

# Earth Observation as an Intrusive Eyewitness in Conflicts and Crises

## Dispatch no. 6 (10)

**Earth observation images obtained from satellites and the subsequent image processing and analysis have become an important tool for a comprehensive understanding of the Earth of today, not least in the realm of security. Image data has also become increasingly accessible to the public as well as to the security research community. Both software and hardware for handling huge volumes of data are affordable today. The following describes some of the methods that can be used in an integrated security analysis and the benefits.**

### **An Integrated Security Analysis Approach**

The combination of conventional and human security covers a wide spectrum of threats to safety. These threats typically cover anything from natural hazards such as earthquakes, floods and droughts to human-inflicted threats like terrorism, small arms proliferation and crises started by civil wars or state failure. From a geographical point of view these security threats vary hugely in location and scale as well as in time. While some threats appear suddenly others develop over the longer term. An earthquake at the bottom of the sea can affect large coastal areas on several continents and may give rise to a need for international aid in years to come. Similarly an attack by terrorists will probably be a sudden surprise although physically it will affect only a limited area. The political and social impact of the terrorist attack, on the other hand, may well spread around the globe.

In contrast to these rapid events, human security threats can evolve slowly and have an increasingly greater impact on the population and the society at large. Such slow-moving developments have conventionally been much more difficult to detect. Consider for instance the ongoing global climate change—a slowly evolving threat to states, societies, ecosystems and human security that needs to be monitored globally over many years if it is to be analysed correctly. The proliferation of small arms and large-scale deforestation are two examples of human-inflicted issues that also affect the security of society in the long term. Both short-term and long-term threats need to be mastered in any conflict- and crisis-sensitive security analysis. This suggests that an integrated security approach is a useful framework.

### *Using satellite monitoring systems*

The monitoring and analysis of threats to the state, societies, ecosystems and individuals as described above, and the subsequent need for support to possible rescue and reconstruction operations, require tools adapted to the very nature of the security threats—that is, instruments capable of covering and detecting security threats on a global level

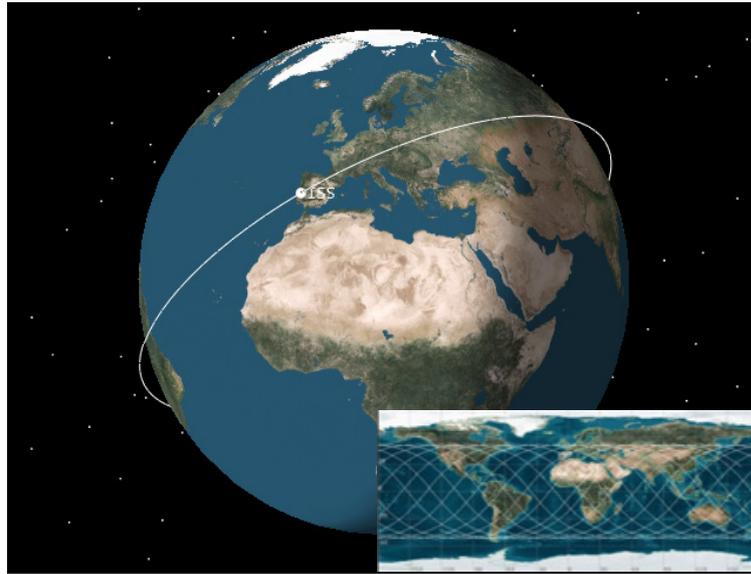
and at the same time with a capacity to provide reliable information for security analysis at the correct time and on a “24/7” basis. The satellite-based earth observation technology and the follow-on analysis tools such as image processing and geographical information systems (GIS) have increasingly come to play a vital role over the last decade. Satellite earth observation technology provides security analysts with an instrument applicable on a global basis, assisting them with fast and untampered information.

### **Satellite Orbits and Fundamental Features of Earth Observation**

An important characteristic of satellites is that they move in predictable space orbits around the globe due to the interaction with the Earth’s gravity, as illustrated in image 1 below. A fundamental feature of satellite-based earth observation that has changed the concept of information flow from crisis areas is the fact that the images are unbiased physical measurements that display the situation on the ground “as is”. Provided that the security analyst has full control of the image tasking and image production, satellites show an objective view of a crisis situation that normally could be closed for the world.

### *Challenges for earth observation*

At the same time it is important to understand the limitations of satellite-based earth observations. Earth observation data only gives a snapshot of what the crisis situation looks like at a specific time. Thus, an image presents what has already happened, be it a gradually increasing global climate change, deforestation or an erupting ethnic cleansing crisis. The interpreter of the images therefore needs to be able to recognise the changes by comparing images over time to understand the course of the security threats—a course which in turn could give an indication of the driving forces, as well as the ambitions and motives of those involved if it is a human-inflicted security threat. However, to understand this, there is a need for an integrated approach to security.



**Image 1:** An orbit of a satellite at low altitude. The orbit plane is not polar and thus the satellite does not cover the globe at high and low latitude. The inset displays the corresponding track on the ground over a particular period of time. Image: FOI.

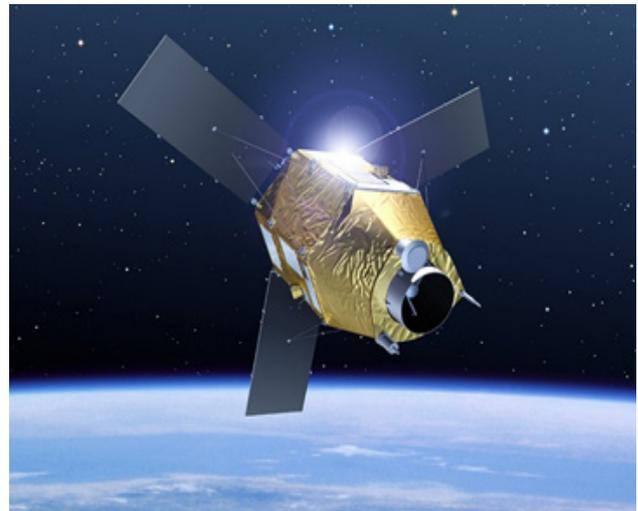
### Prerequisites for Security Assessments based on Earth Observation

The discussion above implies some special considerations when it comes to using earth observation in security assessments. First, the satellite system used should be under the full control of the user, from the ordering of images to the processing and analysis of the data. Second, the earth observation system used should be able to provide the user with the data required and when it is wanted. Access to the data should not be restricted in any way, whether geographically or in a time sense.

Today these requirements are fulfilled not only by the intelligence community, but also by civilian governmental and non-governmental organisations. In a revolution in satellite geospatial intelligence, an increasing number of public actors now have access to vital satellite capacity. For example, the Swedish Defence Research Agency (FOI), under a special agreement between the French space agency Centre National d'Etudes Spatiales (CNES) and the Swedish National Space Board Authority (SNSB), has access to an earth observation satellite system called Pleiades. The satellite system is designed for both civilian and military users and especially suited for rapid response for the detection of changes in a short time. Some of the features are:

- It offers a daily revisit to any point on the globe.
- Based on three programming plans per day the system offers late order requests.
- Data is downloaded from the satellite to the Esrange receiving station in northern Sweden.

- Users can access a search archive to browse through old archived data for comparison with the current security situation.



**Image 2:** Pleiades is an optical observation system consisting of two identical satellites that deliver 50-cm colour images. Credit: CNES.

The agreement with SNSB gives FOI and other Swedish institutional users a unique, controlled, fast and untampered access to earth observation data at low cost. Moreover the agreement gives FOI the right to order the satellites to record images within a specific time frame. That is, the security specialist can act proactively and receive data from an area during a future time period he or she predicts will be of interest for the analysis of the crisis.

### Benefits of Satellite-based Comprehensive Security Analysis

A wide variety of conceptual frameworks and methods for analysing threats to the conventional security of the state, societies, ecosystems, and human-well-being has been developed over the years. Attempts have been made to tailor such assessment tools to crisis and conflict contexts. However, with the development of space based sensors and its increasing availability, satellite data can be an important source of information to deal with threats to comprehensive security concerns. It also works well as a source when implementing complex integrated security analysis because it links both social and technological advances into one framework.

A near-real-time, clear and comprehensive satellite-based information picture is essential if the security community is to be able to perform its assessments, from situation monitoring to crisis management. Earth observation is a vital contributor to this general picture and complements other types of information, ranging from publicly collected data to classified material from human intelligence sources. The information from the satellites can be used for a variety of security reports. For instance it can contribute to:

- Image-based maps on various scales and sizes depending on the area of interest and type of crisis or security threat. These maps may cover whole continents with information regarding deforestation or focus on a small village subjected to ethnic cleansing, showing burnt-down houses.

- Providing direct answers to requests for information of the type “has bridge X in town Y over the river Z been swept away?”, thereby provide up-to-date resources.
- Digital terrain information in 3D thereby providing detailed elevation information e.g. to perform a simulation of the effects of a dam rupture downstream.
- Long-term time series to detect small changes and impacts on ecosystems that indicate a wider global or regional climate change.
- The size or extent of natural resources such as biomass in forests and the volume of the cutaway bedrock from an open-pit mine.
- Progress in the construction of large infrastructure and its possible environmental impacts on the nearby surroundings (see the images below).
- Movements of troops or rebel groups and their vehicles into demilitarised areas, or the deployment of non-authorised weapons to countries under blockade.

### From Continental Coverage to Eyewitness on Village Level – A Piece of Integrated Security

The next two images provide an example of how earth observation images could be used to detect and assess even small, but significant, changes in a wider and complex course of events. The background to the images below is the start of the construction of a large electric power plant dam in Ethiopia called the Grand



**Image 3:** A small village 500 m upstream from the planned GERD dam construction area. Note the kitchen garden around the green trees at the beach to the Blue Nile and several huts as pinpointed by the blue line. Date April 29, 2003. Image: Digital Globe.

Ethiopian Renaissance Dam (GERD). The first image (image 3) shows a small village upstream from the planned dam area prior to construction starting. The next (image 4) shows the same village and area after the start of construction and the impact from the various activities of the dam.



**Image 4:** The same village and area on May 28, 2012 when construction work has started. Note that the huts marked by the blue circle as located in the image 3 above are missing and there is no other trace of the village's inhabitants. All the village agricultural areas are lying fallow and a dirt road has been established along the right-hand edge of the image. Image: Digital Globe.

These two images show how a larger event such as the construction of a dam will drastically impact humans and their habitat. Images from satellites can detect even small and local but significant changes in the environment. Moreover, these changes can also be measured and quantified in a larger area to provide statistically realistic trend analysis for an entire region. The effect of such changes has in this case been the displacement of the local population.

#### **Conclusion: A Widened Understanding of Security by Satellite Data Analysis**

Earth observation based on publicly available satellite images is one of the new techniques being offered today that provide researchers with a global instrument adapted to the requirements of a comprehensive security analysis. Earth observation shows the situation on ground "as is" without being restricted by national borders, political conditions, communication or the speed and time of a crisis. In a comprehensive security analysis the satellite data will be a strong and current near-in-situ factor. FOI today has the capacity to transform this technology into a non-intrusive scouting eyewitness in conflicts and crises.

This brief was written by an interdisciplinary team of scientists at FOI, the Swedish Defence Research Agency. It could be read as a stand-alone document but can also be read in the context of connected briefs on integrated security of which this particular topic is a cohesive part.

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For further information on related activities of this project please consult [www.foi.se](http://www.foi.se).