

# Very High Resolution Satellite Images and Human Security – Yes, It Makes Sense! Dispatch no. 7 (10)

**Interest in satellite-based earth observation is increasing among those engaged in human security analysis. Having previously mainly been a concern for those interested in conventional security analysis, satellite imaging is becoming an increasingly relevant instrument also for those engaged in analysing challenges to human, societal, and ecological systems. A major factor is the increase of readily available very high resolution (VHR) satellite imagery. The imagery makes detailed and objective information easily accessible for any place on the globe and provides new opportunities for the security analyst in tasks such as detailed site assessment and environmental monitoring. The result can then be applied to and support a broader integrated security analysis. In Sweden the use of VHR images in the public sector is specifically supported by participation in the European Pleiades VHR satellite programme.**

## **Very High Resolution Satellite Data and Their Applications**

Very high resolution (VHR) satellite images are usually images that offer, in technical terms, “sub-metre resolution”, meaning that the limit in size of the smallest objects or environmental features that can be clearly discerned may be below 1 meter. This is the highest image quality available from non-military remote sensing satellites today. This type of image as well as the derivative products that can be produced are used on a daily basis in areas such as national security and civilian applications. The VHR images provide an excellent means for the security community to perform assessments—from situation monitoring to crisis management. They can be found in use by public institutions and private entities to meet threats to human security (e.g. to detect assaults and burning of small villages in remote areas), and to support peace support operations (e.g. by monitoring refugee flows and the establishment and growth of refugee camps), emergency services (e.g. monitoring ground movements in support of earthquake disaster relief operations), surveillance and intelligence collection (e.g. on troop movements), environmental protection (monitoring deforestation), and national development.

Satellite-based earth observation and VHR images not only allow for site monitoring, object identification and other similar remote sensing tasks. The satellite images provide an unbiased physical measurement that depicts the situation on ground “as is”. This is particularly valuable for making various assessments in situations where other objective inputs may be closed for the world due to censorship, violence, or some other reason. Satellite-based earth observation and VHR images also involve some challenges. Acquisition of optical images is always weather-dependent. A cloudy rainy season will cause problems for continuous monitoring of an area. Moreover,

earth observation data provides a snapshot of what a crisis situation “looks like” at a specific time. The images present what has already happened, be it gradually increasing global climate change, deforestation or an erupting ethnic cleansing crisis. During the analysis it is therefore imperative that the interpreter is able to recognise the changes by analysing images over time in order to understand the course of the security threats.

### *The Pleiades System – Some Technical Aspects*

An example of a satellite system that provides VHR images is Pleiades. It is an optical satellite observation system with sub-metre resolution designed to offer a high acquisition capability with a daily revisit to any place on the globe. The Pleiades constellation today consists of two identical satellites equipped with sensors that can capture high-resolution (0.7m) black and white (panchromatic) images and four low-resolution (2.8m) colour images, one red, one green, one blue and one near-infrared (NIR). The precision of the geographic localisation of the acquired images is usually within 10m if no ground reference points are used. If ground points are available the localisation can be brought down to approximately 1m.

A number of standard products that enable and support a wide range of operative earth observation tasks are often produced from the raw images. The two most common standard products are a 50-cm resolution black and white image and a 50-cm “pansharpened” colour image (RGB). The latter is the result of fusing the raw high-resolution panchromatic image with the raw red, green and blue lower-resolution images. The pansharpened image contains both the high level of detail found in the black and white image and the colour information from the red, green and blue low-resolution images. It therefore provides an excellent basis for an analyst to detect detailed structures and make interpretations

based on colour using one and the same image. An example of a VHR pansharpened colour image from the Pleiades satellite system is shown in image 1.



**Image 1:** Part of a pansharpened colour image from the Pleiades satellite system showing logging and clear-cutting for the building of barracks for workers on the GERD dam in Ethiopia. The resolution of the image is 50 cm.

### 3D Terrain Data from Images

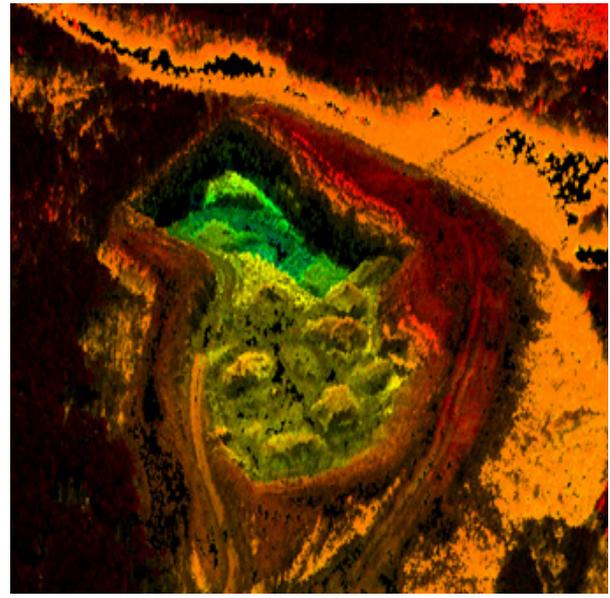
The Pleiades system also offers the possibility of stereoscopic imaging in terms of associated stereo pairs of images. These image pairs can be used to extract 3D information that describes the geometry of the terrain as well as objects on the terrain. The geometry information allows an analyst to directly obtain features such as the length, width and height of objects as well as distance and invisibility between points on the ground. If time series of stereoscopic images are available then the geometrical changes in the environment may also be detected and measured. This information can be used to measure and monitor ground movements, for example, to support disaster relief management in case of earthquakes or landslides. It may also support analyses and predictions for assessment of the potential risk of further movements. An example of extracted 3D information based on stereoscopic images is shown in Image 2 below.

### Increased Data Availability and Potential Operative Impact – a Swedish Perspective

To secure national access to VHR images Sweden is participating in the Pleiades satellite programme. Besides access to images, the participation also aims to support an increased operative use of VHR satellite images as well as the development of new applications. The Pleiades programme is led by France and is designed for both military and civil applications. Through this programme, Swedish public institutions have nearly free access to already captured VHR satellite images from any place around the globe (not only over Sweden). It is also possible to task (order) the satellites to acquire new and recent images should there be no suitable image already acquired.

The conditions for access to the Pleiades data are governed by a special agreement between the French space agency CNES (Centre National d'Etudes Spatiales) and the Swedish National Space Board, SNSB. According to this agreement SNSB has the right to use and allow further use of VHR satellite images from the Pleiades satellites under certain licence conditions: it can grant public institutions in Sweden permission to obtain and use data. The licence conditions allow for free use and the production of derivative products for internal institutional needs. The results obtained may also be distributed to other institutional users. All commercial activities are however prohibited.

At FOI access to Pleiades images has been exploited in the interdisciplinary project SÄKER. In this project FOI's expertise in security analysis, image processing and image interpretation has been put to work in an interdisciplinary case study to support the development of a framework for integrated security analysis. The conclusion is that satellite-based earth observation using the Pleiades VHR images provides an excellent opportunity for human security analysis and fits well in an integrated security analysis framework. There are of course other imaging satellite systems accessible for security research and crisis management besides Pleiades, but no other programme is streamlined to support their use at such a low cost for Swedish public entities.



**Image 2:** To the left: part of one of two VHR images in a stereoscopic image pair from the Pleiades satellite. The image shows a quarry. To the right: 3D terrain data derived using the stereoscopic image pair. The overlaid colours (from green to red) indicate the elevation of the terrain.

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.

The project leader was Mikael Eriksson (Defence Analysis) and lead scientists included Annica Waleij (CBRN Defence and Security), Birgitta Liljedahl (CBRN Defence and Security), Louise Simonsson (CBRN Defence and Security), Christer Andersson (Defence and Security, Systems and Technology), Richard Langlais (Defence Analysis), Michael Tulldahl (Sensor and EW Systems) and Ulf Söderman (Sensor and EW Systems). Many other members of FOI provided support.

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