VERIFICATION SCIENCE

The role of airborne imagery in an on-site inspection

BY ALED ROWLANDS

Image 1:
Tests so far have involved mounting MSIR sensors in an external pod (see white arrow pointing to black box above wheel) on a relatively small helicopter but future tests will involve larger aircraft types.

Figure 1:
By displaying information from different parts of the spectrum, features such as cleared ground (red patches in image on right) are much more obvious than what can be seen in the corresponding image representing the visible portion of the spectrum (left).

The technologies at the disposal of inspectors during an on-site inspection (OSI) are many and varied, making it a truly multidisciplinary effort. Whilst certain OSI technologies such as seismic aftershock monitoring have been applied intensively in field tests and exercises over recent years, others require, and are subject to, developmental work. The acquisition of multi-spectral imagery from an airborne platform is a point in case.

Whilst an inspector scanning the landscape with his or her eyes has the ability to assess the OSI-relevance of features in the visible part of the spectrum, additional information can be gleaned by capturing information in discrete spectral regions (or bands) in the continuum from visible through to infrared (see figure 1). In this context the Protocol to the Comprehensive Nuclear-Test-Ban Treaty refers to this as *multi-spectral imaging including infrared measurements*, which is abbreviated to MSIR.

HOW MULTI-SPECTRAL IMAGING IS USED

An MSIR system comprises different sensors capable of acquiring information across the visible and infrared portions of the spectrum. It can be utilized from different heights above the ground and from different platforms. Potentially, this includes oblique imagery acquired by a sensor held by an inspector on or near the ground. However, the optimal configuration is when it is mounted in an external pod or through a hatch on a fixed-wing or rotary aircraft since this allows imagery for a large area to be acquired efficiently (see image 1 above).

TESTING THE VALUE OF MULTI-SPECTRAL IMAGING IN AN OSI

To test the effectiveness and potential value of an MSIR system to an inspection team, the Preparatory Commission for the Comprehensive Nuclear Test-Ban Treaty Organization (CTBTO) has concluded a series of field tests in Hungary incorporating realistic and

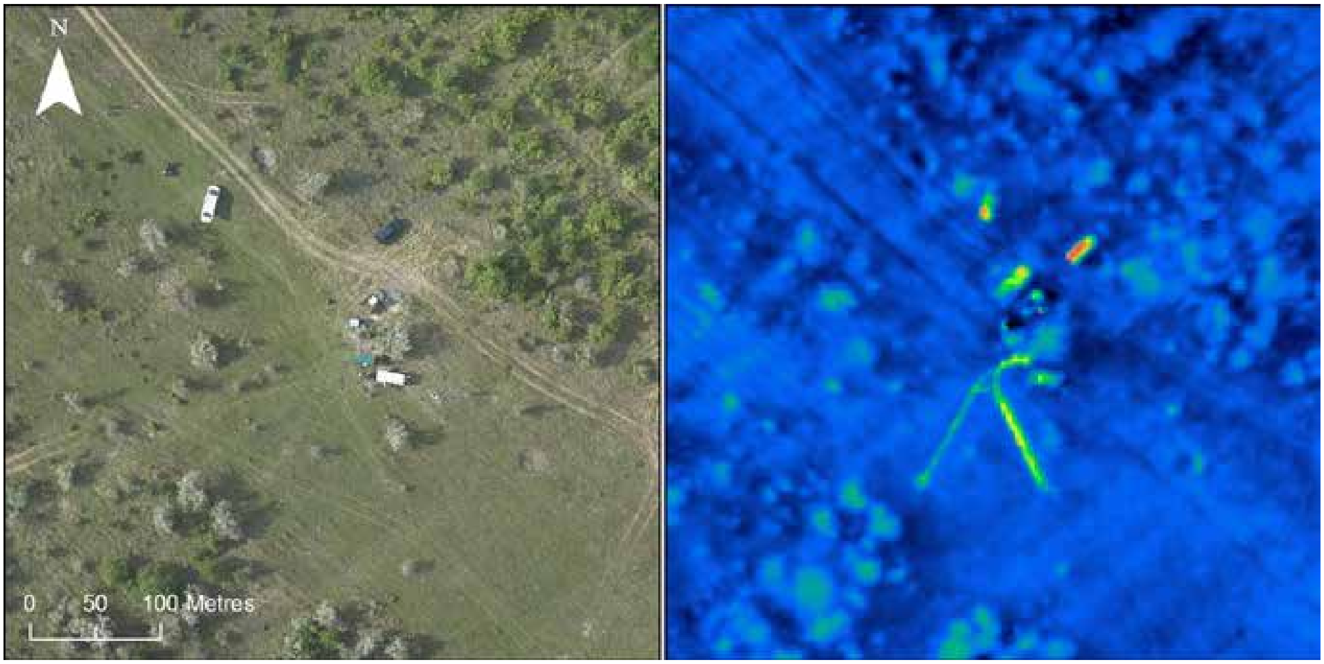

Figure 2:
Using the thermal sensor in the MSIR system, two distinct green linear features representing subsurface warm water can be seen in the image on the right, whereas the corresponding visible image (left) does not reveal these features.

relevant observables related to potential preparation activity for an underground nuclear explosion or to secondary features related to the detonation itself. Tests have also been designed to mimic, as closely as possible, the likely timeframe of an OSI.

Features generated for testing thus far range from surface disturbances caused by vehicle movements and digging activity to changes in hydrology and surface characteristics caused by seismic shocks. To complicate matters, these features are dynamic over time and also vary depending on environmental conditions and may also be masked by surface vegetation cover and unrelated human activity. These complications need to be accounted for and have also been assessed during tests.

DETECTING CHANGES IN GROUND WATER CAUSED BY AN UNDERGROUND NUCLEAR EXPLOSION

One potential impact of an underground nuclear explosion is a change in ground water, with cool subsurface or geothermal water being brought to the surface or to the near-surface. To test the effectiveness of MSIR to detect the consequences of this potential scenario, pipes were buried below the surface and warm or cool water circulated, with water also being allowed to drip from the pipes to the surrounding soil. As water is circulated through the pipes the characteristics of the soil change and the thermal sensor on-board effectively records the change in soil surface temperature (see figure 2).

DETECTING FEATURES HIDDEN BY VEGETATION

Vegetation will mask features but MSIR offers the potential to detect the impact of a detonation on vegetation and is also a means of extracting information on what lies underneath foliage. Topographic features that are obscured to inspectors on the ground or in the air due to vegetation can be revealed by using a lidar sensor, which effectively maps the elevation of the ground. This enables roads or tracks to be located, depressions recorded and subsurface features covered by soil and vegetation to be identified.

Like other OSI techniques, it is necessary to try to differentiate between those that are OSI-relevant and background features unrelated to the OSI. Whilst data processing can help in this respect, the interpretation skills of MSIR experts are fundamental in extracting relevant information from MSIR imagery (see figures 3 and 4 on page 24).

INTEGRATING WITH OTHER OSI TECHNOLOGIES

MSIR is one of several technologies permitted during an OSI and critically MSIR imagery and derived information do not exist in isolation, rather they become integrated with data from other technologies and analysed and displayed through the OSI geospatial system. MSIR can provide valuable information to assist OSI search logic and facilitate the work of other technologies applied during an OSI. One of the derived products of greatest value to an inspection team in this respect is aerial photography. Depending on the height of the aircraft above the ground, this photography can be of high spatial resolution and, in combination with the global navigation satellite system, can enable an inspection team member on the ground to avoid hazards and to navigate to a specific location effectively.

CONTRIBUTING TO OSI INSPECTION TEAM FUNCTIONALITY

Whilst the nature of OSI-relevant signatures are many and varied, transient

Figure 3:
The visible image on the left reveals little about the features lying beneath trees at locations X and Y, whilst lidar (right) shows the presence of two domed features.

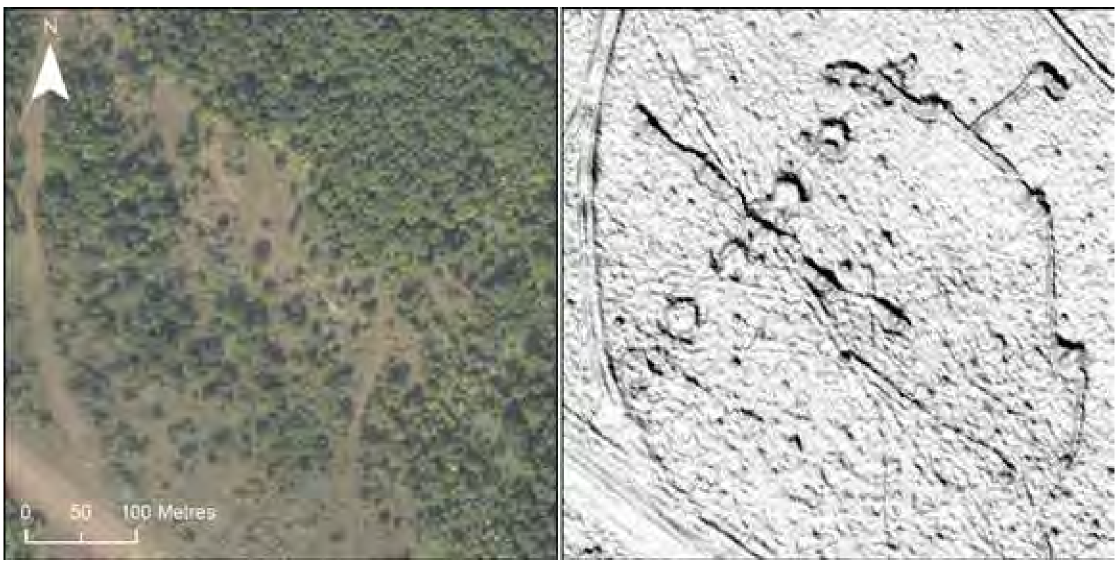

Figure 4:
The extent of depressions and the track network under forest canopy at this location are revealed in the image on the right whilst the visible image for exactly the same area reveals only some tracks leading into the forest.

and may vary depending on environmental conditions, tests conducted to date show, in principle, that the acquisition of MSIR imagery can greatly contribute to OSI inspection team functionality. This means that MSIR has the potential to play an integral role in an OSI in terms of directly promoting or demoting areas of interest and by also providing supporting imagery to the inspection team.

OSI techniques and methods will be tested in 2014 during the Integrated Field Exercise and thanks to the support of States Signatories in the form of expertise and a contribution-in-kind from Hungary, as well as financial support from the European Union, MSIR will be available to inspectors to apply for the first time in the history of the CTBTO.

BIOGRAPHICAL NOTE

ALED ROWLANDS
is a consultant in the On-Site Inspection Division at the CTBTO where he has worked since 2011. In addition to developing the airborne remote sensing component, he has participated in the build-up exercises to IFE14. Previously he held a lecturing position at Aberystwyth University in the UK and also worked in the private sector, where he specialized in the development of space and airborne remote sensing applications.