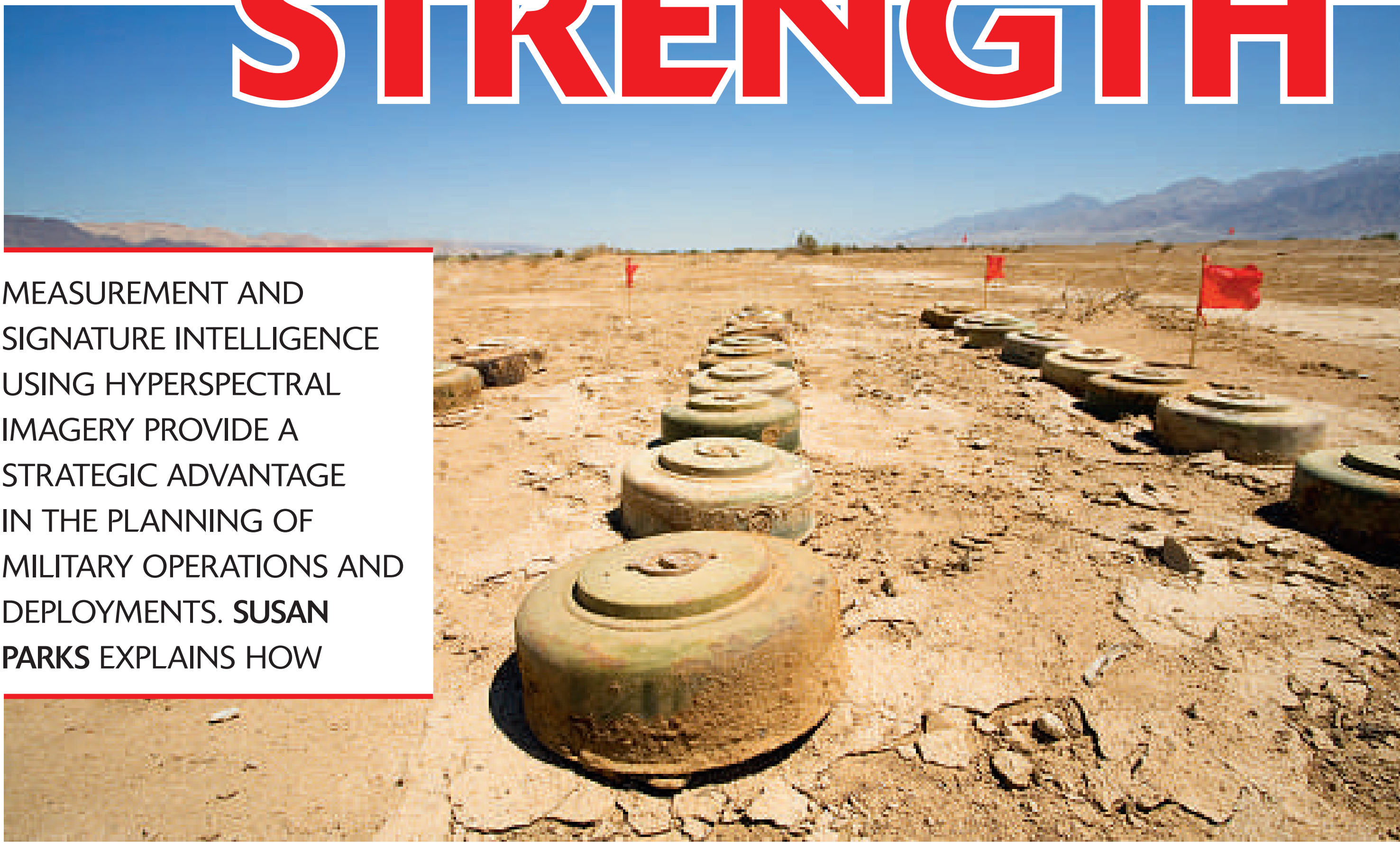
SIGNAL STRENGTH

MEASUREMENT AND SIGNATURE INTELLIGENCE USING HYPERSPECTRAL IMAGERY PROVIDE A STRATEGIC ADVANTAGE IN THE PLANNING OF MILITARY OPERATIONS AND DEPLOYMENTS. **SUSAN PARKS** EXPLAINS HOW



IN THE HYPERSPECTRAL CASE, IT IS OFTEN POSSIBLE TO DETECT CAMOUFLAGED OBJECTS THAT REPRESENT AS LITTLE AS 20% OF A PIXEL

Military efforts today focus on advances in technology and how to deploy these innovations to gain an advantage. From spears and bows and arrows to unmanned aerial vehicles and laser-guided missiles, technological progress has paved the way for advanced weaponry, faster and more durable vehicles, ultra-lightweight uniforms and more.

But while weapons are the most obvious benefits of military research and development, information technology could be the weapon that has most revolutionised warfare. Surveillance technologies, such as radar and spy satellites, can warn armed forces of an approaching enemy, troops can be given orders in real-time from remote locations thousands of kilometres away, and GPS navigation ensure personnel don't get lost.

Information technology, including measurement and signature intelligence (MASINT) and hyperspectral sensing, has not only changed the way wars are fought, it has become a key factor in attaining dominance in military power. This rapidly burgeoning discipline is beginning to delve into more diverse sources of data. Experts are advancing ways of using it to help other intelligence sensor systems, as the successful exploitation of hyperspectral and multispectral imaging sensors depends on the availability of accurate and complete spectral signature libraries. Greater urgencies in both conventional and asymmetric warfare are accelerating the development and deployment of MASINT, as accurate MASINT provides a strategic advantage in the planning of military operations and deployments.

In recent years, MASINT has evolved from a laboratory science to a mature means of detecting, identifying and characterising different threats. Coupled with the appropriate spectral signature library, images collected with imaging sensors provide the means to survey large areas, identifying and characterising materials, distinguishing a wide range of camouflaged targets and detecting disturbed surfaces.

Terrain evaluation

MASINT systems can provide or enhance coverage of areas not under or beyond the range of visual observation. For example, the planning of naval and amphibious operations requires knowledge of the bearing strength and navigability of the landing area, as well as the bathymetry in the vicinity of the landing zone.

Naval vessels depend largely on extrapolative methods to navigate when establishing position with visual aids is not possible. Hyperspectral remote sensing data analysed in conjunction with a field-collected spectral library provides a way to characterise a wide range of soil properties, including soil type, grain sizes and moisture content, that are crucial in estimating the bearing capacity of littoral and near-shore surfaces. Hyperspectral imagery is also able to map the locations of obstacles and provides information on near-shore bathymetry.

In one test, a dataset was created from hyperspectral imagery, field spectral measurements collected using an ASD FieldSpec spectroradiometer, and the measurement of soil properties. The researchers were able to develop a relationship between the field-measured spectral signatures and soil-bearing strength, after which they could accurately map the spatial distribution of the observed field spectral signatures and their associated soil-bearing strength values.

They also found that in depths of less than 2m, water depth could be estimated using a field spectral database of different bottom types, collected at a range of water depths. By matching the change in reflectance observed in the hyperspectral imagery to the sequences of reflectance spectra of a given bottom type, it is possible to produce maps of near-shore bathymetry. A clear understanding of complex terrain is an essential element for successful military operations — whether on land or at sea.

Camouflage characterisation and detection

By comparing spectral signatures, MASINT experts can detect, locate and track targets — even when camouflaged. MASINT generates precise measurements that reveal unique characteristics of targets. The detection of camouflaged or hidden objects requires a measurement that provides a contrast between the object and background materials. Hyperspectral imagery is well suited for this application as the collected spectrum contains information related to the chemical makeup of materials. Additionally, it is often possible to detect the presence of a target spectral signature in sub-pixel quantities when there is sufficient spectral contrast with background materials.

Calibrating ASD's FieldSpec 4 for field collection of camouflage spectral signatures

ASD's FieldSpec 4 helps aid in accurate measurement and signature intelligence for military and defence applications

Soil spectral signatures are strongly dependent on the structure of the surface and where collection of the material significantly alters that structure

Field collection of spectral signatures of both target and background materials is often critical to success since it is difficult to reproduce natural illumination conditions in a laboratory setting. Studies have found significant discrepancies between field- and lab-measured spectral signatures with the largest differences seen for materials such as soils and vegetation whose spectral signatures are strongly dependent on the structure of the surface and where collection of the material significantly alters that structure.

Today, one of the more popular uses of camouflage is to mimic the spectral signature of vegetation, to disguise military

MASINT remote sensing field information combined with hyperspectral sensing helps detect, identify and characterise different threats

personnel and equipment. While the design of such camouflage is relatively easy when the sensor is the human eye, it becomes increasingly more difficult when increasing the spectral resolution and wavelength range of the imaging sensor.

For the hyperspectral case, it is often possible to detect camouflaged objects that represent as little as 20% of a pixel. Given that the dominant chemical makeup (pigments, water, cellulose, lignin) and complex three-dimensional structure of vegetation is nearly impossible to duplicate in camouflage materials, this finding is unsurprising.

Detection of disturbed surfaces

Hyperspectral sensing plays an important role in military logistics because it aids in the movement of supplies, equipment and troops where they are needed at the right time and place. By using hyperspectral sensing to determine optimal routes, forces are able to establish alternative courses if mishaps or traffic jams occur on the most direct route.

In addition, hyperspectral sensing's ability to detect ground disturbances aids in the detection of buried land mines and improvised explosive devices (IEDs). This technique can be used to detect disturbed terrain caused by vehicle movement or digging and placement of IEDs. By collecting two images of the same scene at different times, the combination that results from the images will exhibit where the terrain has been disturbed.

The mineralogic makeup of natural soils in the near surface is highly stratified. Thus any surface disturbance is detectable as a difference in the surface mineralogy in contrast to surrounding areas. With knowledge of the mineralogic depth profile of the soil, the depth of the disturbance can also be inferred.

Advances in remote sensing techniques and technologies have provided essential intelligence information to defence forces around the globe. From terrain evaluation to surveying large areas of land and sea, identifying and characterising materials, distinguishing camouflaged targets and detecting disturbed surfaces, remote sensing and MASINT helps detect, identify and characterise different threats. Combining remote sensing data with field information provides a common platform for analysing situations and providing more accurate and current information to military operations in times of war.

Susan Parks a remote sensing segment manager at ASD (www.asdi.com)