MONITORING AND MAPPING THE CONFLICT IN IRAQ USING SATELLITE IMAGERY

GATHERING INFORMATION ON THE GROUND DURING WARTIME CAN BE BOTH DIFFICULT AND DANGEROUS. ANA ISABEL MARTÍNEZ EXPLAINS HOW MULTI-SPECTRAL SATELLITE IMAGERY WAS USED TO MONITOR EVERYTHING FROM OIL FIRES TO REFUGEE CAMPS AROUND MOSUL IN IRAQ

Monitoring the evolution of wars and conflicts, the damage they produce to the environment, heritage sites and infrastructures, as well as the extent of the humanitarian crises to which they lead can be a complicated task, given the danger that being on-site poses.

Satellite imagery is a key way to both monitor and map a conflict's evolution and impact, without the risks and costs associated with having people on-site. It allows users to capture reliable imagery, and ensures accurate and timely monitoring over sites located in areas affected by ongoing threats, where it's otherwise difficult to get up to date information and verify potential damage.

Deimos Imaging has been monitoring and mapping the conflict in and around Mosul since its beginning using its two satellites: the medium resolution Deimos-1 and the very-high resolution Deimos-2. Both satellites operate continuously, with a global network of five ground station ensuring contact with each of them every orbit to command and download data every 90 minutes (see 'Satellite capabilities').

In this study, a synergistic tipping and queuing has been carried out, collecting information and coordinating activities between Deimos Imaging's sensors. Thanks to its wide swath and high revisit time, Deimos-1 spotted where the main developments were going on in Mosul and its surroundings; then, this information was used to task the very-high-resolution Deimos-2 over the identified areas to get much more detailed imagery.

The ability to record a sequence of images over time at different spatial resolution and the use of the tipping and queuing technique enabled the tracking and capture of the most relevant developments in Mosul's conflict and its dynamics, both in context and in detail.

Moreover, the expansion of camps for refugees and internally displaced people (IDP), such as the one in Hammam al-Alil 25km south of Mosul (Figure 6) was monitored, as were the evolution of the oil fires in Qayyarah (Figure 3) and the changes in the agricultural production in the Nineveh region (Figures 4 and 5).

Thus, Deimos Imaging's imagery helped with the assessment of the humanitarian, economic and environmental impact of this conflict, providing data to decision-makers in a wide range of areas, from NGOs and international organisations to local institutions promoting precision agriculture for the country's recovery post-conflict.

Deimos-2 to analyse and quantify infrastructure damages

On October 17 last year, Iraqi security forces launched a major offensive to recapture Mosul, IS' last major stronghold in Iraq.

During the offensive, multiple churches, mosques and shrines, dozens of antiquities in the Mosul Museum and great parts of the ancient Assyrian city of Nineveh were destroyed. Moreover, the city's infrastructure has been severely damaged by both sides of the conflict.

Deimos-2 imagery was used to identify and assess the damage that occurred during the conflict to infrastructure such as the city's airport and bridges. For this purpose, a pre-event and post-event change detection analysis was carried out, revealing extensive damages (Figures 1 and 2). The analysis of the Deimos-2 high-resolution image captured on February 19 this year allowed the identification of razed buildings and rubble placed along Mosul airport's runaway, and the image captured on March 10 shows the suspended bridges to impede crossing from east to west Mosul.

This data is also useful in post-conflict to quantify damage to infrastructure, so it an important tool in long-term reconstruction programmes. In addition, archive imagery is being continuously updated with fresh images, which is crucial in areas affected by ongoing conflicts where it's difficult to get up-to-date and verified information.

Pollution sources and environmental damage

From August last year to April this year, several fires burned in the oil field of Qayyarah, around 60km south of Mosul. Deimos-1 and Deimos-2, together with other satellites' imagery, allowed Wim Zwijnenburg, project leader at the non-profit, non-governmental organisation PAX, to identify different pollution sources.

"As PAX's core goal is to protect civilians, knowing what is happening on the ground during a conflict proves to be very difficult if you don't have access to area," he says. "This goes for all our programmes, be it monitoring the use of weapons, civilian harm tracking or my area of expertise – the monitoring of the impact of conflict on the environment and related human health risks. Analysis of satellite imagery from Deimos Imaging and UNOSAT allowed us to track the problems with the oil wells in Qayyarah, and to identify attacks and damages to industrial sites in and around Mosul zones in Iraq."

He adds: "We applied similar approaches to monitor the conflicts in Syria, Ukraine and Libya, and we used this information to support public advocacy and send out public alerts about the risks of chemical incidents and/or long-term environmental pollution that can lead to acute or chronic health problems for civilians and their communities."

The images in Figure 3 were created combining red, green and near-infrared bands to show active fires (bright red and yellow) and smoke (black). The vegetation is pictured in red in these false-colour

Figure 1. Deimos-2 image of the city of Mosul showing 2 of the 5 badly damaged bridges. Upper zoom in: Al-Shohada Bridge; lower zoom in: Al-Jamhuriya Bridge. Image captured on March 10 2017

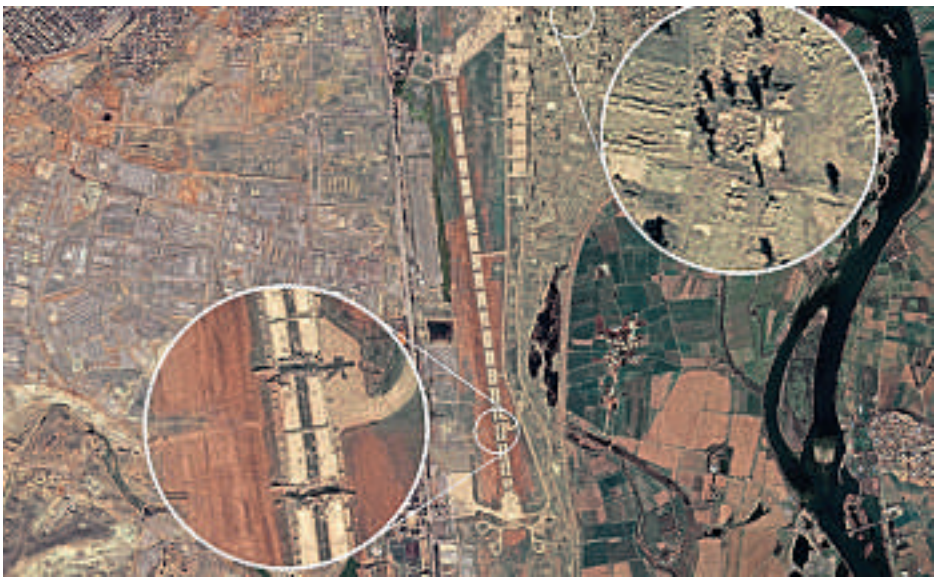

Figure 2. Deimos-2 image of Mosul's Airport: the airport runway was destroyed and infrastructures damaged. Upper zoom in: razed building; lower zoom in: rubble and trenches at runaway. Image captured on February 19 2017

Figure 3. Qayyarah oil fires, Iraq: Deimos-1 image acquired on November 28 2016 (left); Deimos-2 image acquired on October 29 2016 (right). Bright red and yellow show active fires while black represent smoke billowing from the oil fields

Figure 4. Deimos-1 image of Nineveh Governorate, Iraq, April 4 2016

Figure 5. Deimos-2 image of Nineveh Governorate, March 30 2017

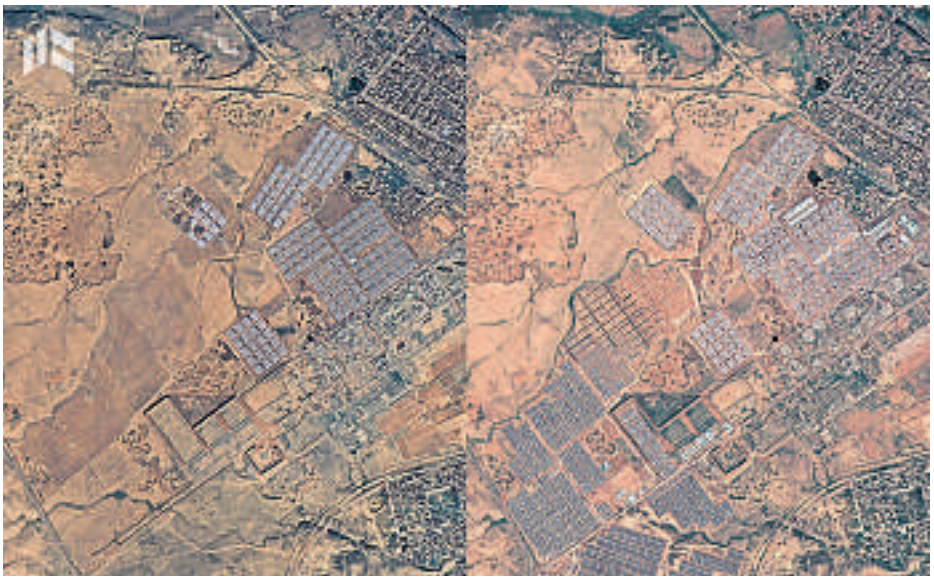

Figure 6. Deimos-2 images of Hammam Al-Alil, Iraq, captured on February 19 2017 (left) and April 22 2017 (right). Careful image analysis showed that the amount of people hosted in the camp incremented from around 22.500 to almost 50.000 between the two acquisition dates. This is a preliminary analysis which has not been yet validated in the field

images acquired in October (Deimos 2) and November (Deimos-1) last year.

The impact on agriculture

The Nineveh province was once Iraq's breadbasket, accounting for almost half the country's overall wheat supply. However, the ongoing conflict is jeopardising the agricultural production, mainly in the regions of the Nineveh, Kirkuk and Salahuddin governorates in Iraq. Deimos Imaging tasked both Deimos-1 and Deimos-2 satellites on the Nineveh Governorate in Iraq (Figures 4 and 5).

The bands of Deimos-1 (RG, NIR) and Deimos-2 (RGB, NIR) have been especially designed for monitoring vegetation. In particular, they provide analytic-ready imagery, supplying the information needed for vegetation indices calculations. These provide an indication of the relative density and health of vegetation for each pixel of Deimos-1 and Deimos-2 imagery. In addition, the satellites' high temporal resolution capacity ensures data is acquired systematically, enabling consistent monitoring and analysis.

In general, this high frequency and high-resolution data can be used to supply a powerful operational service for precision agriculture, with an accurate multitemporal overlay at pixel level. This can empower precision agriculture users at different stages: planning; in-season practices and yield.

The humanitarian impact

Satellite imagery also plays an increasingly important role in monitoring and measuring humanitarian crises. It serves to support decision-making and manage humanitarian aid and response through, for instance, the monitoring of changes in refugee IDP camps. Deimos-2 data helped to detect the evolution of the refugee camp at Hammam Al-Alil, around 25km south of Mosul. The multitemporal analysis of Deimos-2 imagery provided reliable information to measure the camp's growth and density over time, allowing an estimate of the population sheltered there. Accurate multitemporal analysis showed that the number of tents increased from 3,738 on February 19 to 8,136 on April 22. Therefore, the camp grew by 54% in just two months. Given that on average six people are accommodated in each tent, the number of people hosted in the camp increased from around 22,500 to almost 50,000 between February 19 to April 22.

The image captured on April 22 also shows a part of the camp still under construction, which enables a forecast of future occupancy of almost 56,000 people – a number that matches the capacity expectations of the United Nations High Commissioner for Refugees, which is responsible for managing and developing this camp.

Ana Isabel Martínez is communications manager at Deimos Imaging, an UrtheCast company (www.deimos-imaging.com)