2. draft

Use of satellite imagery to document human rights abuses and humanitarian disasters

Possibilities, potentials, and putting it into action

A report conducted for Amnesty International Danish Section

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Background

Earth Observation (EO) technology is becoming available for layman and is increasingly used as documentation for human rights and humanitarian disasters. The technology is under a continuously development, new sensor systems with approximately 1 m resolution has over the past five years opened up new possibilities for independent documentation of humanitarian crises. More and more examples of the use of the technology see the daylight and more international initiatives are taken to use the technology in a broader context including availability for NGO's and UN institutions.

EO is not any longer fully controlled by super powers, the trend is that EO is commercialised and data will be available from any place to everybody. Approximately 30 satellite systems will be operational within the next couple of years with potential capabilities to monitor violations of human rights. The number of nations with own EO systems will rise to above 20 and private companies own some of these. The development will lead to an expansion of the supply of EO images on the free market, which eventually should lead to increasing availability and decreasing prices.

On an international scale there have been attempts to form UN agencies for EO monitoring of human right abuses since 1975 (Dorn, 1987, Bhupendra, 1991). However, formation of international EO cooperation in the form of charters centres and consortia's have first really been initiated within the last five years. Humanitarian disasters weather they are coursed by nature or man made accidences are well covered by funded charters and centres, however, for human right abuses they still have to be defined.

The aim of this report is to give human rights and humanitarian NGO's an overview of the application, status, and trends of EO data in relation to human right crises. The report will cover the applicability of EO to provide indicators to document human right abuses, how fast documentation can be delivered and to what cost. Furthermore, the report will cover basic concept of EO imagery including copyright rules and describe the current international development of the technology, in terms of research, projects, and centres in relation to human rights abuses.

Indicators of humanitarian crises from the sky

The big advantage of EO data is it can collect evidence from remote locations and “no-fly”-zones where no other information sources is available. They can represent a proof that is verified in a scientific manner solid enough to convince the decision makers, media, and the general public in order to take action at an early stage. However, some general considerations on possible indicators should be given.

Consideration for indicators of abuses

The use of EO data for documentation of human right abuses require some quality, first of all to be convincing and secondly not to oversell the technology. There are a number of cases where EO data have been used in a non-convincing manner: The documentation of chemical factories in the US lead Iraq war, Zaire where a few number of people walking along a road didn’t lead to international action, and to present a smoke fan coming up from a single village on a large scale image is a weak indicator. In general the aim for indicators should be:

- A certain coverage(statistical) and quality to make them reliable and convincing,
- Before and after situations will be needed in most cases.

The use of very high-resolution images can be very costly over larger areas. By the use of lower resolution EO data some of the indicators can not be directly seen but have to be analyzed together with other images or supported by other GIS (Geographic Information Systems) data to produce indicators – this type of analysis requires more ground verification to be convincing.

Listing of possible indicators

So far the indicators used for documentation of human rights abuses have been related to destroyed, burned or burning houses or villages; indication of masses of refugees and/or individuals, and mass graves. However, change detection of land use can also indicate human rights abuses.

Destruction of infrastructure

The use of high resolution EO data is more or less self-explaining. It can be regarded as a photo witness of:

- Burning and / or destruction houses
- Removal of homelands/chantey towns
- Destruction of dams

Refugees - thermal – human presence

Refugees on the run can be spotted by their campfires, which will be visible in night images from i.e. Landsat TM thermal band, and be compared with older images to spot changes and eventually indicate their presents.

Change in cropping/land use

Change in land use and cropping from one season to another can be a clear evidence of instability and/or forced removal of people. There is a multiple of possibilities: No or few crops, burnt crops, overgrown fields. In pastoral societies, management of water points can be a source of war and the evidence can be by EO.

Outbreak of diseases

Furthermore, satellite images have been used as thematic map source in GIS to model and analyze the spread of diseases like Malaria, Ebola and hunt for infectious 'kissing bugs´.

The above mentioned themes are the known indicators but most cases doesn't look like one before, thus it can be expected that indicators may vary from one case to another and in some instances it will be needed to digitally enhance the images or introduce an combination with GIS analysis to derive them.

Examples of use of EO data to document human abuses

Mass Burial sites

In Kosovo an US spy plane of the type U2 took some images that appeared to be mass burial sites (figure 1). The image is of the high altitude aerial image and degraded to approximately 1-2 m, but could principally have been recorded by a high-resolution satellite sensor.

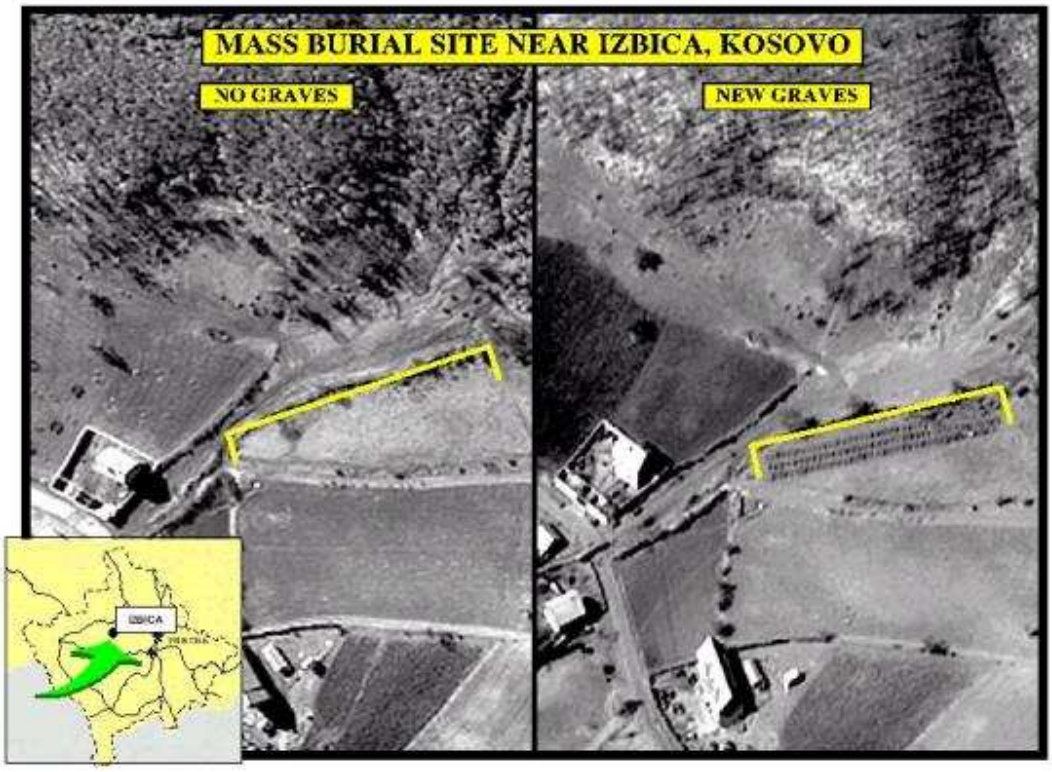

Figure 1. Mass burial site, Kosovo, recorded probably by high altitude US spy plane U2, approximately resolution 1 m. Source: http:www.fas.org

Similar images have been recorded in the Bosnian Herzegovina conflict (figure 2), where many examples can be viewed at http://www.fas.org/irp/imint/bosnia.htm

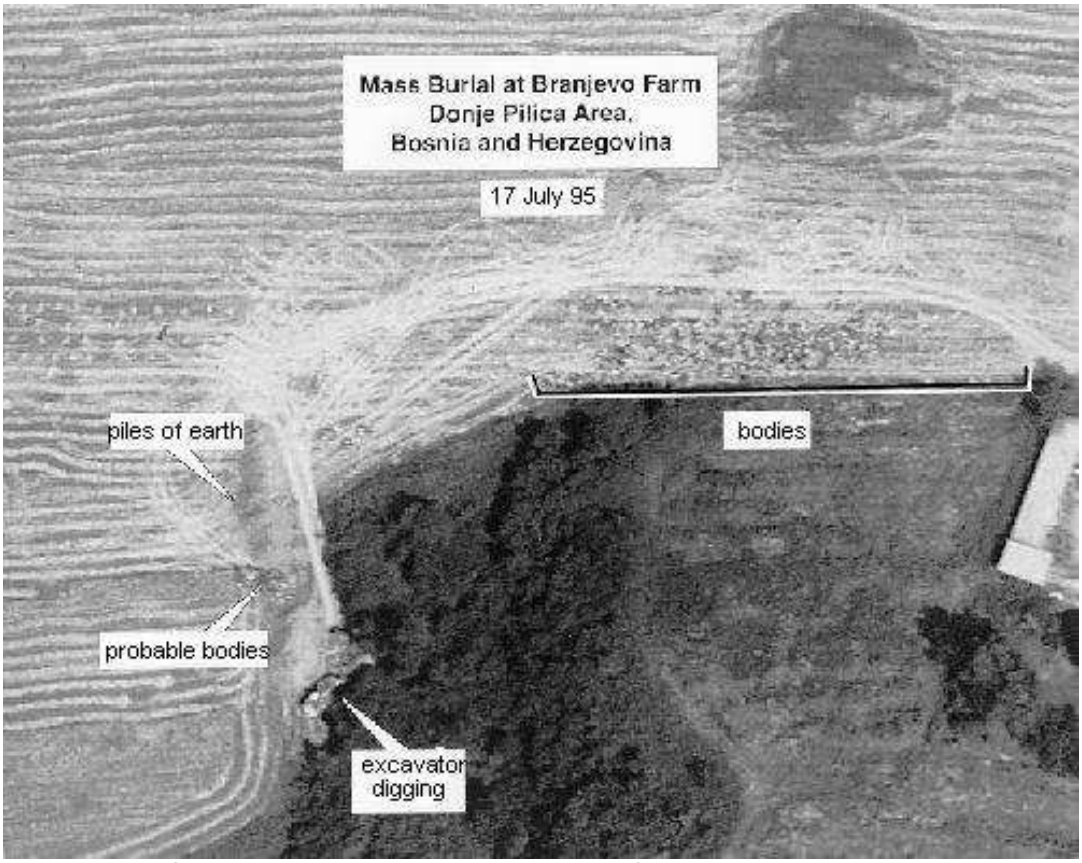

Figure 2. Mass Graves, recorded probably by high altitude US spy plane - Branjevo Farm, Donje Pilica, 17 Jul 95. Source John Pike www.fas.org/irp/imint/bosnia16.htm.

The above-illustrated examples are pan-chromatic images. By the use of multi-spectral images, it is rather easy to differentiate between vegetation, soil, and other issues, and between different soil moisture, which can be used to identify areas where digging has taken place.

Destroying of houses in Zimbabwe

Ethnical de-housing usually of poor communities is a well-known human rights abuse. Several examples are known from the past from i.e. the Bosnian conflict and lately cases from South Africa and Zimbabwe. Figure (3) is a recent example from Harara where UNOSAT has documented 'removal' of townships by the use of data from the IKONOS and QUICKBIRD satellites.

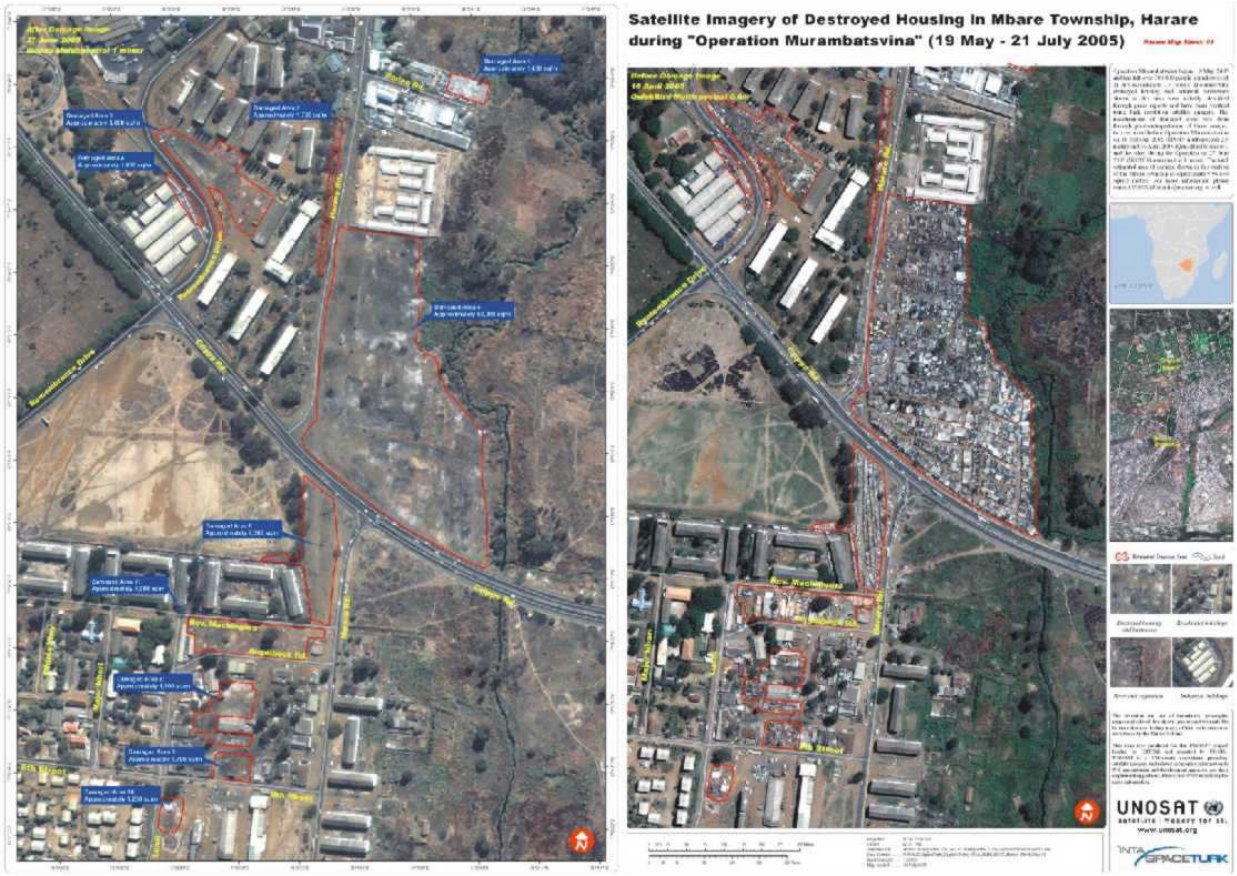

Figure 3. Use of IKONOS and Quickbird satellite data to document removal of townships in Harare. Image to the left: The situation after the removal (inside the red lines). Source: UNOSAT http://unosat.web.cern.ch/unosat/ IKONOS: Copyright INTA Space Turk 2005 QUICK BIRD: Copyright Digital Globe 2005

Burning of houses and villages in Bosnia and Darfur

Burning of houses is a common phenomenon in rural ethnical conflicts, most well known EO documentation is from the Bosnian conflict (figure 4) observed by US military. More than half of the houses have been destroyed. The images have been recorded in a period where no high-resolution images were available to the public. However, by the use of pan-sharpened images with 10 m GSD from the SPOT satellite it would have been possible in 1993 to document the extent of the destruction.

Figure 4. Documentation of destroyed houses in Bosina June 1993 recorded by US military. The image shows that approximate half of the houses have no roof (the intact are pale) and the structures of rooms are visible. Source:http://www.fas.org/irp/imint/bosnia14.htm

In the recent Darfur crises, satellite images were used to document the burning of villages. The Darfur crisis was covered by very high-resolution images by US-AID (figure 5), where the images proved absents of roofs as an indicator of burned huts.

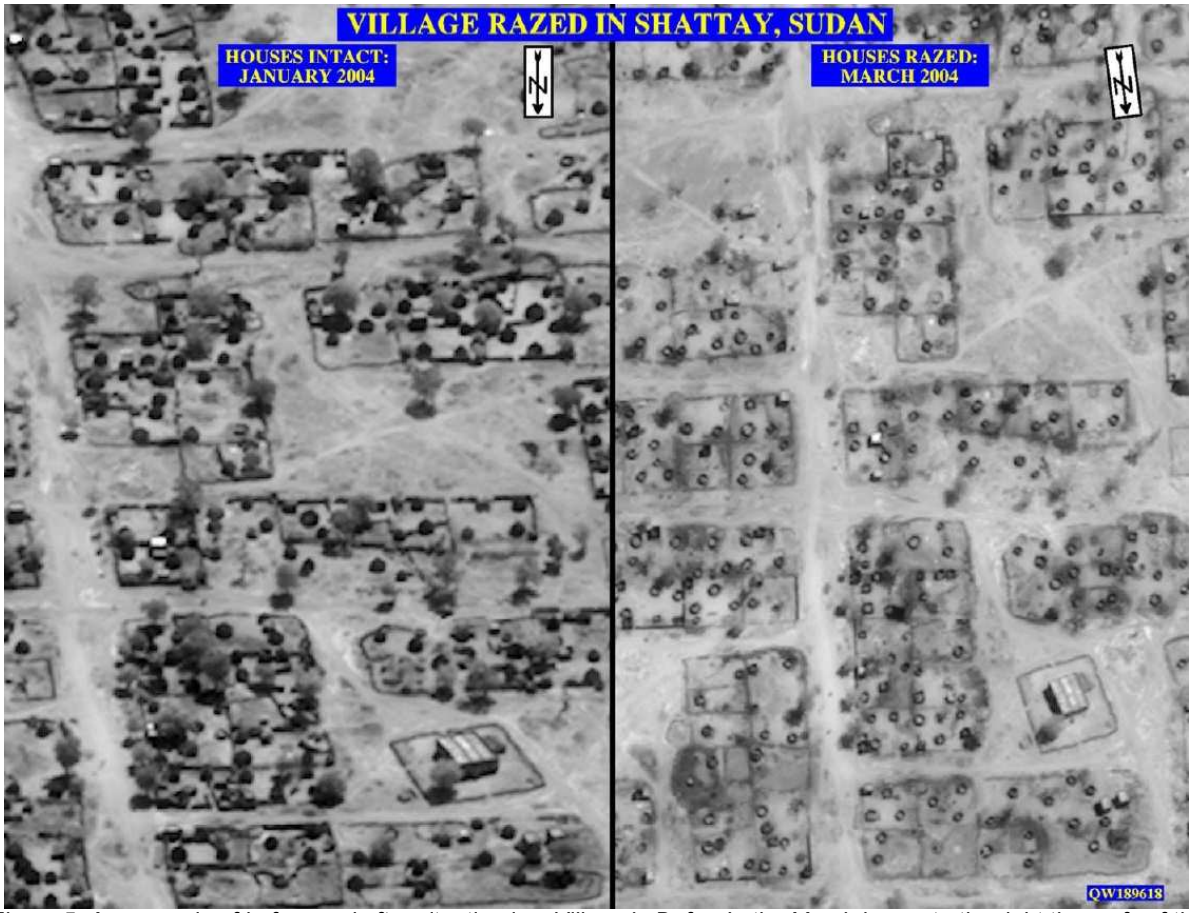

Figure 5. An example of before and after situation in a Village in Dafur. In the March image to the right the roofs of the huts have been burnt. Source: U.S. Government Humanitarian Information Unit (HIU) DigitalGlobe Quickbird imagery

Amnesty International also covered the Darfur case. This study used the 15-30 m resolution Landsat satellite data, where houses could not be identified individually (figure 7). However, by digital change detection analysis it was possible to detect villages that had significantly darker signatures by comparing images from the same period in 2003 and 2004. The darker signatures were related to the present of burnt material in villages. The pattern of burnt villages was confirmed by reports from the area and can be viewed in figure 6.

Figure 6. Photos of burning villages in Darfur, recorded from an civil airplane - the burnt material of the village left a strong enough contrast to be picked up by a change detection of two Landsat 7 images. Photo Credit: Brian Steidle © Courtesy of United States Holocaust Memorial Museum

The principle difference between the two studies is the digital approach. The US AID study had high enough resolution to assess single huts by visual interpretation while the Amnesty operated on digital difference between seasons and village signatures. If the US aid study should have been carried out by a commercial company following the marked prices of Quickbird data the price would have been up to 1000 times the Amnesty study.

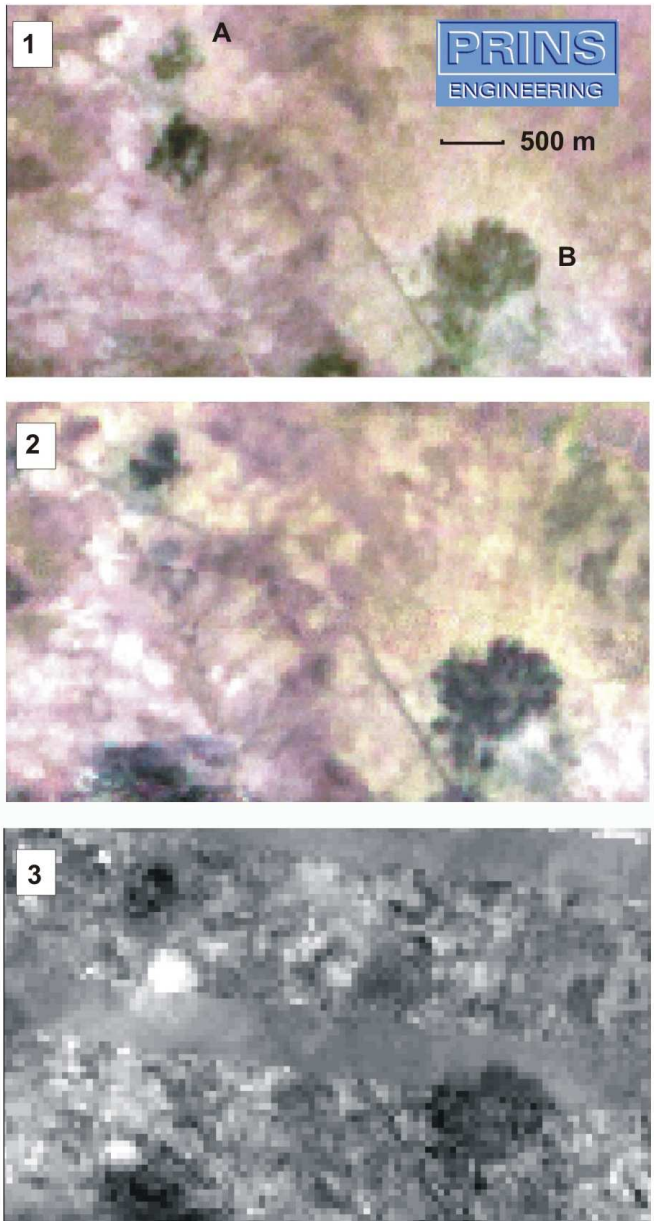

Figure 7. Example of two burnt villages (A and B), image 1 is from 2003, 2 from 2004 and 3 the change detection. The images have been calibrated to each other. The villages appear clearly darker in image 2. The bush fire-scare occurring in image 1 south of village A, has partly been washed away during the rainy season and thus, turns up as a bright spot in the change detection analysis in image 3. http://web.amnesty.org/library/index/engafr540722004

Refugee camps and population estimation

There are many cases of mapping of refugee camps from EO data (RESPOND). Estimation of population in the camps can be done with a high accuracy by extraction the number of tents and calculate with average inhabitants. This can be done from high-resolution images such as images from the IKONOS satellite with accuracy over 95% (Gaida et al 2003 a and b).

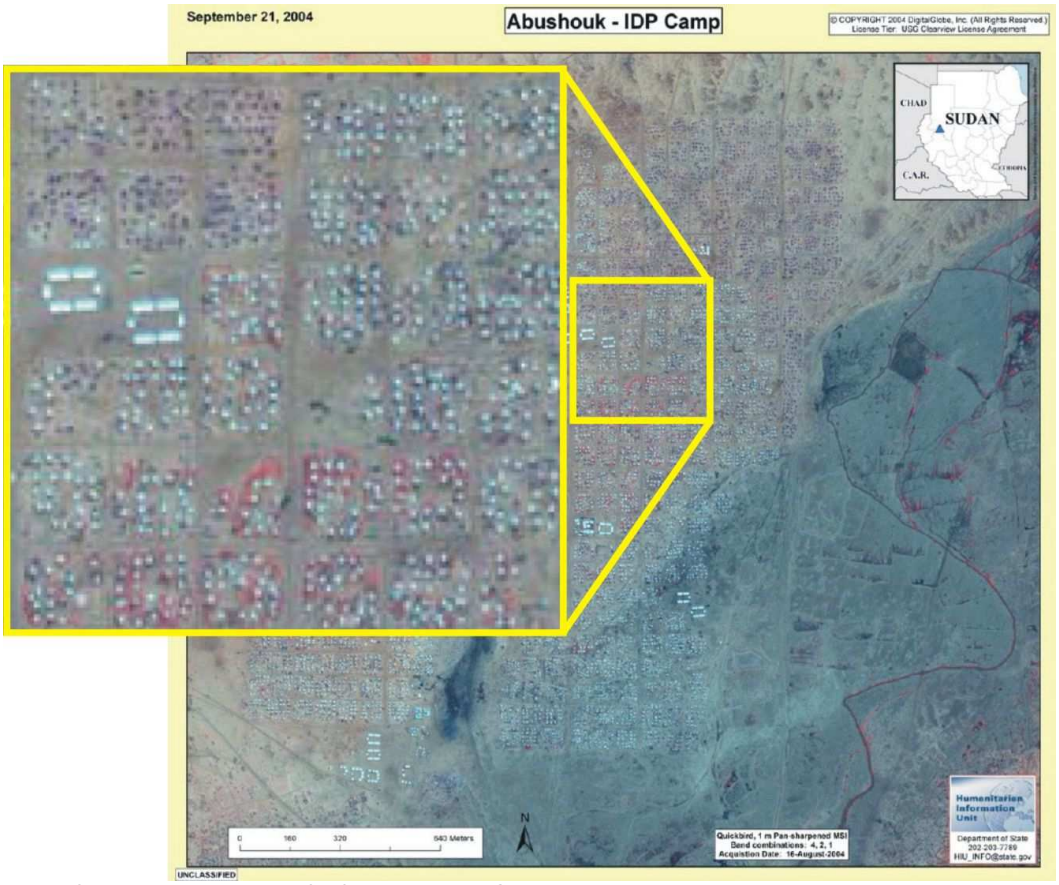

Fig 8. QickBird observation of refugee camp in Sudan, the zoom-up show visible single tents, huts, growing vegetation (red) etc. Source: U.S. Government Humanitarian Information Unit (HIU) Digital Globe Quickbird imagery.

Shelling and bombing of civilians

According to international law, it is not allowed to bomb or shell civilians. However, there are endless numbers of cases where civilians have been bombed and or shelled. Shelling and bombing leave craters and other damages that can be observed by high or very high EO data (GlobalSecurity.org).

Characteristics of relevant satellite

Technical characteristics of EO data

Panchromatic

Imagery is in short 'back and with' images like camera films created on the basic of light reflectance

Multi-spectral

Imagery is recording of the same image in several light bands, usually three to seven enabling it to detect very subtle characteristics and differences among surface features especially in vegetation, soil, and rocks.

Hyper-spectral

Imagery is, technically speaking, the same as multi-spectral imagery, but instead of measuring energy in only a few bands it measures reflectance in numerous which means that potentially more objects can be identified with the same resolution.

Optical images can only be taken under cloud free condition and nearly all systems have sun-synchronous orbits with imaging between 9:30 and 11:00 pm.

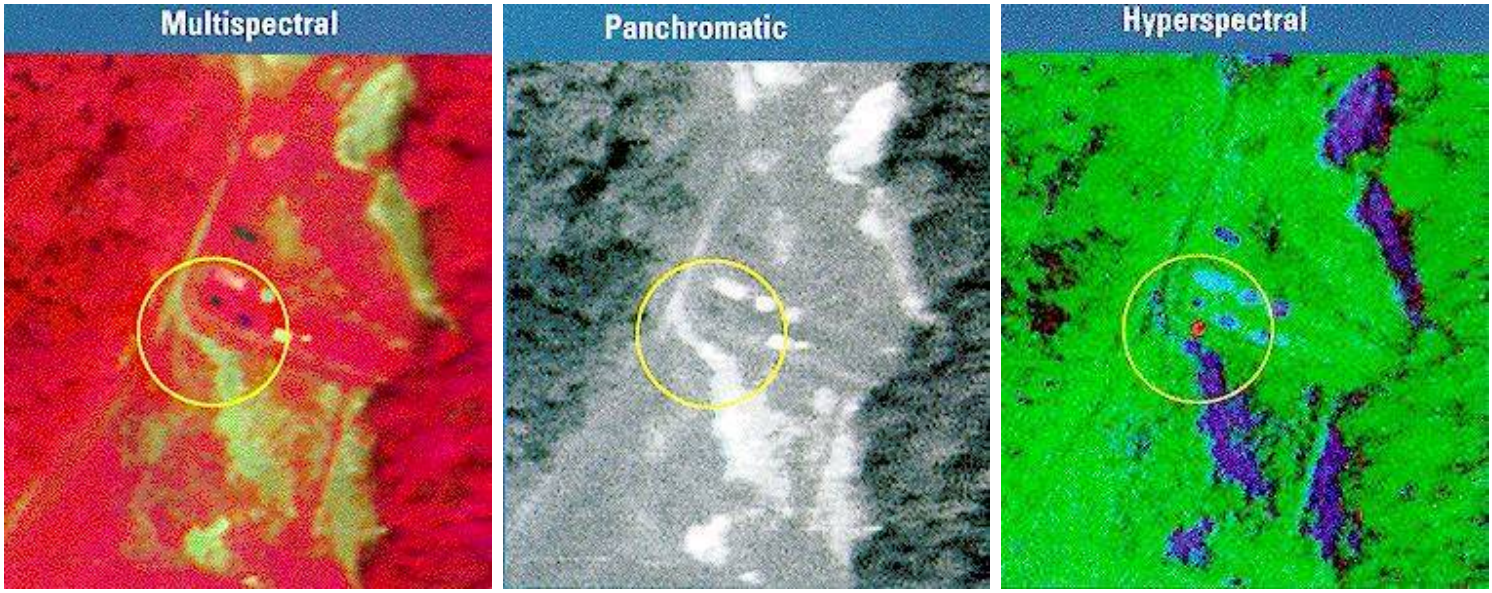

Figure 9. Three images of the same area taken with a panchromatic, multi-spectral, and hyper-spectral imaging sensor respectively. Unspecified images. Image copyright (c) TRW. In the hyper-spectral imagery, an object is clearly detectable, which is undetectable in the panchromatic or multi-spectral imagery. Source: Federation of American Scientists, at http://www.fas.org/irp/imint/hyper.htm

Thermal

Some sensors are measuring thermal infrared radiation. This can be especially useful to detect fires in the night or emitting from power plants. Thermal sensors are generally of lower resolution due to comparable lower emitting differences.

SAR

Synthetic Aperture **Radar** (SAR) - In popular terms it can be said that the SAR measures the surface roughness. It can operate regardless of weather and time of day. However, the images are characterized by 'speckle' or noises, which make not only the processing of the images complicated but also the interpretation of them. So far, this data type has been useful to detect flooding, oil spill etc. At present with the limited resolution of this image source, it is difficult to point out potential application for detection of humanitarian abuses. However, in the future there are plans on 2 m resolution SAR, which can have some implication for mapping of destroyed houses etc.

Resolution of images

Spectral resolution – digital information in the images

A satellite image is a scanning the Earth's surface. Spectral resolution is a measure for how much information that can be stored into a pixel (image element). I.e. 8 bit data can store 256 values and 10 bit 1024 values in the greyscale. For multi- spectral imaging each pixel on a computer monitor, can potentially hold 256^3 (16777216) in 8 bit compared to the 256 differences in the panchromatic, thus multi-spectral images can have a lot more information than the panchromatic and some objects can potentially be detected in multi-spectral images even if they are not directly visible in the image.

Ground Sample Distance / Ground resolution

The definition of high-resolution satellite imaging systems is not fixed; it depends upon the application (Jacobsen 2005). The most commonly used data are from ***medium-resolution*** sensors such as Landsat TM, IRS, and SPOT. The ***high resolution*** (finer scale) data is usually referring to 1-5 meter ground resolution (IKONOS and QuickBird, each with approximately one meter resolution) and ***very high resolution*** below 1 m. The size of each ground area measured is called the ***Ground Sample Distance*** (GSD) and is often referred to as the ***spatial resolution*** of an image

The GSD is a key factor in determining the value of satellite imagery since it is the primary factor determining the size of objects detected in an image. An example of what can be seen at different resolutions can be viewed in figure 10.

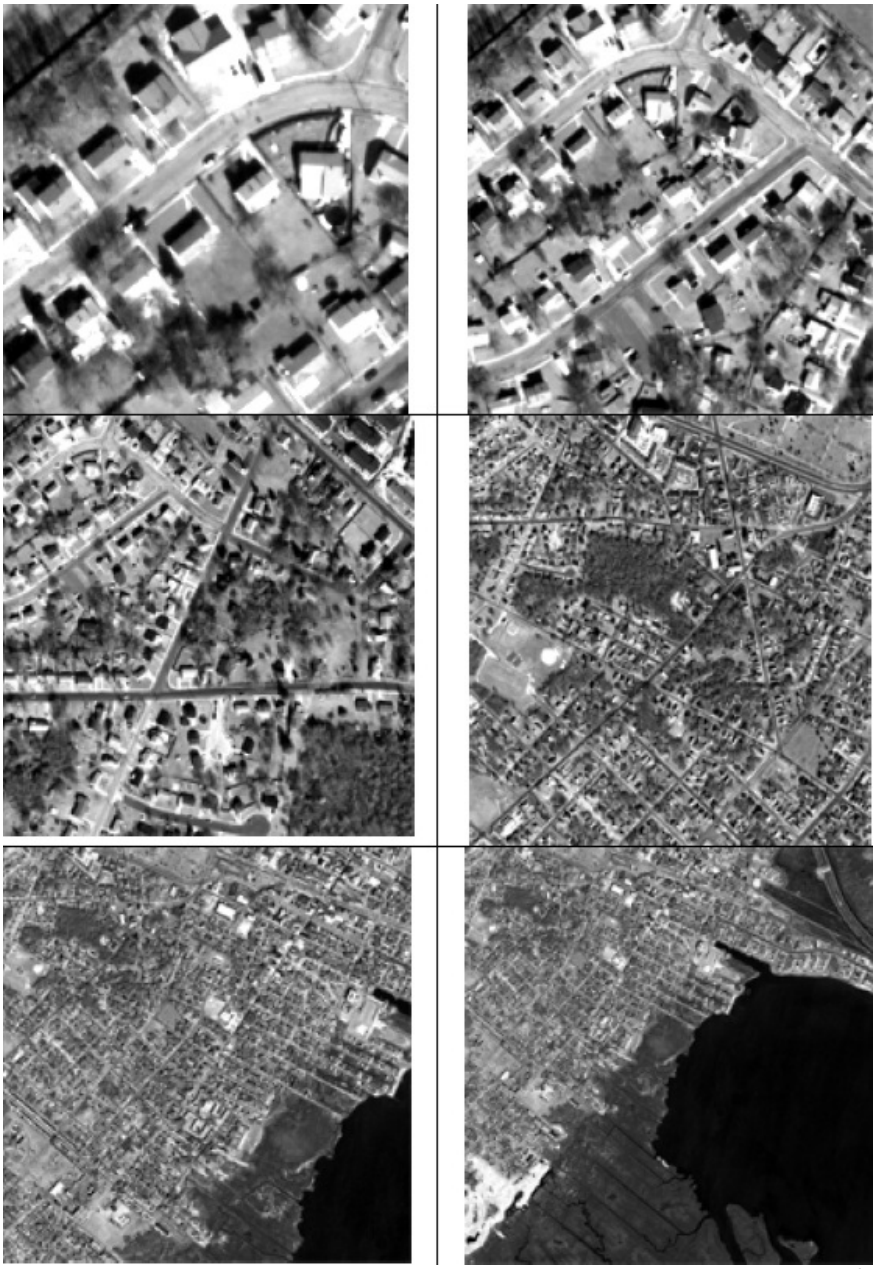

Figure 10. QuickBird sub images showing 0.6 m, 1 m, 2 m, 5 m, 10 m and 15 m ground resolution (from Jacobsen 2005)

It is possible to detect objects that are much smaller than the area covered by the GSD.
An example of comparable smaller object can be seen in a Landsat TM image (figure 11) from south-western Sudan. Two villages A and B are present in the images as well as dirt roads and tracks leading from the villages, some of the tracks are much less than 5 m wide, but the contrast from the surrounding agricultural landscape is so different that the tracks will be visible in the 30 m pixels. The dotted signature of the villages can be related to the singled circular households, which can be viewed in figure 6.

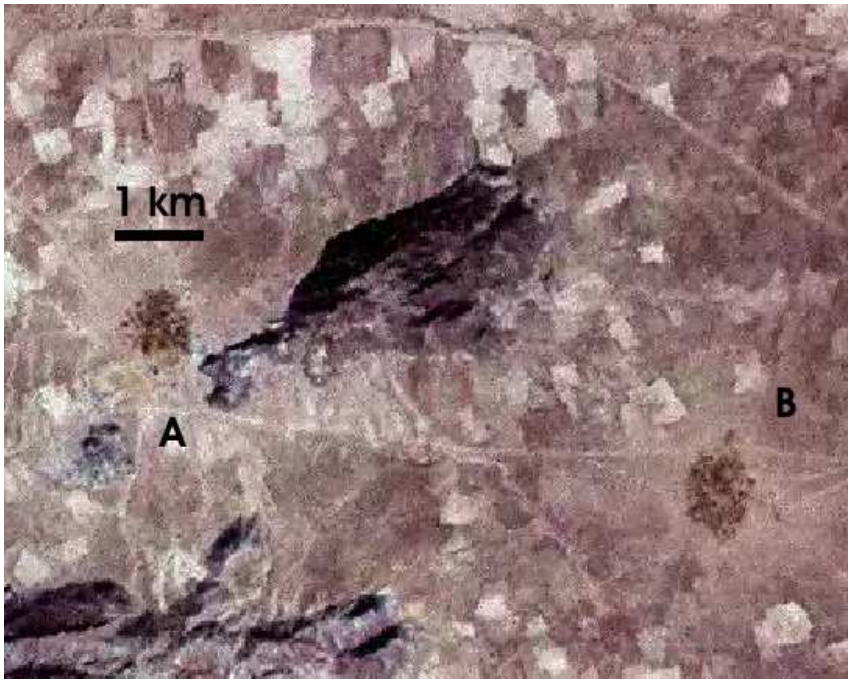

Figure 11. Landsat TM image from south west Sudan with 30 m resolution, two villages (a and b) can be seen as well as tracks and dirt roads leading to them. White segments are farm fields.

Visual interpretation versus digital analysis of images

Normally, very high-resolution satellite images are not image processed. Apart from image contrasting, they are commonly used for visual interpretation on screen or as backdrop in GIS were they can substitute aerial photos. They are often delivered geo-processed with an accuracy of approximately 5 m. Most of these images are uncomplicated to handle even for inexperienced people, as they also are available in TIFF format.

Digital processing of very high-resolution satellite images is currently under development. The higher the resolution of the imagery, the more man made objects can be identified. The human eye – the best image processor of all – can quickly detect and identify these objects. However, phenomena like shades, complicates the auto or semi automatic processing. Thus, handling the very high-resolution images requires an operator to identify objects and manually add them into the GIS database, which can encompass a rather big workload if the study area is big. The high-resolution images usually only cover limited areas and a swath (with along the track), which is usually 10-30 km. However, this image source does not need the same amount of verification as mid resolution images where the man made objects are not visible to the same degree.

Mid-resolution images as SPOT, Landsat and IRS are commonly digitally processed in order to calibrate, enhance information and/or for image classification where they are converted to a single thematic map (i.e. for forestry, crops etc) and can eventually be used for change detection. In some cases, differences can be extracted, although they in the original images look alike. An example of this is the Landsat based change detection analysis of burnt villages in Darfur (figure 7). Another advantage with mid resolution images is that they commonly cover larger areas (swaths are generally between 70 to 600 km) and are comparable cheep (look table 4).

Availability of data

Image data have been available for nearly tree decades, and until five years ago, it was commonly only research institutions and specialized companies who have been dealing with the data. However, the situation has changed since the increasing availability of very high resolution EO data. Now they can be acquired, downloaded, and paid by credit card through the Internet.

Main optical sensor systems

The listed table below contains available main optical sensor systems and those that are planed for the future.

System	launch	GSD m pan / ms	swath [km]	Details on internet
Larger optical space sensors				
SPOT 2 France	1990	10 / 20	60	http://www.spotimage.com
SPOT 4 France	1998	10 / 20	60	-
SPOT 5 France	2002	5 / 10 2.5 HRS 5*10	60 120	-
Landsat 7 ETM Damaged in 2003	1999	15 / 28.5	175	http://landsat.org/
Landsat 5 TM, USA	1986	28.5 MS	175	http://landsat.org/
JERS-1 Japan	1992	OPS 18	75	http://www.eorc.jaxa.jp/JERS-1/
MOMS 02 Germany	1993	4.5 / 13.5	37 / 78	http://www.op.dlr.de/ne-oe/fo/moms-02.html
MOMS-2P Germany	1996	6 / 18	48 / 100	http://www.nz.dlr.de/moms2p/
IRS-1C India	1995	5.7 / 23	70 / 142	http://www.dlr.de
IRS-1D India	1997	5.7 / 23		-
IRS P6 India Resourcesat	2003	5.7 MS	24 / 70	-
KOMPSAT-1 South Korea	1999	6.6 pan	17	http://www.kari.re.kr
CBERS-1 China + Brazil	1999	20	113	http://www.obt.inpe.br/index.html
CBERS-2	2003			-
Terra USA / ASTER Japan	1999	15 30 90 all MS	60	
IKONOS-2 USA SpaceImage	1999	0.82 / 3.24	11	http://www.spaceimaging.com

EROS A1 Israel Imagesat	2000	1.8 pan	12.6	http://www.imagesatintl.com
TES India	2001	1 pan	15	
QuickBird-2 USA DigitalGlobe	2002	0.62 / 2.48	17	http://www.digitalglobe.com
OrbView-2 USA OrbImage	2003	1 / 4	8	http://www.orbimage.com
FORMOSAT -2 (ROCSAT-2) Taiwan	2004	2 / 8	24	http://www.nspo.org.tw/e60/ menu0402.html
IRS-P5 Cartosat-1 India	2005	2.5 pan	30	http://www.dlr.de
IRS Cartosat-2 India	2005	1 pan	10	
ALOS Japan	2005	2.5 / 10	35 / 70	http://alos.nasda.go.jp/index-e.html
KOMPSAT-2 South Korea	2005	1 / 4	15	http://www.kari.re.kr
Resurs DK1 Russia	2005	1 / 2.5-3.5	28	http://www.sovinformsputnik.com
Monitor-E Russia	2005	8 / 20	94 / 160	-
EROS B Israel	2005	0.7 pan	14	http://www.imagesatintl.com/
EROS C Israel	2009	0.7 / 2.8	11	-
RazakSat Malaysia	2005	2.5 / 5	20	http://www.atsb-malaysia.com.my/news-eng.asp
CBERS 2B China Brazil	2005/ 2006	2.5 / 20		http://www.obt.inpe.br/index.html
CBERS-3 China Brazil	2008	5 / 20	60/120	-
CBERS-4 China Brazil	2008	5 / 20	60/120	-
WorldView 1 DigitalGlobe	2006	0.5 / 2		http://www.digitalglobe.com
OrbView 5 OrbImage	2006	0.41 / 1.64	15	http://www.orbimage.com/
THEOS Thailand	2007	2 / 15		http://www.skyrocket.de/space/ doc_sdat/theos.htm
Pleiades 1 France	2008	0.7 / 2.8	20	http://smsc.cnes.fr/PLEIADES/index.htm
Pleiades 2 France	2009			-

Table 1. Specification of larger optical satellite sensors and near coming missions.

ms = multispectral, pan=panchromatic.

Access to images is well organized by commercial companies. SPOT Image and Indian data is distributed over a net of commercial distributors. SPOT Image furthermore, got the exclusive distribution right of FORMOSAT-2. ASTER images are available on the web for a handling fee (50 US$) by US administration, who also distribute Landsat images. The not more active JERS-1 is like IRS and MOMS-images distributed via the DLR. The distribution KOMPSAT and CBERS is currently not developed but possible.

Private companies operate the very high and high-resolution systems IKONOS, QuickBird, OrbView, and EROS A1. The use is dominated by military, but the free capacity is commercially available. There are still 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. This is similar for most of the systems.

Satellite data can be acquired directly on the web where quick looks of archive images can be viewed for quality and clouds. They can be paid on-line by credit card and delivered by ftp or on a media like CD or DVD within 1-3 days. Especially, the high-resolution images, which use moveable sensors, need to be programmed. This is usually costly and can prolong the ordering process.

Main sites where data can bee acquired:

EROS:	http://www.imagesatintl.com
IKONOS and IRS 5 m:	http://www.spaceimaging.com
IRS:	http:/www.euromap.de / http://eoweb.dlr.de
Landsat and ASTER:	http://edcsns17.cr.usgs.gov/EarthExplorer/
QuickBird:	http://www.digitalglobe.com/
SPOT and FORMOSAT:	http://www.spotimage.com

Landsat data is available as reference data from the early 1970'ties. Local receiver stations can have the most comprehensive archives covering their geographic area. An overview of major receiving stations and their quick look programs are available on:

http://geo.arc.nasa.gov/sge/landsat/lptables.html or
http://landsat.gsfc.nasa.gov/groundstations/lgslist.html

High resolution optical sensors and small satellites

A higher number of optical satellite systems are announced (tables 1 and 2) and some of these are carried on small satellites. However, it should be noted that the proposed launch time often is delayed and some systems may disappear or the launch may fail.
So far, the data accessibility from the small satellites has not been easy since they have not been produced for international service.

However, the formation of the Disaster Monitoring Constellation (DMC) will probably improve the situation. The DMC satellites should be designed to a daily revisit anywhere in the world. The Idea is by sharing space and ground assets membership of the DMC consortium confers the benefit of access to a seamless global monitoring service. This should be possible with only a few satellites because they are designed to image a large area of up to 600 x 600km. All DMC Members agree to provide 5% of capacity free for daily imaging of disaster areas, and this data is channelled to aid agencies through Reuters AlertNet in the beginning of a crises. The DMC Consortium has agreed to consider participation in the International Charter for Space in Major Disasters, contributing daily imaging capability to fill the existing 3-5 day response gap. UK-DMC also provides data through an ESA project called RESPOND.

The DMC should distribute data through http://www.dmcii.com/

System	Launch	GSD [m] pan / MS	Swath [km]	Remarks	Internet
Small optical space sensors					
UOSAT 12 UK	1999	10 / 20	10 / 30	CCD arrays	http://www.ee.surrey.ac.uk/SSC/CSER/UOSAT/missions/uo12/
KITSAT 3 South Korea	1999	15 MS	50		http://krsc.kaist.ac.kr/english/res_kitsat3.html
Alsat 1 Algeria	2002	32 MS	600	DMC	http://www.sstl.co.uk/
BilSat 1 Turkey	2003	12 / 28	24 / 53	DMC	http://www.sstl.co.uk/
BNSCSat UK	2003	32 MS	600	DMC	http://www.sstl.co.uk/
NigeriaSat Nigeria	2003	32 MS	640	DMC	http://www.sstl.co.uk/
Announced small optical space sensors					
DMC China	2005	4 / 32	600	DMC	http://www.sstl.co.uk/
VinSat-1 Vietnam	2005	32 MS	600	DMC	
ThaiPhat Thailand		36 MS	600	DMC	
TopSat UK BNSC	2005	2.5 / 5	10 /15	free view direction	http://www.sstl.co.uk/
TDI X-Sat Singapore	2006	10 MS	50		
RapidEye Germany commercial	2007	6.5 MS	78	free view dir. 5 sat.	http://www.rapideye.de/

Table 2 . Operational and near-coming small optical satellite sensors.

Disaster Monitoring Constellation (DMC) design, distribution of data http://www.dmcii.com/

Processing and geo-registration, data formats and examples of commercial prices

Few satellite data sources are now sold (apart from archive data) without any geo-projection applied. Most satellite data can be acquired with a geo-reference applied to the images, so they more or less can be integrated into GIS systems as a map where other geo-registered map data can be overlaid and interpreted. However, the onboard geo-registration is more or less accurate, which commonly also is reflected in the data price. Landsat TM/ETM are often delivered with a offset of 50-150 m for the basic data, IKONOS with 15 m. Improvement of the accuracy to i.e. 20 m (from a map source) for Landsat data typically takes one days work.

Most data types can be acquired in the common graphic TIFF format, which give the opportunity to view the data in ordinary graphic programs. It should be mentioned that it does not take much more than a bit of IT flair and basic geographic knowledge to handle most images. Delivered as TIFF files with geo-coding they can be viewed in normal graphic programs or in easy to use free GIS viewers as ArcExplore. Prices on products and dealers can be found in table 1-4.

Satellite	Product	Resolution (m)	Area (km×km)	Price (US$)	Price per area (US$/€ km^{-2})
Landsat 4&5	Thematic Mapper	30 pan/MS, 120 thermal IR	183×172	From 600 € (Europe), 450 $ and less outside Europe	0.014 0.014
Landsat 7 (damaged)	-	15 pan 30 MS	183×172	275 to 600	-
Quickbird *Eurimage Price-list*	Pan-sharp	0,62 pan 2.45 MS	Smallest area: 25-km^2 archive 64-km^2 - new collects	Minimum 425 €, scene: 4352-12240 €	16 -45 €
SPOT Archive Before 2003 1,200 €/scene *www.Spot.com*	Level 1A,1B, 2A	10 pan/ 20 MS 5 pan/ 10 MS 2.5 pan/ 5 MS 2.5 MS	60×60 60×60,40x40 30x30,20x20 60×60,40x40 30x30,20x20 60x60	1900, € 2700, 2025 1350, 1020, 5400, 4050, 2700, 2040 8100	0.53 € 0.75, 1.27 1.5, 2.55 1.5, 2.54 3, 5.1 2.25
SPOT Programmed Priority Programming + 3100 €	Level 1A,1B, 2A	10 pan/ 20 MS 5 pan/ 10 MS 2.5 pan/ 5 MS 2.5 MS	60×60 60×60,40x40 30x30,20x20 60×60,40x40 30x30,20x20 60x60	2700, € 3500, 2825 2150, 1820, 6200, 4850, 3500, 2840 8900	0.75 € 0.75, 1.77 2.39, 4.55 1.72, 3.03 3.89, 7.1 2.47
IRS-1C&D *Eurimage Price-list*	System corrected Carterra 5-P	27 MS 5 pan	140x140 70×70 70x70	2,700 € 1,700 2,500	0.14 € 0.35 0.51
EROS 1a	Pan	1-1.9 pan	14 x 14	Minimum 125 $	From 5
IKONOS 2	Geo-product with 15 m accuracy	1 pan/4 MS/ 1 pan/4 MS/		Min. 50 km^2 Min. 100 km^2	Archive 16-18 $ New 21-23 $

Table 3. Examples of imagery costs and coverage. Pan: panchromatic, IR: infrared, XS: multispectral SPOT, MS: multispectral.

Shutter control

The phenomenon shutter control refers to governments who have made use of their power to temporarily or permanently forbid companies based on their territory to sell images over particular geographical areas. The Russian government, for instance, has more or less permanently refused to sell high-resolution images of North Korea, China, Serbia, Bosnia, and Russia. Also worth noticing, is that *The American Israel Public Affairs Committee* successfully lobbied in the White House for an exemption that forbids US-based satellite companies to sell images of any place in Israel with a resolution better than what is routinely available from commercial sources. Further, during the first Iraq crises it was difficult to get programming time on SPOT data etc. However, with the evolving market the phenomenon is likely to decrease or more or less disappear in the future.

Legal issues - Copyright rules and data share

Copyright rules are rather strict for most EO data. Apart from older Landsat data that can be freely distributed the general terms are becoming stricter as the spatial resolution increases. Down listed is a part of SPOT data copyright, uses, and restrictions which exemplifies the rules that is quite similar to those of Quickbird, IKONOS and other high and very high resolution images.

"COPYRIGHT, USES, RESTRICTIONS. The SPOT Data is owned by SPOT Image Corporation or its suppliers and is protected by United States copyright laws and international treaty provisions. Therefore, you must treat the SPOT Data like any other copyrighted material except that you may make copies of and/or provide access to the SPOT Data solely for the purpose of facilitating use by the licensed entity.

- *You may copy the written materials accompanying the SPOT Data solely for use by the licensed entity.*
- *You may analyse, process, and display the licensed SPOT Data and may make such SPOT Data and the results of such analysis or processing available to employees of your organization.*
- *You may make an unlimited number of print and internet display copies of the SPOT Data for use outside your organization, provided that: (1) all copies include the copyright notice prominently displayed in or adjacent to the SPOT Data; (2) you may not sell any copies made for such purposes; and (3) you prohibit and prevent this data from being downloaded or screen captured by individuals or organizations located outside of the licensed entity.*
- *You may prepare textual reports and other non-image materials based upon the licensed SPOT Data and publish or distribute such materials, but only if such materials do not reproduce in any way the licensed SPOT Data. You may not sell or otherwise commercially distribute any such textual reports or other non-image materials, which are developed from the licensed SPOT Data.*
- *You may make the licensed SPOT Data available to contractors and consultants, but only for use on behalf of your organization, and only if each such person agrees in writing (a) to be bound by the same limitations on use as apply to you; and (b) to return to you all SPOT Data upon completion of the contracting or consulting engagement."*

The rules and policy may change from one place and seller to another; i.e. in USA, the data policy is generally softer than in Europe. It further seems as when the GSD decreases the restriction of the use increases. Thus NGO's should especially be aware of the copyright notice prominently displayed in or adjacent to the image data when it is published in reports and high resolution images can normally not be distributed around as such if they have been acquired as single user license. Copyright rules are available on the web from the image data provider (table 1).

Current technical state and prospects

Availability of image data sources – status and trend

Available space images have a spatial resolution that is coming close to aerial photogrammetric. They are in an increasing numbers becoming available on the Internet or through networks of service providers - even if some countries still try to restrict it.

The required technical knowledge has formerly been limiting the imaging satellites to a few countries. Today you can order whole systems on the open market. The same is true for the small satellites, thus, the price for a satellite system including launch and ground station today may be in the range of 10 million US$ (Jacobsen 2005).

There is a general tendency in the development of high-resolution optical space sensors. The resolution is improving and the new systems have a flexible view direction, which means a significant shortening of the revisit time. This means that we today have means to a daily coverage of high-resolution images as well as medium resolution images. However, the cloud factor should not be ignored.

Recently USA has made contracts with the space companies Digital Globe and OrbImage for operating satellites with at least 50 cm GSD in the panchromatic range. More and more countries are entering the field of commercial very high-resolution optical systems. The USA, India, Israel, France, South Korea, and Russia will support a GSD of at least 1m in 2005. Up to 2.5m GSD in addition there are Malaysia, China, Brazil, Thailand and the UK.

Timing and cost – status and trend

Prices on high and very high-resolution images are still high and Digital Globe and OrbImage currently dominate that market, but as distribution of the new systems will become available, the prices are likely to drop.

Archive data are already available on the Internet where they can be ordered by credit card and transferred within 1-3 days, even though archives of high-resolution images are far from complete on a global scale and are so far focused on urban areas.

Fresh high and very high resolution images will normally need programming of the satellite which increases the price and the delivery time from few days to week, but in the coming years with the much higher data coverage both delivery time and costs are expected to decrease.

International initiatives for using EO to document humanitarian crisis

Ten years ago, satellite image data beyond metrological use was traditionally only used by selected research institutions with limited applications. This situation is changing at a high speed. Over the past 5 years, the use of satellite imagery has increasingly been put into frames by international organisations.

Recent institutional development

In 2003, thirty-three nations plus EU adopted a declaration that signifies political commitment to move toward development of comprehensive, coordinated, and sustained earth observation systems. The initiative is an outcome of the World Summit on Sustainable Development in Johannesburg 2002 and the G8 meeting in June 2003, which affirmed the importance of EO as a priority activity. As a result an ad hoc intergovernmental Group on Earth Observation (GEO) have been established which have initiated a 10-year implementation plan of a more international or global use of EO data. In 2004, GEO expands to 43 countries, EU and 25 international organizations to form Global Earth Observation System of Systems (GEOSS) which in 2005 have formulated a 10 year plan to the establishment of operating systems, principles and institution build up in relation to GEOSS. In other words, it is an initiative that will aim at establishing worldwide systems or approaches to cover monitoring of environment and security by EO data. However, spotting of humanitarian right abuses has so far not been mentioned as thematic themes and can only weakly be identified in the main thematic themes.

EU's major contribution to the GEOSS will be through the joint European Space Agency (ESA) /European Commission initiative of the GMES[1] (Global Monitoring for Environment and Security). GMES can in some respect be regarded as a European forerunner for GEOSS. GMES have established 8-12 service elements covering main themes of environment and security, including RESPOND, which is a service element for the humanitarian-aid community. According to ESA (Bally *et al*, 2005) the RESPOND services will be an EU contribution to the GEOSS, which give some perspectives for the future in terms of how services will be organized.

In the following text, main centres and activities will be described with special relation to use of EO data and humanitarian crises and abuses.

[1] GMES will define and implement systems that use advanced information sources and systems to place useful information in the hands of citizens and European Institutions. The GMES initiative seeks to bring together the needs of society associated with the issue of environment and security with the advanced technical and operational capability offered by terrestrial and space borne observation systems. It is a direct response to the growing concerns amongst policy makers to ensure access to information on the environment at global, regional and local scales without sacrificing independence in the relevant policy areas. http://www.gmes.info/

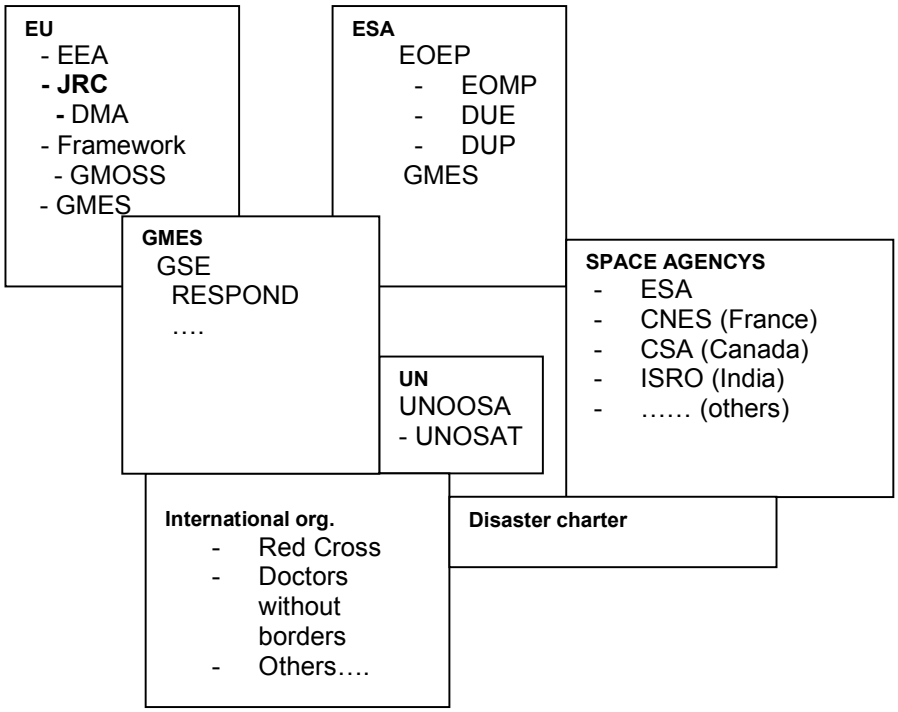

Figure 12. International initiatives and involvement of organizations in major program/projects that involves EO and humanitarian disasters. Overlap indicates that the father organizations are in the background; contact between boxes means they are part of project / programme.

International Charter on Space and Major Disasters

The *'International Charter on Space and Major Disasters'* (http://www.disasterscharter.org) has been operational since 2000. The aim of the charter is to provide a unified system of space data acquisition and delivery to those affected by natural or man-made accidental disasters through authorized users. It is a European initiative, which includes specialized UN agencies, in addition to national emergency authorities. The charter works with emergency 24 hours on-call officers to reflect on any incoming information from users. In mid 2005, the charter has been activated more than 80 times for 65 different disasters. As such, the charter does not handles political/human conflicts that lead to human right abuses, although, the technical setup could very well be used for documentation of human right abuses

EU and ESA

Traditionally ESA has been the leading independent organization for space technology in Europe. EU has also been very active especially through scientific framework programs. However, EU and ESA seem to be moving closer to each other in terms of programs and policy.

ESA

Over the years, ESA have established some working relationship with key humanitarian organizations through Earth Observation Envelope Programme (EOEP) i.e. from the DUP[2] HUMAN and the EOMD[3]

[2] The Data User Element (DUE) is established to encourage the establishment of a long-term relationship between user communities and Earth Observation. The DUE has now been integrated in the second period of EOEP, covering the time frame 2003 to 2007. http://dup.esrin.esa.it/about_due.asp

UNOSAT projects, which have matured into RESPOND. EOEP is development and research programs within ESA, where definitions and methods are formed that eventually can be established as a GSE. Currently, there are two projects with relevance to human right crises.

ESA – EOMD – UNOSAT

The UNOSAT project is a long-term market development activity, which addresses thematic mapping for humanitarian aid and international development. UNOSAT is lead by the United Nations Office for Projects Services (UNOPS).http://unosat.web.cern.ch/unosat/

ESA – DUE – EPIDEMIO

EPIDEMIO is an ESA Data User Element (DUE) project with the objective to demonstrate uses of EO data in the context of support actions to reduce epidemic diseases in Africa. The project aims at displaying risk zones by modelling of data from EO data and knowledge of the spread of epidemic diseases. The scope of the project is that satellites open up new opportunities to predict and help combat epidemic outbreaks, as well as joining the hunt for the origin of pathogens.
http://www.epidemio.info

RESPOND

RESPOND is a consortium of European value-adding companies and public agencies involved with geo-information and especially EO to support humanitarian aid including humanitarian crises and abuses. The RESPOND consortium (http://respond-int.org/) is a GMES Service Element (GSE), and is established as a network of organizations and agencies such as the European Commission, Joint Research Centre, UNOSAT, and the German space agency, AlterNet from the Reuters, Non-Governmental Organizations (NGOs), and aid agencies. RESPOND is established to provide updated map products across the range of humanitarian actors: from the UN to a small NGO, from headquarter buildings to the crisis zone. They should react to crisis and provide up to date mapping covering relevant parts of the crisis cycle - thematic information relevant to the crisis i.e. refugee camp location and damage mapping.

The service providers are paid by funds that have been made available to the project by national contributions to the GMES. The present project is about to go into second phase, which eventually will expire in 2008. RESPOND seems to be a first step towards a sustainable set of services offered by an open service partnership that includes some 20 international members. At present, the services are provided for free for members of the consortia who also internally will evaluate which cases that will be serviced. In the long term it is the idea that the services should be paid or partly paid by users depended on agreements made with organizations to contribute to this service.

EU

Apart from the joint GMES initiative with ESA, EU supports several EO projects through their research frameworks. It is the general idea that applications developed through the framework projects should be included into the GMES services. Some of these have directly relevance for development of tools to monitor human right abuses. However since the WTC attack and recent Madrid attack, the European Commission has launched a research program named "*Preparatory Action in the field of Security Research PASR - Research for a Secure Europe*" and more effort have been put into establishment of EO based measures to increase the security. Recently there have been established a panel (SPASEC: Panel of Experts on Space and Security) for identification of leaks and needs in EU's capabilities within space and security (EU 2005). One of the main recommendations of this report is an identification of potential users and production of user networks so actual needs can be identified. Included are

[3] Earth Observation Market Development (EOMD) (http://www.eomd.esa.int/) is an element of activity within the ESA EOEP which runs from 2003 to 2007. The purpose is to strengthen Europe's industrial capacity for providing geo-information services, based primarily on EO data, within Europe and beyond.

humanitarian right abuses and conflicts. However, the program also involves military interests and how these can be linked with the human rights watchers is an open question.

GeoCrew - Study on Crisis Management and Situation Awareness Centre – A PASR program

The GEOCREW is a project under PASR, established to formulate structures for early crisis detection. The study will develop a concept for an early warning situation awareness architecture, which will integrate different information sources (e.g. geospatial intelligence data, open sources and other intelligence information). It especially aims at identifying contributors, users with functional and information requirements throughout the EU. The results of this study should be available at the end of 2005. Contact point Jürgen Wiess, tell: + 49 89 9216 2300

EU Joint Research Centre Ispra - **Institute for the Protection and Security of the Citizen**
JRC institute IPSP, is involved in several project for developing EO applications for crises management. They provide information to several EU DG's and especially through their EU Frame work 6 project: Information Support for Effective and Rapid External Action (http://dma.jrc.it/isferea) , they are contributing to development of applications for GMOSS and RESPOND and have following users: Council of Europe, World Bank, UNDP, United Nations High Commissioner for Refugees (UNHCR), WFP, FAO, OCHA and EU Member States. One of the main activities is development of the Global Crisis Atlas which is Web based containing satellite image analysis and/or geo-spatial analysis. The Global Crisis Atlas maintains baseline information as well as security related such as disputed borders, conflict areas, and security events in conflict areas

GMOSS

Global Monitoring for Security and Stability **-** http://gmoss.jrc.it
GMOSS deals with the technical application side of EO and is a network in the aeronautics and space priority of the sixth framework program. The project is mainly dealing with development of analysis methods for high resolution images i.e. feature recognition, change detection algorithms, and software. The aim of the GMOSS network is to integrate Europe's civil security research so as to acquire knowledge and expertise to develop global monitoring using satellite earth observation. The working area includes development of tools that can be used for EO monitoring of humanitarian crises and abuses. I.e. rapid remote assessments of damage of buildings, monitoring of international treaties protecting against proliferation of weapons of mass destruction.

GMOSS will run until 2008 and initially consists of 25 organizations from the public and private sectors. The joint program of research will aim to meet the priorities of users from the civil security sector. The project is open for associated partners and potentially NGO's that have interests to be involved (contact: Hans-Joachim.Lotz-Iwen@dlr.de).

UN

As mentioned above UNOSAT is a United Nations initiative from 1999 to provide the humanitarian community with access to EO data and GIS services. UNOSAT is made for servicing UN organizations and NGO's as long as they comply with UN policy. UNOSAT is not a project as such but meant to be a permanent undertaking. They further have several free map products that can be found and downloaded from their website www.unosat.org. Their services for i.e. NGO's are running on a project basis, which they are able to offer on a cost price by using reduced rates for some data sources, and by providing no overhead on their working hours.

National Programs

The "Centre for Satellite Based Crisis Information" (ZKI) is a service of DLR's German Remote Sensing Data Centre (DFD). The Centre seems to be the most developed national centre for rapid acquisition, processing, and analysis of satellite data and the provision of satellite-based information products on natural and environmental disasters, for humanitarian relief activities, as well as in the context of civil security. The analyses are tailored to meet the specific requirements of national and international political bodies as well as humanitarian relief organizations. ZKI operates in national, European and international

contexts, closely networking with German public authorities at national and state levels (crisis centres, civil security, environmental protection), nongovernmental organizations (humanitarian relief), satellite operators and space agencies. ZKI also undertakes the German involvement in the "International Charter on Space and Major Disasters." Info: http://www.zki.caf.dlr.de, mailto:zki@dlr.de

Concluding remarks on international initiatives for the use of EO data

Research into the use of EO for documentation of humanitarian crisis and development of tools for human right conflicts are mainly carried out within EU frameworks and ESA development programs, which are open for participation of NGO's.
There is a current trend in the formation of EO centres, where many international actors are represented. Centres with thematic themes of EO are already established on regional scale and formulations of are under way for global centres. However, many centres covers humanitarian disasters / crises but only few human right abuses!

Notes on what to do when EO images are needed

The following considerations are made for NGO's who want to use EO data for advocating human right abuses – and want to acquire the service from a centre or a service provider. The description includes notes on workflow from first information on humanitarian crises to remote sensing documentation: What to consider, who to contact, how fast and cost issues.

Usability – collect information on indicators

NGO's have several opportunities to gather information's about an evolving humanitarian crisis through ReliefWeb or AlertNet but it is more likely that their own networks will inform them.

As a first step a NGO has to filter the information that they receive from the field and consider what the actual conflict consist of and consider what kind of potential evidence it can leave on the ground that could be observed from the sky (look above for indicator examples). Further, to facilitate the discussion with a given service provider and reduce the effort/cost it has to collect precise information on locations, including site names and/or preferably geographic coordinates.

Consideration on how fast the service can be provided

- High resolution images can be acquired relatively fast in some cases within some days, however, reference data to compare with may not be available and have to be recorded first, unless the images are self-explaining.
- Medium resolution images are available from archives and new can be acquired; however, processing and change detection can take some weeks to carry out.

Consideration on prices

Consider a budget for the cost of the study/analysis - prices on data is indicated in table 4.

- High-resolution images are still costly. Processing will normally not be more than the data price but they cover only limited areas and the price of the raw data per km^2 is high and handling of many 'small' images can be an expensive project.

- Medium resolution images are comparable cheep but can have processing requirements of 5-20 times the data price.

Consideration on data share and copyrights

Restriction on data share is somehow following the resolution of images. High-resolution images are typically limited to the use of the buyer, who optionally can buy multi-seated licenses for more users within an organization. Display in reports etc. is allowed provided the data source is mentioned. It can only be recommended to look carefully into the rules.

Communication with service providers and centres

Currently EO services can be gathered from various sources on the free market (ESA registered companies within geo-hazard and risk management) including the above-mentioned centres. Some service providers have 24 hr respond 7 days a week.
It can be recommended to get more than one offer for a service and further investigate if one of the centres is willing to provide the service free or at reduced price.

CENTERS

Currently there are two major international centres that service human right abuses.

RESPOND
Project Manager: Lars Holledig: +44 (0) 1252 362051, Lars.Holledig@infoterra-global.com
Technical Officer: Morwenna Bradly:+44 (0) 1252 362070, Morwenna.Bradly@infoterra-global.com
www.infoterra-global.com

UNOSAT
Phone: +41 22 767 4020 (UNOSAT Managers – Einar Bjorgo for Human right conflicts)
Fax: +41-22-917 8062
24/7 hotline: +41-76 487 49 98
e-mail: info@unosat.org

SELECTED COMPANIES

There are many companies that provide EO services. The selected down listed companies have carried out services with direct relation to human right abuses.

PRINS Engineering Denmark
Telephone +45 4586 8518 / + 45 2621 8518
Web Site http://www.prinsengineering.com
Contact Email prins@c.dk

SERTIT France
Telephone +33 (0)3 90 24 46 47
Web Site http://sertit.u-strasbg.fr
Contact Email kader@sertit.u-strasbg.fr

VTT Finland
Telephone + 358 9 4561
Web Site http://www.vtt.fi / http://www.vtt.fi/tte/research/tte1/tte14/
Contact E-mail Tuomas.Hame@vtt.fi

Infoterra
Email: info@infoterra-global.com
Phone: +44 (0)116 273 2300
Web Site http://www.infoterra-global.com/

Participation in ESA research projects

ESA funds research and development projects (i.e. ESA DUE) for establishment of EO methods. These are formed as consortia's where NGO's in principle can participate if the projects are formulated to cover human right abuses.

Conclusion and Recommendations

Scoop of using EO data for documentation of human right abuses

EO data is a highly valuable data source for documentation of human right abuses. It will provide evidence on what are happening in 'no go' areas. The satellite images are spectacular and have a huge effect in the media – it can so to speak engage the witness situation to the viewer.

Usability

EO data can document various sorts of human right abuses that leave evidence on the earth. The details of available high-resolution images are good enough to visually document burning of huts or counting of tents in refugee camps. Most examples are related to destruction and/or burning of houses or other human constructions, spontaneous established refugee camps, or anomaly in land use patterns as a reflection of instability. Tracing of campfires by thermal sensors is another operational service. Development of applications or EO methods to document human right abuses will evolve in the future when new cases appear. More data that are available, EO sources and GIS data will further facilitate the process.

The use of multi-spectral satellite data further enhances the possibility to derive indicators from EO data. Even objects hard to observe on the ground can be detected from the sky. Verification is an important part of the use of EO data, weathers high and very high-resolution images are more or less self explaining the mid-resolution images and digital analysis requires more 'ground-truth' information to form a solid argument in the case of human right abuses.
<<<<<<<<<<<<<<<<<<<<
In general, on a larger scale NGO's do not have the capacity to carry out test and develop methods of EO imagery. however, they have the option to participate in development programs thorough i.e. ESA and EU frame work programs on aeronautics and space together with research institutions and service providers.

Technical status / availability of data

When the internet just came up it was only used by nerds, here 15 years later everyone has a Web site. It looks like EO imagery is going to take a similar evolvement - before single governments could decide what they want to show the public from crises areas, today everybody can acquire high resolution EO images on the web – a development that just started few years ago and will expand with the increasing amount of images that will be available. Driven by technical advances that have enabled the creation of complete packaged of satellites systems for as little as $10 to 20 Million has resulted in at least 14 countries have mid to high resolution satellites in orbit and by the end of the decade there will be 20. For the moment, there is approximately 30 operational high and mid resolution sensor systems producing daily coverage and by the end of the decade there will be 20 more. All of the data are from open sources, and defined as civil systems; the majority of the systems have web sites that contain detailed descriptions of the satellites and their sensors. By Googling, they are easily found and locate relevant news items. Data availability is provided on the web sites or through well established reseller, network and most images can be delivered in graphic formats so they can be viewed in common graphic PC packages or easy-to-learn GIS viewers or programs.

Prices and copyrights

Prices on the commercial market for high resolution images is still probably more than most NGO's are willing to pay - at least if documentation encompass of human abuses on a larger scale where many high resolution images will be required. On the other hand use of mid resolution EO data is an alternative where the data is an economic attractive solution which covers large areas in one image. However, it takes experience to enhance information that is not directly visible in the images and require higher demands for ground verification.

Over the past decade, we have seen the Americans dropping their prices of Landsat data in 1999 to approximately 1/10 or equivalent to production cost. High resolution images are still expensive, especially if they are ordered as rush service, here prices like 3000 € for image data can be expected for even small areas off less than 100 km^2. Archive images can be acquired for approximately a third depended on the

source. The market is currently dominated by two suppliers; however, this is likely to drop in near coming future with the launch of 13 new sensor systems with resolution below 2.5 m GDS.

Copyright rules are still rather strict - especially for high resolution, images and it can only be recommended to read the individual rules carefully before distribution of any product. However, as it has gone for prices on mid-resolution Landsat data, the copyright rules has also been soften, and with the current development of available high resolution images there is reasons to believe that the copyright rules will be soften in time.

Centres and service providers

With the support from EU, ESA, national governments and UN, there have been established several centres, dedicated to provide service for documentation of human right abuses. Currently, these centres are primary supported by national funds, which in the case of RESPOND are canalized out through the ESA/EU GEMS Service Element (GSE), to provide services to formalized users. So far, during the 'demonstration' phase, the service has been free of charge, however services are planned to be charged in the near coming future and will gradually increase towards the end of the GSE in 2008[4]. The ESA initiative UNOSAT is established to service UN organizations by taking care of EO and early warnings and crises respond including documentation of human right abuses. UNOSAT looks like a permanent undertaking which will service UN organizations but also carry out projects for NGO's at cost price.

There is for the moment some discussion between major organizations and data providers on the policy of future data availability. The formation of the International Charter "Space and Major Disasters", in 1999 where the major space agencies are participating, the image products are provided for free for the registered users, however, the charter doesn't encompass humanitarian abuses. Following the advice of the world summit in 2002, initiatives have been taken to integrate EO into centres like the GEO, GEOSS, and IGOS with common themes and strategies. So far, it has not been possible to identify any centres that clearly formulate human right abuses as a theme.

Through the various service providers and centres, and the current development in available sensors from various states - it should be possible to get high resolution imagery to document of human right abuses from a host of independent sources that is not longer and with the current technological development the service can be provided within days.

Recommendations

As long as there is no international funded EO centre to spot human right abuses and NGO's have to use the free market to require EO documentation – it can be recommended to gather offers from several service providers.

Gather the humanitarian NGO's involved in documentation of human right abuses to formulate common strategies for EO applications for spotting of humanitarian abuses.

Create an atmosphere or frame where NGO's, donor organizations, data providers and EO researchers can co-operate. The optimal situation is formation of a centre or a theme within the centres that are currently under development that will service EO documentation of human right abuses.

Large NGO should increasingly participate in research programs i.e. under EU or ESA to establish acknowledged methods that eventually could be adopted in charters and centres.

There is still a lot of research and development within the field of documenting human abuses by EO data – these will most likely be developed and tested when new crises arises. In the case of a new crisis, it can

[4] Lars Holledie/RESPOND project manager personal communication 20 Sep. 2005.

be useful to have a forum of EO experts who can interpret the situation and suggest analysis/ documentation methods.

Acronyms and definitions:

DLR = Deutsches Zentrum für Luft- und Raumfahrt
EC = European Commission
EO = Earth Observation
EOEP = Earth Observation Envelope Program
ESA = European Space Agency
EU: European Union
GEO = Grope on Earth Observation
GEOSS = Global Earth Observation System of Systems
GMES = Global Monitoring for Environment and Security
GMOSS = Global Monitoring for Security and Stability
GSD = Ground Sampling Distance
GIS = Geographic Information Systems
GSE = GMES Service Element
HALE = aerial images coming from High Altitude Long Endurance
SAR = Synthetic Aperture Radar
SPASEC = Panel of Experts on Space and Security
TDI = Time Delay and Integration
UAV = Unmanned Aerial Vehicles

Bibliography

Bally P, Béquignon J, Arino O and Briggs S 2005: Remote Sensing and Humanitarian Aid. ESA bulletin 122 - may 2005 Directorate of Earth Observation Programmes, ESRIN, Frascati, Italy.

Dorn W. H. 1987: Peacekeeping Satellites for the United Nations. Peace Magazine Dec 1986/Jan 1987, p.32. http://www.peacemagazine.org/archive/v02n6p32.htm

Bhupendra, Jasani 1991. 'Outer Space A Source for Conflict or Co-operation?'. Tokyo; United Nations University Press, pp. 42-43

Bjorgø, Einar 1999: *Use of Very High Spatial Resolution Satellite Sensor Imagery in Refugee Relief Operations* (Dr. Scient thesis defended at the Nansen Environmental and Remote Sensing Center, University of Bergen, Norway, July 1999).

EC 2005: REPORT OF THE PANEL OF EXPERTS ON SPACE AND SECURITY
March 2005 Space and security panel of experts Project Number: 200446
http://europa.eu.int/comm/space/news/article_2262_en.html

Giada, S; T De Groeve; D Ehrlich; P Soille 2003a: Can satellite images provide useful information on refugee camps?. International Journal of Remote Sensing, Vol. 24, Number 22, November 20, 2003, pp. 4249-4250(2).

Giada, S; T De Groeve; D Ehrlich; P Soille 2003b: Information extraction from very high resolution satellite imagery over Lukole refugee camp, Tanzania. International Journal of Remote Sensing, Vol. 24, Number 22, November 20, 2003. pp. 4251-4266 (16).

Grunewald, François 2000: “From Airborne Images To Ground-Truthing In Turbulent Times ; From Military Purposes To Citizen Control: Potentials, Myths And Dangers Of New Satellite Technologies From The Ngo Perspective” A Contribution To The Conference “The Use Of Satellites And Integrated Technologies For Humanitarian Purposes” 19 - 20 September 2000 Varese, Italy.

K. Jacobsen 2005: High Resolution Satellite Imaging Systems – Overview. University of Hannover. jacobsen@ipi.uni-hannover.de

Lane, Charles, and Shanker, Tom, 'Bosnia: What the CIA Didn't Tell Us', *The New York Review of Books*, 9 May 1996.

Stix, Gary, 'Public Eye', *Scientific American*, August 1996, at
http://www.sciam.com/0896issue/0896scicit01.html

Vulliamy, Ed, 'Bosnia: The Crime of Appeasement', *International Affairs*, Vol. 74, No. 1 (January 1998).

Willum, Bjørn (1999) From Kosovo to Chechnya, Selling Images from Above. Christian Science Monitor (USA) November 30, 1999

Internet References

ASTRONAUTIC, Malaysia: http://www.atsb-malaysia.com.my/news-eng.asp

Digital Globe: http://www.digitalglobe.com/

DLR – German Aerospace Center: http://www.dlr.de/

Federation of American Scientists, *'Public Imagery Intelligence'*, http://www.fas.org/eye/imint.htm

Federation of American Scientists, *'Imint Overview'*, at
http://www.fas.org/spp/military/program/imint/overview.htm

ImageSat Intl.: http://www.imagesatintl.com/

ISRO: http://www.isro.org/index.htm

ITC Launch schedule: http://www.itc.nl/research/products/sensordb/Launch_Schedule.aspx

NASA Space Warn Bulletin: http://nssdc.gsfc.nasa.gov/spacewarn/

NATO imagery of burned houses: http://www.fas.org/irp/imint/bosnia.htm

NATO web site http://www.nato.int/kosovo/all-frce.htm

NSPO: FORMOSAT-2 Spacecraft: http://www.nspo.org.tw/e60/menu0402.html

JAXA EORC: http://www.eorc.jaxa.jp/en/index.html

KARI, Korea Aerospace Research Inst.: http://www.kari.re.kr/

Orbimage: http://www.orbimage.com/

RapidEye: http://www.rapideye.de/

RADARSAT International.: http://www.rsi.ca/

Sovinformsputnik: http://www.sovinformsputnik.com

SpaceImaging: http://www.spaceimaging.com/

SPOT Image: http://www.spotimage.com

SSTL: http://www.sstl.co.uk/

Stoney, W.E., 2004: ASPRS Guide to Land Imaging Satellites, http://www.asprs.org/news/satellites/