NAVAL GAZING

CHIARA SOLIMINI AND **ANA ISABEL MARTÍNEZ** EXPLAIN HOW TIPPING AND CUEING WITH TWO DIFFERENT SATELLITES HAS ENABLED MILITARY DEVELOPMENTS IN THE SOUTH CHINA SEA TO BE MONITORED AND ANALYSED

Composed of about 130 small coral islands, rocky outcrops, atolls, sandbanks and reefs, the Paracel Islands are located in the disputed territory of the South China Sea. They are distributed over a maritime area of around 15,000 square kilometres, and are claimed by China, Taiwan and Vietnam.

Although they are largely uninhabited, these islands have a very high geostrategic interest. They are located in a major shipping route and are home to fishing grounds; there may also be reserves of natural resources around them. Rival countries have wrangled over territory and sovereignty in the South China Sea for centuries, with tension steadily escalating in recent years. Dredging works have been carried out in several reefs by the disputing countries, with some of them developing into more extensive constructions of both military and civil character.

Remote sensing is a key tool for change detection and maritime surveillance, especially in locations that are very distant from each other and where having people on the ground is difficult. Thus, satellite imagery is the perfect source of information to monitor the evolution of the dispute in the South China Sea. It enables the capture of reliable imagery and ensures accurate and timely monitoring of sites located in remote areas, where it's otherwise difficult to obtain up-to-date and reliable information.

With the raising of tensions in the South China Sea in early 2016, Deimos Imaging launched a monitoring campaign to acquire archive imagery over this area and demonstrate the coordinated use of its two satellites for imagery intelligence applications: the wide-swath, medium-resolution Deimos-1 and the narrow-swath, very-high resolution Deimos-2.

Both satellites operate continuously as part of a 24/7/365 service and a global network of five ground station ensures a contact every orbit with each of them.

Synergistic tipping and cueing

Deimos-1 captures 22m multi-spectral imagery with a very wide swath of 650km. The satellite has a collection capacity of more than 5,000,000km^2 with a three-day revisit time worldwide. Very high revisit frequency is crucial for monitoring applications and it guarantees the delivery of sufficient cloud-free images, which is one of the challenges when capturing satellite imagery of this area.

Deimos-2 is a very high resolution, agile satellite, providing 75cm pan-sharpened images and an off-nadir pointing capability of ±45º. The system capacity is more than 150,000km^2 a day with a two-day revisit time worldwide, allowing it to monitor any area of interest accurately, timely and cost-effectively. Images are 12km wide and up to 200km long, and with maximum tilt, the field of regard can be extended to more than 600km from nadir.

Here, the technique used was synergistic tipping and cueing, which allowed us to collect information by coordinating activities between the sensors. Synergistic tipping and cueing involves tasking one satellite with a wide swath – Deimos-1, in this case – to get the broad picture of a hotspot and detect possible changes, activities and elements of interest. A careful analysis of the data collected provides a general overview and critical knowledge that can be used as a base map to then task other satellites with different spectral and spatial resolution. The very high spatial resolution of Deimos-2 is important to identify relevant targets in the image, such as construction, military facilities, ships and planes. Having different spectral resolutions and the use of different spectral

bands is also very useful, as it can highlight and better discriminate different features.

Revealing new constructions

Our campaign over the Paracel Islands started in March 2016 and is still ongoing. Multitemporal acquisitions with both satellites allowed us to compare fresh imagery with archive data, as well as to track and capture the most relevant developments of this disputed region, in context and in detail.

Thanks to its wide swath and high revisit time, Deimos-1 enabled us to monitor at a glance the large and widespread area that covers the Paracel Islands, scattered over an area of approximately 15,000km^2 (see Figure 1). The images were analysed to identify areas where possible changes might have happened. Ideally, automatic change detection algorithms can also be used to minimise analysis time and automate information extraction. The near-infrared band of Deimos-1, which depicts vegetation in bright red, is the perfect tool to distinguish manmade constructions from plant-covered land. This was essential to identify new atolls, dredged reefs and land clearing for the construction of facilities. The data gathered by Deimos-1 was examined and compared over time and, when significant changes were identified, the very-high-resolution Deimos-2 was tasked to further investigate and recognise those developments in greater detail.

Deimos-2 imagery was used to identify and assess changes in the main islands' facilities. For this purpose, a change detection analysis was carried out over multitemporal imagery, revealing key developments. Figure 2 shows Woody Island, the largest island of the archipelago, as seen from Deimos-2 on October 17 2017. This island sports a protected harbour capable of hosting large numbers of vessels and an airstrip. Further cloud-free imagery of this island was captured on March 18 2016, July 12 2016 and March 25 2017. A multitemporal analysis of the images served to identify HQ-9 surface-to-air missile batteries deployed on the northern coast of the island on March 2016. These weren't in the image captured on July 2016, with reports

Figure 1. Deimos-1 false colour image, Paracel Islands, September 6 2017. False colour imagery is processed including the R, G, NIR spectral bands, a band combination traditionally used to assess vegetation status.

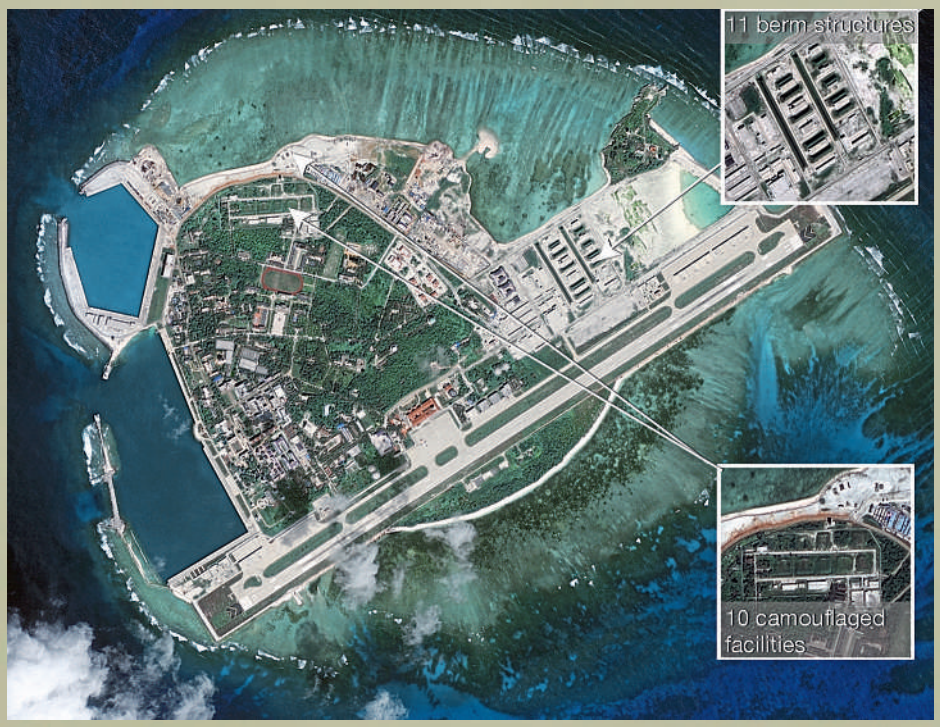

Figure 2. Deimos-2 image, Woody Island, captured on October 17 2017. The zooms on the right show 11 berm structures (top) and 10 camouflaged facilities (bottom)

A battleship in the Singapore Strait

Figure 3: Deimos-2 images, Tree Island, captured on March 18 2016 (left) and October 17 2017 (right). Big differences can be appreciated between one date and the other, with a harbour, a helipad and a solar power installation visible on the most recent image

suggesting they were removed following the conclusion of military exercises in the area.

All the images from 2017 showed camouflage netting laid out in that area. In addition, different boats were docked at the harbour in different days, and the image captured on July 12 2017 showed what could be an amphibious warfare ship. A plane on the airstrip was also spotted on October 17 2017, as well as 10 facilities camouflaged under vegetation and 11 berm structures erected to shield the buildings they protect from explosions.

Figure 3 shows Tree Island as captured by Deimos-2 on March 18 2016 and October 17 2017. Since the first image was captured, a considerable expansion of land has been dredged, a harbour and a helipad completed, and photovoltaic solar installations constructed.

Figure 4 shows changes in North Island, captured on March 18 2016 and October 17 2017. There were attempts to connect North Island with neighbouring Middle Island in 2016, but the land bridge visible at the bottom right of the image was washed away by Typhoon Sarika on October 2016. There are no military facilities in this island, but what appears to be a large administrative building was constructed; there has also been clearing of land and possible preparations for a harbour are currently undergoing.

This imagery shows how activity, even though slowed down in the last years, has continued over recent months. Not all of the settlements in the Paracel Islands currently contain significant infrastructures, some of them are little more than sandbars. Some others seem to have no activity at a glance. However, the identification of specific features suggests ongoing activities in these areas – such as the airplane identified in Figure 2. This may indicate that new constructions are likely to continue in this area in the near future.

Given the remote location and the rising tensions amid the countries involved, the information provided by satellite imagery will be crucial to get actionable intelligence and monitor the evolution of this dispute over time, at different spatial and spectral resolutions, and to provide the whole picture both in context and in detail.

THE INFORMATION PROVIDED BY SATELLITE IMAGERY WILL BE CRUCIAL TO GET ACTIONABLE INTELLIGENCE

Chiara Solimini is product marketing manager and team leader and Ana Isabel Martínez is communications manager at Deimos Imaging (www.deimos-imaging.com)

Figure 4. Deimos-2 images, North Island, captured on March 18 2016 (left) and October 17 2017 (right). Manmade constructions and changes can be appreciated from one image to the other