic coverage was important, so the most often used CORONA 4-serious was equipped with 2 convergent mounted cameras. The Soviet Union preferred frame cameras for getting the 3rd dimension – they used for example the KVR-1000 in combination with the TK-350.

Space images got a growing market share in photogrammetry. They have been established as a completion and partially as replacement of aerial images. They can be used in remote locations and "no-fly"-zones. In several countries aerial images are classified and a commercialisation is complicate or impossible. Because of the availability of very high resolution space imagery there is no more justification of such a classification, but some governmental organisations like to keep their importance by such restrictions. Space images can be used by private companies for the generation of the different photogrammetric products even if some countries still try to restrict it.

There is a general tendency in the development of high resolution optical space sensors: the resolution is improving and the new systems do have a flexible view direction. By reaction wheels the whole satellites can change the attitudes in a controlled manner very fast and precise enough to generate images also during the rotation. This has advantages against the change of the view direction just across the orbit direction – a stereoscopic coverage can be generated within some seconds, while for the view direction across the orbit, the second image has to be taken from another orbit; that means under optimal conditions at the following day – if this is not possible, problems can be caused for automatic image matching. SPOT Image reacted to this problem with the additional HRS-sensor on SPOT5 viewing with two optics 23° forward and 23° backward, allowing a stereoscopic coverage within approximately 100 seconds. A similar solution is also available for ASTER and Cartosat 1. Based on 3 view directions it has been used by MOMS before.

The very high resolution systems IKONOS, QuickBird, OrbView and EROS A1 are operated by private companies. Without financial support by military contracts they would not survive, so in reality they are belonging to dual use – the use is dominated by military, but the free capacity is commercially available. There are some restrictions – the images from the US companies are not released within 24 hours of its collection and for EROS A1 images the military has the priority of data collection.

The very high resolution systems EROS A1 and TES are not equipped with TDI-sensors, so they have to enlarge the exposure time by continuous change of the view direction (see Fig. 1). This has only a limited influence to the radiometric and geometric image quality, but it is reducing the imaging capacity.

SPOT 5 with the super mode and OrbView are improving the GSD by staggered linear CCDs. An edge analysis of both image types did lead to a GSD identical to nominal resolution. But the analysed images have been edge enhanced like most of the space images and this is leading to too optimistic results.

The access to the images is well organised by commercial companies, but also SPOT Image and India are using a net of commercial distributors. For the FORMOSAT-2 SPOT Image got the exclusive distribution right. The ASTER images are available Web-based for a handling fee over US administration. Also Japan has solved the distribution of the not more active JERS-1 images like Germany for the existing MOMS-images via the DLR. For KOMPSAT and CBERS the distribution is more difficult, but possible.

The required technical knowledge and the access to the required components was limiting the imaging satellites to just few countries, but today the major components and also whole systems can be ordered. So the FORMOSAT-2 satellite has been made by the European EADS ASTRIUM. A similar cooperation exists for the small satellites. The launch is also not a problem – there is a strong competition. Because of the lower price Russia is dominating the launches, followed by the USA, China, Europe, the private Sea Launch and India.

With the reduced size and weight of electronic components, the imaging satellites can be smaller today, leading to small satellites with a weight below 200 kg. These systems are not included in Tab. 1 because of the limited access to the collected images mainly used only by the owning countries. A strong position in this field has the Surrey Satellite Technologies (SSTL), SSTL made the UOSAT12 and a group of satellites belonging to the disaster monitoring constellation (DMC). In the case of natural disasters the DMC satellites are cooperating to generate as fast as possible images from the affected area. The satellite constellation guarantees a daily coverage of the earth by images having the Landsat-ETM bands 2, 3 and 4. SSTL is using off-the-shelf components and so the price for a satellite system including launch and ground station today may be in the range of 10 million US$. The small satellites do have a free view direction. Partially they are equipped with CCD-arrays instead of CCD-line.

Optical images only can be taken under cloud free condition and with sufficient sun light. So all systems listed in Tab. 1 and the

Tab. 2: Announced larger optical space sensors.

System	**launch**	**GSD [m] pan / MS**	**swath [km]**	**remarks**
IRS Cartosat-2, India	2005	1 pan	10	free view direction
ALOS, Japan	2005	2.5 / 10	35 / 70	−24° nadir +24° in orbit
KOMPSAT 2 South Korea	2005	1 / 4	15	free view direction
Resurs DK1 Russia	2005	1 / 2.5–3.5	28	free view direction
Monitor-E Russia	2005	8 / 20	94 / 160	free view direction
EROS B Israel	2005	0.7 pan	14	free view dir., TDI
EROS C Israel	2009	0.7 / 2.8	11	free view dir., TDI
RazakSat Malaysia	2005	2.5 / 5	20	free view direction, inclin. 7°
CBERS 2B China, Brazil	2005/2006	2.5 / 20		+/−32° across
CBERS-3+4 China, Brazil	2008	5 / 20	60 / 120	+/−32° across
WorldView 1 DigitalGlobe	2006	0.52 /		free view dir., TDI
OrbView 5 OrbImage	2006	0.41 / 1.64	15	free view dir.. TDI
THEOS Thailand	2007	2 / 15		free view dir., TDI
Pleiades 1+2 France	2008/2009	0.7 / 2.8	20	free view dir., TDI
KOMPSAT-3 South Korea	2009	0.7 / 2.8		free view dir., TDI

mentioned small satellites do have sun-synchronous orbits with imaging between 9:30 and 11:00 pm local time – the day time with the best viewing condition. This is different for radar satellites. Radar is an active system, independent upon the sun light. For SAR images the GSD of 10 m and larger, is not sufficient for topographic mapping. So only in tropical rain forest areas SAR-images have been used for this. But in interferometric constellation (InSAR) SAR-image combinations can be used for the generation of height models. So ERS-1 and ERS-1 have been operated for a period of approximately 1 year in the tandem constellation for DEM generation. By the Shuttle Radar Topography Mission (SRTM) a homogenous and qualified DEM covering the earth from 56° southern up to 60.25° northern latitude has been generated.

A higher number of optical satellite systems are announced (Tabs. 2 and 3). The proposed launch time often is delayed and some systems may disappear or the launch may fail. The specification of the systems may change or in some cases they are not fixed or published jet. But today it is not any more so time consuming to assemble qualified reconnaissance satellites, so additional systems may come. There is a general tendency – the GSD is getting smaller, the weight is reducing, TDI will become standard, very high resolution SAR sensors will come and dual use is reducing the expenses and is enabling a commercial use. Nearly all satellites will be equipped with reaction wheels leading to high agility and free view direction. ALOS is designed especially for 3D-mapping based on three cameras having the view in orbit direction for the generation of stereo models with only some second difference in time.

Tab. 3: Announced high resolution small optical space sensors.

System	launch	GSD [m] pan/MS	swath [km]	remarks
DMC China	2005	4/32	600	DMC
TopSat UK BNSC	2005	2.5/5	10/15	free view dir., TDI
X-Sat Singapore	2006	10 MS	50	
RapidEye Germany commercial	2007	6.5 MS	78	free view direction, 5 satell.

Within the NextView program of the USA contracts have been made with DigitalGlobe and OrbImage for operating satellites with at least 50 cm GSD in the panchromatic range. The GSD for nadir view will be smaller, but the USA is restricting the GSD to at least 50 cm, so the commercial available images will be limited to this. More and more countries are entering the field of commercial very high resolution optical systems. A GSD of at least 1m will be supported by the USA, India, Israel, France, South Korea and Russia. Up to 2.5 m GSD in addition there are Malaysia, China, Brazil, Thailand and the UK. The military systems are not respected here.

Again the small satellites are listed separately because of the often missing distribution systems. Most of the small optical satellites are assembled by SSTL including also Rapid Eye. Rapid Eye will be a system of 5 small satellites, mainly for use by high tech agriculture. It will be the first commercial system outside the area of dual use.

With SAR-X Cosmo-Skymed-1 and Terra SAR-X two radar systems with a GSD of 1m are announced. SAR images with such a resolution can be used for mapping purposes. The information contents of the 1 m SAR-images may be in the range of optical images with 2 m GSD. SAR-images do have the big advantage of being independent upon the cloud coverage – this is important for regions like Germany having only few cloud free days. With RADARSAT-2 and RISAT two systems with a GSD of 3 m will come in addition.

Terra SAR-X will be operated under private public partnership of the German Aerospace Center DLR and EADS ASTRIUM. SAR-X Cosmo-Skymed-1 will be operated by Italy in cooperation with

Tab. 4: Announced SAR space sensors;
ppp = private public partnership.

System	launch	GSD [m]	swath [km]	remarks
SAR-X Cosmo-Skymed-1, Italy	2006	1-several 110th	10-few hundreds	X-band 3.1 cm
RADARSAT-2, Canada	2006	3–100	20–500	C-band 5.6 cm, full polarisation
TerraSAR-X Germany ppp	2006	1/3/16	10/30/100	X-band 3.1 cm
RISAT India	2006	3–50	10–240	C-band
Surveyor SAR, China	2007	10/25	100/250	C-band 5 satellites

France within the dual use ORFEO program. Under this cooperation France will operate two very high resolution optical system Pleiades and Italy four SAR-system.

The Tandem X project is under investigation which shall include a second TerraSAR-X in tandem configuration for the generation of digital elevation models with better than 12 m DEM point spacing and a vertical accuracy of 2 m and better. For the SAR-X Cosmo-Skymed-1 the so called Cartwheel is studied, it could include one active SAR-satellite together with 3 to 4 passive micro satellites for the generation of DEMs with a standard deviation of 1 m.

4 HALE UAV

High altitude long endurance (HALE) unmanned aerial vehicles (UAV) may be in future a completion, on the contrary also a competition to space and aerial images. Up to now UAVs are mainly used for military reconnaissance, but it seems to lead also to civilian application. The Belgian Flemish Institute for Technological Research VITO plans the first test flight of its HALE UAV Pegasus for 2006. The sun powered Pegasus is designed for continuous operation over several month (Biesemann et al. 2005). It shall operate in a height of 20 000 m, over night it will go down to 16 000 m and raise again at the next morning. This altitude is above the aeronautic control, avoiding safety problems. In a partially autonomous flight it can be directed to the area for imaging. It shall carry a digital camera with 4 spectral bands and 12000 pixels having a GSD of 20 cm. This later shall be extended to 10 spectral bands and 30 000 pixels and SAR and LIDAR may be included.

Conclusion

The conditions for mapping with high and very high space images are improved permanently. More and more sensors are entering the field leading to better coverage and the possibility to select the optimal solution. The image data bases are becoming more and more complete, allowing a fast access corresponding to the requirement. The competition between the different distributors has improved the order conditions and partially was leading to reduced prices. On the other hand the high expenses for the large systems cannot be covered by civilian projects. Without dual use the private companies in this field cannot survive. This may change with the raising capacity of small satellites.

Not only the optical images, also SAR has to be taken into account. With the very high resolution of the announced systems, SAR is becoming important for mapping purposes. With InSAR accurate digital surface models can be generated. Only in cities and mountainous areas InSAR and also SAR do have some problems by lay over.

The operation of high resolution satellites is not any more restricted to few countries with advanced technology. More and more components of the shelf can be used and in addition satellites can be ordered from different manufacturers. So in the above listed tables in total 22 countries are mentioned.

With the improving ground sampling distance space images do come into competition with aerial images. Because of classification of aerial photos, in some regions space images became more important than in countries without restrictions. In near future with the HALE UAV there will be a stronger overlap of the applications. Very high resolution space images are not only a supplement or competition to aerial photos; they are also in use for new applications.

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