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Evolving beyond deriving three-dimensional information from images, photogrammetry is now being integrated into various activities involving geospatial data. Here’s a look at factors bringing about this change and the increasing applications of photogrammetry such challenges.

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The rapid advances in sensor technology in the last few decades are largely as a result of their applications in defence and internal security. Battlefield surveillance is an essential prerequisite for conduct of modern warfare, with sensors being deployed on land, aerial platforms, in space and underwater, to keep a 24x7 watch over the battle zone. They are required by internal security agencies for border surveillance, detection of explosives, chemical and biological agents and to assist in crime detection. Sensor based access control and intrusion detection systems are a must even in civil establishments.

The Technology Perspective and Capability Roadmap (TPCR), recently released by the MoD, which is derived from the Long Term Integrated Perspective Plan 2012-27 (LTIPP), lists the requirement of high end sensor technology for India’s defence forces. Some of the critical sensors that need to be developed include advanced Earth Observation (EO) and infrared (IR) sensors with optical correlation. Sensors for targeting and weapon seekers are an area where indigenous capability is very limited. Laser based systems for detection and imaging of targets need to be developed. Though we are strong in basic fundamental radar technology, however, its practical application for defence purposes in sensors is lacking. Radar technologies are required for Synthetic Aperture Radar (SAR) and Inverse SAR (ISAR), with enhanced processing capabilities for our manned and unmanned aerial platforms. Active Electronically Scanned Array (AESA) radars with multimode capabilities would be required. Electro-optical devices may not be effective in fog, smog and dust, radars would be required in such conditions.

Much needs to be done for enhancing the night fighting capability of our mechanised and infantry units, which are currently largely ‘night blind.’ Passivisation of active IR sensors has been achieved but there is a need to graduate to Thermal Imaging (TI) based devices with enhanced all-weather performance. Our border surveillance systems require sophisticated ground based sensors, both attended and non attended, and can be a mix of electro optical, thermal, seismic and acoustic devices. Nanotechnology can help in miniaturisation of sensors and in designing unobtrusive micro audio bugs.

With a variety of sensors deployed in large numbers, data is flowing continuously. Satellites provide imagery from space and aircraft and UAVs provide full motion streaming videos. The EM spectrum is constantly monitored to collect valuable SIGINT. Also, there is HUMINT provided by ground troops, obtained from informants and through interrogation. “We’re going to find ourselves in the not too distant future, swimming in sensors and drowning in data,” said Lt Gen David Deptula, Deputy Chief of Staff, ISR, USAF. There is just too much data pouring in from myriad sources to be handled manually. The process of storing, filtering, synthesising this data and communicating it in time as actionable intelligence has to be automated. The challenge that industry faces today is to ‘make sense from the sensors’- develop technologies that make this task easier, faster and less manpower-intensive.
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100-Megapixel Camera from China

A camera featuring 100-megapixel charge-coupled device (CCD) chip has been developed by the Institute of Optics and Electronics under the Chinese Academy of Sciences (CAS). The camera, IOE3-Kanban, is capable of producing images with 10,240 x 10,240 pixels and is said to be the China’s highest pixel camera. The small and light camera is equipped with advanced optical systems, camera control systems and high-capacity data recording systems, and can be used at temperatures ranging from minus 20 degrees centigrade to 55 degrees centigrade.

Sensor Can Detect Gunshot Location

Tamil Nadu Police Academy is reported to have successfully tested a technology that can accurately detect the source location of a random gunshot and accordingly direct a UAV to the spot for capturing live visuals. Besides gunshots, the sensor is capable of detecting other types of sounds like the sound of a jeep in a forest, etc. The advanced acoustic sensor, developed by the Madras Institute of Technology (MIT), can be used for VVIP protection or can be installed on vehicles, buildings, etc or deployed along the border areas, forests or various inaccessible terrains.

Overwatch Partners with RSI Softech

Overwatch, an operating unit of Textron Systems, a Textron Inc. company, recently announced that it has entered the Indian geospatial intelligence market by establishing a relationship with RSI Softech Private Ltd (RSI), a Hyderabad-based company. According to the company, the two will work together to support the requirements of Indian defence agencies, central armed police forces and other government agencies through the development and deployment of geospatial and intelligence tools.

Recognising that India has pre-existing capabilities, Overwatch and RSI will provide options via an integrated systems approach in which the solutions either integrate with or augment existing capabilities with more advanced systems, according to the company. Overwatch capabilities may also be extended to fill gaps and requirements not fully served by pre-existing systems.

India’s First Navigation Satellite Successfully Launched

ISRO’s Polar Satellite Launch Vehicle, PSLV-C22, successfully launched IRNSS-1A, the first satellite in the Indian Regional Navigation Satellite System (IRNSS), recently from its Satish Dhawan Space Centre in Sriharikota. This is the twenty third consecutively successful mission of PSLV. The ‘XL’ configuration of PSLV was used for the mission.

IRNSS-1A is the first of the seven satellites constituting the space segment of the IRNSS. IRNSS is an independent regional navigation satellite system designed to provide position information in the Indian region and 1,500 km around the Indian mainland. The system would provide two types of services, namely, Standard Positioning Services (SPS) - provided to all users - and Restricted Services (RS) provided only to authorised users.

A number of ground stations responsible for the generation and transmission of navigation parameters, satellite control, satellite ranging and monitoring, etc., have been established in as many as 15 locations across the country. The entire IRNSS constellation of seven satellites is planned to be completed by 2015-16.
Northrop Grumman to Offer Improved Navigation Solution

Northrop Grumman Corporation has been awarded a phase two inertial navigation system-related contract from the Air Force Research Laboratory to continue improving geo-registration accuracy for positioning and pointing applications, even in GPS-denied conditions.

Geo-registration of data is critical for accurate interaction between systems, such as locating targets and handing off coordinates to another aircraft. Geo-registration of images involves pairing unreferenced images with the physical locations or exact coordinates of depicted items. This allows aircraft to create accurate maps by stitching together photos and correlating them with their world-based locations, which is useful for intelligence gathering and targeting.

In the first phase of the Maintain Accurate Geo-registration via Image-nav Compensation (MAGIC) programme, Northrop Grumman integrated geo-registration algorithms in a vision-aided inertial navigation system that can even operate in GPS-denied conditions. Having successfully demonstrated a prototype system in phase one, Northrop Grumman will flight-test the integrated system in phase two as well as incorporate additional improvements such as highly detailed 3-D map generation in the algorithm.

The MAGIC programme’s objective is to develop and demonstrate advanced real-time geo-registration and navigation algorithms using a combination of cameras, an inertial measurement unit and GPS information.

**Functional Testing of First GPS III Satellite Bus Electronic Systems Completed**

A Lockheed Martin-led industry team has completed successful functional integration tests of the spacecraft bus and network communications equipment on the first satellite of the next generation GPS, known as GPS III.

The recent testing of GPS III space vehicle 1 (SV 1) bus – the portion of the space vehicle that carries mission payloads and hosts them in orbit – assured that all bus subsystems are functioning normally and ready for the final integration with the satellite’s navigation payload. Systems tested included: guidance, navigation and control; command and data handling; on-board computer and flight software; environmental controls; and electrical power regulation. The SV 1 satellite’s network communication equipment subsystem that interfaces with the ground control segment and distributes data throughout the space vehicle also passed all tests as expected.

GPS III SV 1’s navigation payload, which is being produced by ITT Exelis, will be delivered to Lockheed Martin’s GPS Processing Facility (GPF) near Denver later in 2013. The hosted nuclear detection system payload has already been delivered and mechanically integrated. The satellite remains on schedule for flight-ready delivery to the US Air Force in 2014.

Lockheed Martin is currently under contract for production of the first four GPS III satellites (SV 1-4), and has received advanced procurement funding for long-lead components for the fifth, sixth, seventh and eighth satellites (SV 5-8).

**MX-LVSS Unveiled**

L3 Wescam recently unveiled its new Land Vehicle Surveillance System, the MX-LVSS. Based on its leading MXSeries of multispectral, highly stabilised imaging systems, the MX-LVSS is a modular and rugged solution consisting of mast-mounted and remote-mounted surveillance suites with an integrated vehicle operator control station. According to the company, the rugged system, adaptable to a wide range of platforms, obtains timely and accurate surveillance data on surrounding terrain and adversaries, day or night, while the host vehicle is stationary or on-the-move, mast-mounted or dismounted, in all weather conditions.

“As a turnkey ground vehicle ISR
solution, the MX-LVSS provides state-of-the-art stability technology to ensure agile, responsive and adaptive surveillance. This greatly expands mission capability in real-world scenarios where the host vehicle is moving,” said Paul Jennison, Vice President of Government Sales and Business Development for L-3 Wescam. “The system’s scalable design supports a full range of surveillance capability and complexity, providing our customers around the world with system-level solutions customised to their precise specifications and budget. The new system is ideally suited for multiple platforms, such as the upcoming Canadian Light Armoured Vehicle (LAV) Recce Surveillance System (LRSS).”

The MX-LVSS’ performance is configurable from a basic mid-range surveillance capability with variable sensor payloads to a powerful long-range system with integrated ground surveillance radar. This flexibility extends to the host vehicle’s interior, with capability ranging from a basic localised sensor control package to a robust and fully integrated mission management system supporting the collection, storage, processing, manipulation, fusion and digital sharing of sensor data and imagery across the battlefield to enhance situational awareness at all levels.

BAE Systems Bags Geospatial Imagery Contract from DHS

The Geospatial Management Office within the Department of Homeland Security (DHS), US, has selected BAE Systems to provide geospatial imagery and analysis for real-time intelligence products. This award identifies BAE Systems as one of the four prime contractors on DHS’s Remote Sensing Services to Support Incident Management and Homeland Security Indefinite Delivery Indefinite Quantity (IDIQ) contract. The ceiling value of all task orders to be released under the five-year IDIQ is USD 50 million.

BAE Systems’ intelligence experts will acquire, process and disseminate geospatial data and airborne imagery to produce high-resolution maps that reflect current environmental conditions. The data will be used to produce real-time intelligence products to support a variety of DHS missions like emergency management of natural and manmade disasters, and security planning for special events. The geospatial intelligence products may also be used to assist public safety and law enforcement with tactical planning and incident response.

Raytheon Anschuetz Brings New Training Simulator Onboard

A new onboard navigation simulator that allows operators to train with the system they will use at sea was recently unveiled. Raytheon Anschuetz, a German based, indirect, wholly-owned subsidiary of Raytheon Company, has developed the embedded, simulation-based training system in partnership with Canadian-based Virtual Marine Technology (VMT).

A flexible solution, the simulator can be carried onboard a ship in harbour or installed on deployed ships, eliminating the need to conduct only shore-based operator training. If needed, the simulator features an upgraded visualisation system to provide the realism to support effective, land-based training as well, added the company.

The comprehensive training solution incorporates a complete set of scenarios, environmental conditions, geographic navigation options, and vessel types to simulate a wide range of training exercises and mission objectives. Fully integrated with Raytheon Anschuetz’s Synopsis Intelligent Bridge Control System, the training system leverages the platform to provide operators effective and efficient real-world training with the actual navigation system, said the company.

New Malware-Detection Product to Protect Against Targeted Inbound Threats

General Dynamics Fidelis Cybersecurity Solutions has introduced Fidelis XPS Vector, a new product in the Fidelis XPS portfolio that provides comprehensive detection, analysis and prevention against inbound malware and associated command and control traffic. Fidelis XPS Vector protects customers against both common and targeted malware and exploits used by adversaries to penetrate networks.

According to the company, Fidelis XPS Vector can analyse hundreds of inbound objects per second and can block sessions containing malware. It identifies and extracts malicious content hiding in e-mails, instant messages, Microsoft Office files, PDFs and various other formats that are sent through applications such as social networks, web mail and over all Internet protocols including HTTP, SMTP and FTP. Once the malware is detected or blocked, security practitioners are instantly alerted with a detailed analysis report that includes information about the source of the malware, the decoding path, details about the protocol, encoding and compressions and execution forensic details.

Fidelis XPS Vector includes an integrated management console and network sensor that starts detecting inbound malware immediately after being installed. It requires no configuration or tuning, and automatically receives updates from Fidelis Insight Threat Intelligence Feeds. As requirements and needs for visibility and detection across the entire threat lifecycle expand, customers can easily upgrade to other Fidelis XPS solutions to provide
Trimble recently introduced its next generation Unmanned Aircraft System (UAS) — the Trimble UX5 aerial imaging rover with the Trimble Access aerial imaging application. The new solution builds upon the strengths of its predecessor, the Trimble Gatewing X100, to offer enhanced image quality and intuitive workflows. Combined with the Trimble Business Center photogrammetry office software module, the Trimble UX5 is the first complete UAS photogrammetric mapping solution specifically designed for surveyors and geospatial professionals, said the company.

**Intuitive Workflows and Automated Procedures**

The new Trimble Access aerial imaging application is field software for planning UAS missions, performing flight checks and monitoring flights—all with intuitive workflows.

**Enhanced Imagery**

Incorporating a mirrorless 16-megapixel camera with a fixed focal-length external lens, the Trimble UX5 provides high-resolution imagery and accurate deliverables. The large field of view from the camera allows the UX5 to cover 50-75 per cent more area to enhance efficiency and reduce operational costs. In addition to the increase in flight efficiency, the Trimble UX5 is capable of producing 3D surface deliverables with a ground sampling distance of approx. 2.4 cms (about 1.0 inch).

**Durability and Performance**

Designed to operate in real-world conditions, the Trimble UX5 is capable of flights between 75 and 750 meters (approximately 246 and 2,460 feet) above ground level and can be flown in light rain and windy conditions, up to 65 kph (approximately 40 mph).

**Powerful Deliverables**

Orthophotos, contour maps, point clouds, digital surface models (DSMs) and feature maps can easily be created from aerial images using the Trimble Business Center photogrammetry module. Single-click processing for stitching images streamlines the office process for generating powerful deliverables.

In addition to producing these powerful photogrammetric deliverables, Trimble Business Center allows surveyors and other geospatial professionals to combine aerial photography with data collected from GNSS receivers, total stations, 3D laser scanners and more, for a one-of-a-kind integrated solution. By easily combining imagery from the Trimble UX5 and any Trimble VISION instruments, users can visualise their project from both aerial and terrestrial perspectives, measure points within the images and create 3D models of the infrastructure and terrain, said the company.

**Nga to Overhaul its Products**

The National Geospatial-Intelligence Agency (NGA) of the US is reported to be working on rebuilding its entire geospatial model. The agency is said to be looking for a contractor which can convert its holdings into text and Open Geospatial Consortium formats. According to reports, this is being done due to an increasing volume in demand for maps and related data from the Pentagon.

NGA currently provides geospatial data to military agencies in formats which cannot be easily shared.

**Raytheon Acquires Analytics Business**

Raytheon Company has acquired a privately held company, Visual Analytics Incorporated, thus extending its capabilities to meet the data analytics, data visualisation and information sharing needs of its...
Far below, according to the University of Michigan. “For the defence and intelligence communities, this could add a new set of eyes,” said Mohammed Islam, Professor of electrical engineering and computer science and biomedical engineering at the University.

The system, which is made of off-the-shelf telecommunications technology, emits a broadband beam of infrared light. While most lasers emit light of one wavelength, or colour, supercontinuum lasers like this one give off a tight beam packed with columns of light covering a range of wavelengths – a blend of colours. Because this beam is in the infrared region, it is invisible to human eyes. But it can illuminate deep information.

New Eyes for Military

A new laser that can show what objects are made of could help military aircraft identify hidden dangers such as weapons arsenals far below, according to the University of Michigan. “For the defence and intelligence communities, this could add a new set of eyes,” said Mohammed Islam, Professor of electrical engineering and computer science and biomedical engineering at the University.

“Faster, More Precise Airstrikes Within Reach

Air-ground fire coordination — also known as Close Air Support or CAS — is a dangerous and difficult business. Pilots and dismounted ground agents must ensure they hit only the intended target using just voice directions and, if they’re lucky, a common paper map. It can often take up to an hour to confer, get in position and strike — time in which targets can attack first or move out of reach. To help address these challenges, DARPA recently awarded a contract for Phase II of its Persistent Close Air Support (PCAS) programme to the Raytheon Company of Waltham, Massachusetts, US. PCAS aims to enable ground forces and combat aircrews to jointly select and employ precision-guided weapons from a diverse set of airborne platforms. The programme seeks to leverage advances in computing and communications technologies to fundamentally increase CAS effectiveness, as well as improve the speed and survivability of ground forces engaged with enemy forces.

PCAS designs currently include two main components, PCAS-Air and PCAS-Ground. PCAS-Air would consist of an internal guidance system, weapons and engagement management systems, and high-speed data transfer via ethernet, existing aircraft wiring or wireless networks. Based on tactical information, PCAS-Air’s automated algorithms would recommend optimal travel routes to the target, which weapon to use on arrival and how best to deploy it. Aircrews could receive information either through hardwired interfaces or wirelessly via tablet computers.

PCAS-Air would inform ground forces through PCAS-Ground, a suite of technologies enabling improved mobility, situational awareness and communications for fire coordination. A HUD eyepiece wired to a tablet computer like that used in PCAS-Air would display tactical imagery, maps and other information, enabling ground forces to keep their eyes more on the target and less on a computer screen.

SafeNet and Oceus Networks Join Hands

SafeNet, Inc., one of the leaders in data protection, and Oceus Networks Inc., a leading provider of broadband solutions to government agencies and industry, have announced an agreement to jointly secure the US Defense Department’s (DoD) operational deployment of Fourth Generation Long-Term Evolution (4G LTE) for field operations. Oceus Networks will integrate SafeNet’s security framework for mobile devices into its Xiphos family of mobile

customers. “The addition of Visual Analytics will further strengthen Raytheon’s capabilities in the area of data analytics,” said Lynn Dugle, President of Raytheon’s Intelligence, Information and Services (IIS) business. “This will allow us to bring new, innovative visualisation offerings to our customers as they address the continuous challenge of increasing analyst efficiency and effectiveness while transforming data into actionable intelligence.”

New Eyes for Military

A new laser that can show what objects are made of could help military aircraft identify hidden dangers such as weapons arsenals far below, according to the University of Michigan. “For the defence and intelligence communities, this could add a new set of eyes,” said Mohammed Islam, Professor of electrical engineering and computer science and biomedical engineering at the University.

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UK Selects ScanEagle

In order to boost its surveillance and reconnaissance capabilities, UK’s Ministry of Defence is said to have entered into a contract worth about USD 45 million with Boeing to purchase an unarmed ScanEagle UAV. The drone with an over three-metre wingspan weighs 22kg and is capable of flying at around 60 knots. It can be launched by a pneumatic catapult from the ships’ deck. Manufactured by Boeing’s subsidiary Insitu, ScanEagle is said to be the first drone ever designed specifically for the purpose of maritime operations.

L-3 Wescam Launches Two Products at the Paris Air Show

L-3 Wescam recently announced the launch of two new products that directly reduce the costs associated with development testing and the sustainment of fielded electro-optical/ infrared (EO/IR) surveillance and targeting systems. The new MX-Emulator and MX-RAid products support L-3 Wescam’s portfolio of MX-Series systems for military, internal security and airborne law enforcement use.

According to the company, the launch of the MX-Emulator enables system integrators and OEMs to dramatically reduce the System Integration Lab (SIL) development costs associated with critical integration activities. Engineered to replicate the exact functionality of airborne and ground-based MX systems, the MX-Emulator provides connectivity to all standard control systems, including handcontrollers, operator control units, joysticks and mission grips. L-3’s concurrent launch of the MX-RAid, Internet version, provides a remote diagnostic capability for the evaluation of fielded MX-Series EO/IR systems, said the company, adding, this exclusive capability gives L-3 Wescam’s customers immediate access to an in-house factory technician who can diagnose in-service system issues from afar.

Originally conducted over a satellite connection, this new Internet-based connection option provides a data link between an L-3 Wescam technician and the fielded MX-Series system, enabling live video, voice or text chat capability, and the streaming of live system video. The MX-RAid technology returns some systems to operational status from the field and reduces the number of systems being sent to service facilities with ‘No Fault Found’ (NFF) systems issues.

Saab Receives Order for the Underwater Vehicle System AUV62

Saab recently signed a contract with an undisclosed customer for delivery of Autonomous Underwater Vehicle systems, AUV62, in training configuration. The order has a total value of MSEK 148 (about USD 22.5 million) and system deliveries will take place during 2014.

Equipped with an acoustic payload, AUV62 is an advanced and capable system for cost efficient training of a navy’s Anti Submarine Warfare (ASW) forces, according to the company. The AUV62 is an artificial acoustic target that mimics a submarine in a way that is compatible with any torpedo- and sonar system available in the
market today, said Saab, adding, the AUV62 system fully replaces the use of a submarine in the role as a manoeuvring training target.

Available in several different configurations, AUV62 is equipped with a Synthetic Aperture Sonar (SAS) payload and is said to be an efficient system for mine search, reconnaissance and seabed mapping.

**SkyView Compact - an All-in-One Integrated C2 System**

ThalesRaytheonSystems has launched SkyView Compact, a new ‘all-in-one’ command-and-control (C2) product packaged in transportable units for easy deployment. This product brings an affordable, off-the-shelf solution that is available at short notice and guarantees interoperability with NATO systems.

SkyView Compact is packaged in transit cases and performs all the key functions of a modern C2 center at execution level. It offers armed forces a scalable C2 solution with a high degree of automation and a set of intuitive, easy-to-use tools that help operators to learn procedures quickly while reducing their workload. The product can be delivered within four months, enabling customers to meet any urgent operational requirement for airspace surveillance and protection. It is designed around an open, service-oriented architecture and can also be interconnected with tactical L11 and L16 datalink networks, said the company.

“SkyView Compact packs all the know-how of ThalesRaytheonSystems in air command and control systems into a single ‘all-in-one’ product. It is designed for customers who need a solution that can be implemented quickly, for example, to protect the airspace around a major sporting event or around military forces deployed in a theater of operations,” said Philippe Duhamel, CEO of ThalesRaytheonSystems SAS.

**Defence Cyber Protection Partnership**

The UK Government and a group of Britain’s leading defence and security companies have recently announced that they have joined forces to launch the Defence Cyber Protection Partnership (DCPP), aimed at bolstering security of the country against cyber attack through action within the defence industry.

**Collective expertise**

Recognising that cyber attacks are a serious threat to the security and economic well-being of the UK, the Centre for the Protection of National Infrastructure (CPNI), Government Communications Headquarters (GCHQ), Ministry Of Defence and nine companies, BAE Systems, BT, Cassidian, CGI, Hewlett Packard, Lockheed Martin, Rolls-Royce, Selex ES and Thales UK have come together to use their collective expertise in defending against this threat. The DCPP model is intended to lead the way in industry collaboration and action on cyber security and to act as a useful template which can then be followed by commercial sector.

**Eurofighter Signs Contract for Meteor Integration**

Eurofighter Jagdflugzeug GmbH has signed a weapon system integration contract with NETMA, the NATO Eurofighter and Tornado Management Agency, to facilitate and secure integration of MBDA’s Meteor Beyond Visual Range Missile system. The contract was signed at the Paris Air Show 2013.

The Meteor missile system, integrated with the current class-leading M-Scan radar (and in the future the advanced E-Scan radar) fitted to the Eurofighter, and utilising the full potential of two-way datalink communication, will greatly increase the ‘no-escape-zone’ around the aircraft enhancing both its effectiveness and lethality, said the company.

In December 2012, BAE Systems, one of the four Eurofighter Partner Companies within Eurofighter, completed a test-firing of a Meteor missile from a Eurofighter Typhoon, Instrumented Production Aircraft 1 (IPA1) off the coast of Wales. Further design and test work on the missile system will continue as part of the integration programme as BAE Systems, Cassidian, Alenia Aermacchi embed the system within the programme in the UK, Germany, Italy and Spain.
Photogrammetry is now being integrated into many activities involving geospatial data. This is partly due to the nature of digital data which encourages convergence of data from different sources and partly due to the explosion of different sensors and platforms to collect images. Imaging systems range from traditional aerial photography to LiDAR and radar. Platforms now include unmanned aerial vehicles (UAVs), mobile terrestrial vehicles and satellites as well as the traditional aircraft. Handheld consumer cameras are also a valuable source and images from this type of camera, uploaded on social networks, are also becoming an important source of volunteered geographic information (VGI). Software is now reliable and user friendly and there is a division between high-end software from established vendors to less expensive products from new entries in the photogrammetry software market. Many mapping companies are finding life difficult at the moment, given the weak economic conditions, but the range of applications of photogrammetry is increasing and new companies are emerging to exploit these markets.
WHAT IS PHOTOGRAMMETRY?

Twenty years ago the answer to this question would have been technical in nature, explaining that photogrammetry is the science of deriving accurate three-dimensional information from images. Now the answer is more complex because, although the principle is exactly the same, photogrammetry is embedded in many different processes and the user may be quite unaware of what photogrammetry involves, or what it is. There is less distinction between different branches of geomatics and organisations pick and choose the technique which best suits their purpose. Diagram 1 shows the basic operation of photogrammetry. The central green boxes represent the core component of photogrammetry which requires an understanding of the geometry of images, the principle of collinearity and the importance of accuracy.

The situation is further complicated by the fact that technology has produced new sensors which do not involve images but are processed in a manner similar to imagery. Laser scanners actually measure distance and direction and produce a point cloud which is identical to a point cloud generated from matching stereo images. From these point clouds, we can compute digital elevation models at scales ranging from macro, with accuracies of less than 1mm, to global. The point cloud can be processed in the same way, whatever its source; however, it is generated by different techniques. Laser scanning is done from airborne platforms, often referred to as LiDAR, and from terrestrial scanners. We will consider both laser scanning and image systems as part of photogrammetry. Synthetic Aperture Radar (SAR) also measures distance and can be used to generate DEMs and orthoimages, so we will also touch on it, but in less detail.

Diagram 2 shows the different sensors, data types, processes and products which we may consider as part of the general area of photogrammetry.

The diagram shows the stages in product generation. Note the differentiation between georeferenced images and other products - georeferencing is done in two-dimension and does not require full orientation or a DEM and is not a rigorous product. Ortho images can be accurately registered with orthoimages generated from other data sources and with maps.

ECONOMIC BACKGROUND

There is an undisputed need for accurate information from images. The industry survey carried out by the American Society for Photogrammetry and Remote Sensing (ASPRS) in 2008 (Photogrammetric Engineering &
Remote Sensing, 74(11) revealed that of the 512 responses from 58 nations (mainly from North America and Europe), the majority require geolocational accuracy of better than 1m and that the need for this is greater than the supply, as shown in Graph 1. The ASPRS Industry Forecast was based on a survey in 2007, but still gives a good idea of the current situation:

Previous Forecast reports highlight that the demand for the highest levels of resolution was clearly not met; data users wanted higher resolution content. Phase V shows that this trend continues in the global market. Digital aerial sensors, as well as the continued operation of high-resolution satellite systems, have expanded the global demand for better than half metre data. Provision of data lower in spatial resolution than half metre is now an area of potential overcapacity. LiDAR, hyperspectral and IfSAR were identified as the three data sources that need exceeded current use. Data fusion appears to be considered more in these results than reliance on a single sensor or data source. Satellite sources of data versus aerial sources are used more in developing regions of the world. Restrictions on remote sensing data were viewed as a hindrance in every region of the world. However, the survey indicated that respondents from East and South Asia, Africa and Oceania felt that effects of restrictions on data, licensing and governmental controls most limiting on their activities. The most significant issues that continue to represent large challenges and opportunities with the industry are: the demand versus cost in an uncertain economy for high spatial resolution and new sensor data, both aerial and satellite, meeting the increase in demand for higher levels of education in GIS and newer imaging technologies, and the conflicting roles of national governments in developing remote sensing platforms and products while limiting access and use of data.

CURRENT TECHNOLOGY

Sensors are evolving all the time, driven by the equipment manufacturers. Users respond to this; and software developers follow with improved software packages. Here are the main sensors and software packages.

Sensors

Images now come from many sources, ranging from mobile phones to highly sophisticated digital cameras used on aircraft or satellites. In addition, the use of laser scanning is now widespread. Radar is still the preserve of specialist users, although companies such as Intermapping have used airborne SAR to generate their Nextmap products and the private public partnership of Astrium and DLR is producing global DEMs from Tan-Dem-X. These sensors are used from many types of platforms, ranging from handheld and small UAVs to mobile mapping vehicles carrying cameras and LiDAR to survey aircraft and satellites. Although images are still the main source of data for mapping, a source in Leica says that LiDAR is now a more important source of revenue than cameras.

Digital Cameras

Digital cameras are now mainstream, although there has been a significant diversification from the original cameras from Leica, Z/I, and Vexcel. The use of smaller, less expensive cameras is also widespread. Table 1 shows the characteristics of the large and medium format cameras. These are cameras which replace the 230 x 230mm film cameras from the 1990s. They typically have 9,000-12,000 pixels across track and collect data in panchromatic and multispectral bands. These large format cameras are complemented by smaller cameras from companies such as Trimble and Optech. All of these companies now offer a suite of products acquiring image data and LiDAR. Tobias Toelg from Trimble GeoSpatial tells of a company with a small plane in Africa which first bought a small camera and gradually upgraded to have a full navigation system with a camera and LiDAR.

Satellite sensors are an important source of images for photogrammetric processing. A full review of sensors and description of techniques can be found in ‘High Resolution Optical Satellite Imagery’ by Dowman, Jacobsen and Konecny, published by Whittles Publishing.

Airborne Laser Scanning (ALS) or LiDAR

Airborne laser scanners, often referred to as LiDAR, produce a point cloud which is generated from the measured distance and
orientation of a point from the sensor. Sensors for ALS all have similar characteristics - all collect a number of returns from each pulse and also record the intensity of the return signal. The important parameters which affect accuracy and density of points are the scan rate or scan frequency and the pulse rate of pulse frequency and the flying height. Most systems allow selection of these parameters and manufacturers also offer a range of systems for different applications depending on the flying height. Most systems also record the waveform which allows detailed analysis of the vegetation cover which is very useful for forestry applications.

Table 2 shows some of the airborne LiDAR systems, including the Hawkeye system used for bathymetric measurement.

**Terrestrial Laser Scanning**

Terrestrial laser scanning (TLS) is one of the big success stories of recent years, with a range of scanners in the market now from the major companies including scan arms that reach difficult places and are capable of close range scanning with 0.2mm accuracy. A major new application of laser scanning is to provide data for Building Information Models (BIM). At the moment, the main use of TLS is to provide point clouds of interiors from which as-built drawings can be generated, but within the BIM concept there are other applications including site detail during planning and as-built survey during construction.

**Other Sensors**

There are new sensors now in the market such as Photonic Mixer Device (PMD) ‘Smart-Pixel’ sensors which are able to capture a complete 3D scene in real-time without any moving parts. The sensor works by transmitting a modulated optical signal which illuminates the scene to be measured. The reflected light is detected by the PMD sensor, which is able to determine the time-of-flight per every single pixel. There are also cameras which record texture which would assist interpretation of images.

Another new device is the SpheronVR SceneCam™ which uses high dynamic range imagery and takes two panoramic 360º images from which a 3D scene can be generated. The SceneCenter™ database can be used to manage and archive the images and is used for many applications such as forensics and indoor mapping.

Other techniques which have been around for some time but have not yet been fully exploited are thermal imaging, images sequences, video theodolites and also combinations of sensors in sensor networks.

<Diagram 2: The stages of generating photogrammetric products>

<table>
<thead>
<tr>
<th>Sensors</th>
<th>Digital large and medium format cameras</th>
<th>Digital small format cameras</th>
<th>Consumer quality cameras</th>
<th>LiDAR</th>
<th>Radar</th>
<th>Range cameras</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data</td>
<td>Image</td>
<td>Point clouds</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Process</td>
<td>Georeferencing</td>
<td>Matching</td>
<td>Feature extraction - manual and automatic</td>
<td>Orthorectification</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Data</td>
<td>Georeferenced images</td>
<td>Maps</td>
<td>DEMs</td>
<td>Orthoimages</td>
<td>Visualisations</td>
<td></td>
</tr>
</tbody>
</table>

<< The use of unmanned aerial vehicles is having a big impact on photogrammetry. They have significant advantages over traditional air photography including being highly transportable which allows for rapid mobilisation >>

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<< The use of unmanned aerial vehicles is having a big impact on photogrammetry. They have significant advantages over traditional air photography including being highly transportable which allows for rapid mobilisation >>
PLATFOMS

Mobile Mapping Platforms

Mobile mapping systems were first developed in the 1980s using fairly coarse navigation systems and cameras. The navigation systems have improved using GNSS positioning systems and inertial navigation systems. As the technology has improved, laser scanners have been added to the platform.

Cyclomedia has its own camera systems and has 30 years of experience in developing its camera systems. It has a partnership with the University of Delft in developing the camera systems and already has a ninth generation recording system. Companies like Navteq also operate their own vehicles but the new data source which may be called a sensor is data collected by users on the routes which they are driving which can be used for updating: this is volunteered geographic information (VGI) or crowd sourced data.

Oblique Imagery

Developments in inertial navigation systems and stabilised mounts have allowed the use of oblique imagery. Pictometry is a patented system which captures aerial images of all sides of a building as well as a vertical image from above. These perspectives can then be joined together to form 3D models from which measurements can be taken of dimensions and areas on the building. Swiss company Helimap System SA operates a versatile helicopter to capture oblique images. This has found applications in many areas such as ski resorts and mountain management, cliff mapping as well as the more conventional infrastructure mapping.

Unmanned Aerial Vehicles

The use of UAVs is having a big impact on photogrammetry. Professor Armin Gruen of ETH Zurich says, “It is safe to say that in the years to come, we will see an increase in UAV making activities, both in terms of hardware and software development, a most interesting and challenging area for research, development and practice. This makes a clear transition from toys to tools.” [Geoinformatica 1-2012]. What has made this transition possible are small digital cameras and powerful software which enable large numbers of small format images to be calibrated and oriented through use of photogrammetric block adjustment. UAVs have significant advantages over traditional air photography, including being highly portable which allows for rapid mobilisation. UAVs can also typically operate below cloud coverage, making them less dependent on weather conditions. Systems such as Gatewing and the Sensefly Swinglet Cam come as a complete package, providing mission planning and processing software. They can operate at a flying height of 150 metres above ground level and can achieve a ground sampling distance (GSD) of 5cm. UAVs however are not without problems. The need to obtain permission to fly in many countries and ensuring safe operation and the safety of the public are important issues which require close attention. Academics and amateurs have been using UAVs for a long time, but the UAVs are now being used for commercial mapping.

SOFTWARE

A number of software packages exist for photogrammetric processing. All basic photogrammetric operations can be performed including automatic interior orientation and automatic aerial triangulation with automated blunder detection and self-calibration. Some automation of feature extraction will be provided, although most of this requires human input. Table 3 lists the main packages with key features.

Recent improvements in software packages include improved speed using new architectures and new graphical processing units (GPUs). A key feature of many of these packages is their interface with packages such as ArcGIS and Autocad which enables users of these packages to integrate accurate imagery into their workflow.

Image matching is an important component in photogrammetric software and this is constantly being improved. The semi-global matching method, which matches every pixel and assesses the quality...
of every match, has given improved
generalised results. Remote Sensing Solutions
GmbH and its associate company 3D
Reality Maps are using semi global
matching on satellite images to
produce spectacular 3D visualisations
which are widely used by the tourism
industry, overlain with useful
information about walking trails, ski
runs and hotels, for example.

Another key development in
software has been the introduction
of bundle adjustment packages
which can handle large blocks
collected by UAVs or basic digital
consumer cameras. Photosynth
is a software application from
Microsoft that can take large
number of images and generate
a three-dimensional model from
the photos and a point cloud of a
photographed object. Bundler is a
similar package.

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>Leica Geosystems</th>
<th>Leica Geosystems</th>
<th>Intergraph</th>
<th>Ultracam</th>
<th>Optech</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model</td>
<td>Leica ADS100</td>
<td>Leica RCD30</td>
<td>Z/I DMC II Digital Mapping Camera</td>
<td>Eagle</td>
<td>D-8900 Aerial Digital Camera</td>
</tr>
<tr>
<td>Type of sensor</td>
<td>–</td>
<td>–</td>
<td>Frame</td>
<td>Frame</td>
<td>Frame</td>
</tr>
<tr>
<td>Format size (pixels) across track</td>
<td>20000 pixels</td>
<td>8956 x 6708 pixels single head</td>
<td>12096 x 11,200 pixels</td>
<td>20010 x 13080 pixels</td>
<td>8,984 x 6,732 pixels</td>
</tr>
<tr>
<td>Spectral bands</td>
<td>RGB, Near-infrared</td>
<td>RGB NIR</td>
<td>PAN, RGB, NIR</td>
<td>PAN, RGB, NIR</td>
<td>RGB</td>
</tr>
<tr>
<td>Field of view</td>
<td>Forward 65.2° across track</td>
<td>Range of focal lengths available</td>
<td>50.7°(across track)</td>
<td>–</td>
<td>Range of focal lengths available</td>
</tr>
<tr>
<td>Data storage</td>
<td>Joint volume 2.4TB</td>
<td>–</td>
<td>–</td>
<td>Solid-state disc pack. Unlimited with use of multiple data units with approximately 3.3 terabytes (3,800 images) per unit</td>
<td>Removable storage unit – 800 GB solid state drives, 8,000 images</td>
</tr>
<tr>
<td>Forward motion compensation</td>
<td>–</td>
<td>Yes</td>
<td>Yes</td>
<td>True FMC</td>
<td></td>
</tr>
<tr>
<td>Other cameras in range</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>UltraCamXp, UltraCamXp Wide Angle, UltraCamLp, UltraCam, Broadband, UltraCam, T4800, T7200, T13000, T13000, D13000, T4800</td>
<td></td>
</tr>
</tbody>
</table>

Table 1: Large & Medium Format Imaging Sensors

MAPPING ORGANISATIONS

Companies like Blom, EuroSense,
COWI and Fugro continue to
produce data for a wide range
of clients. The main activities of
mapping companies have not
changed a lot in a long time, and
the demand is still for DEMs, digital
orthoimages and the generation
of data from stereo restitution.
However, the techniques for doing
this have changed and LiDAR is
used for larger scales, particularly
corridor mapping, often using
helicopters. Mapping from
terrestrial sensors is becoming more
important and many companies
report increased demand for
detailed survey using terrestrial
laser scanning and mobile mapping.
Prof. Dr.-Ing. Ralf Schroth, CMD
and Operations Manager, Eastern
Europe, BLOM Romania SRL sees UAV
technology closing the gap between
terrestrial and airborne mapping.

National Mapping Organisations
(NMOs) are major users of
photogrammetry. NMOs such as
OSGB are important in developing
new methods for national mapping
by working with hardware and
software providers to meet their
specific requirements in a rapidly
changing environment. China
has completed an update of the
1:50,000 coverage of the whole
country requiring the use of many
data sources, primarily images,
and the integration of these
data to form a high accuracy,
quality checked product. This,
in turn, required techniques
of image matching, semantic
integration, generalisation,
database management and conflict
resolution. Automatic processing
could be used in many cases, but intelligent human interpretation and judgment remained essential.

The field of use of 3D data is already very wide, covering a lot of applications. A great breakthrough of any new application is not in sight, according to Ralf Schroth. There is still a debate about the use of 3D city models. Ralf Schroth sees the market for 3D city models as already mature as many cities have their own data and commercial Internet suppliers like Google, Microsoft or Blom are even partially delivering these data for free.

There has also been an increase in the number of companies primarily concerned with collecting images over wide areas as a speculative venture and selling finished products, usually orthoimages, off-the-shelf to customers. These include satellite operating companies who provide visualisation and image analysis services. The products which these companies offer make use of photogrammetric software. Saab Rapid 3D Mapping™ is of particular note because of the near real-time production of 3D models. Many of these products are aimed at the defence market. Companies such as Astrium offer special services. Astrium has announced Go Monitor which will detect changes anywhere in the world using satellite imagery and image analysts from different thematic areas.

THE FUTURE

Research in photogrammetry is still focussed on automation; the large volumes of data available today make this necessary and the cloud assists in making it possible. A number of areas of research have been active for a long time, such as building reconstruction: these are difficult areas and will probably not move to production in the near future. There is also a lot of research being undertaken in automatic building reconstruction and extraction of road networks. Processing of point clouds is a continuing area for intense research. Data fusion, of images and laser scanning data, is another important research area. Registration of data sets is important as a result of the many sources of data available.

The rapid generation of photorealistic 3D scenes has been made possible because of new image matching software. While development of this will continue, one of the challenges which users face is whether to use laser scanning to collect point clouds directly or to use photographs and image matching.

We have seen that UAVs are emerging as very important source of data. The development of this technique will continue. The use of a swarm of such platforms is one possibility and the improvement of accuracy using new techniques for camera calibration and bundle adjustment will be developed.

VGI will also develop. Professor Dieter Fritsch of the Institute for Photogrammetry, University of Stuttgart, opines that VGI will become increasingly important and

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>Leica</th>
<th>Trimble</th>
<th>Hawkeye</th>
<th>Reigl</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model number</td>
<td>ALS70</td>
<td>Harrier 68i</td>
<td>HawkEye™ II</td>
<td>RIEGL VQ-580</td>
</tr>
<tr>
<td>Scan frequency [Hz]</td>
<td>60 – 200Hz</td>
<td>10 - 200 Hz</td>
<td>13Hz</td>
<td>25 – 190 Hz</td>
</tr>
<tr>
<td>Pulse frequency (min-max) [Hz]</td>
<td>Max 500 kHz</td>
<td>80 – 400 kHz</td>
<td>4 kHz for bathymetric measurement</td>
<td>50 – 380 kHz</td>
</tr>
<tr>
<td>Max. scan angle (FOV) [deg]</td>
<td>0° – 75°</td>
<td>45°-60°</td>
<td>-</td>
<td>60° (+30° / -30°)</td>
</tr>
<tr>
<td>Max. no of recorded echoes/ pulse</td>
<td>Unlimited</td>
<td>-</td>
<td>-</td>
<td>unlimited</td>
</tr>
<tr>
<td>Full-wave form digitisation</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Recording of intensity of return signal</td>
<td>Yes</td>
<td>Yes</td>
<td>-</td>
<td>Yes</td>
</tr>
<tr>
<td>Data storage</td>
<td>Removable 500 Gb SSD*</td>
<td>Portable</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Platform types</td>
<td>Fixed wing a/c, helicopter</td>
<td>Fixed wing a/c, helicopter</td>
<td>-</td>
<td>Helicopters or UAVs</td>
</tr>
<tr>
<td>Maximum flying height [m]</td>
<td>ALS70-CM: 1 600m ALS70-HP: 3 500m ALS70-HA: 5 000m</td>
<td>1600 m</td>
<td>250 - 500 m</td>
<td>5 000 m</td>
</tr>
<tr>
<td>Comment</td>
<td>Different models for different applications</td>
<td>Other systems available</td>
<td>Dual wavelength for bathymetric measurement</td>
<td>Range of systems available, can be integrated with camera.</td>
</tr>
</tbody>
</table>

Table 2: Airborne Lidar

*SSD - solid state disk
will be able to meet NMOs’ accuracy standards; data will be stored in the cloud and software will be developed to conflate VGI data from different sources. VGI will extend to 3D and Professor Fritsch is developing an ‘app’ for 3G phones and tablets which will allow a 3D model to be generated from photographs taken of the building or object. It is not clear how VGI will fit into existing business models, nor whether the information will be used by NMOs. The new catchphrase for photogrammetry is ‘the crowd and the cloud’.

New applications are being developed all the time. Bathymetric LiDAR of coastal waters is well established but work is now on to use LiDAR over inland streams to obtain accurate channel depth to enable modelling of river flow to obtain in-depth understanding of hydrological processes. LiDAR can also be used to determine water level in turbid reservoirs and to obtain information on forest structure.

**CHALLENGES**

The basic principles of photogrammetry are well established and an essential part of extracting information from images and data from laser scanning and radar. It seems unlikely that there will be major changes in the techniques and implementation of photogrammetric principles. There will undoubtedly be improved sensors and improved software and research will be needed to implement these. The standard mapping programmes for photogrammetry applications will be reduced in their traditional markets like Western Europe but will still be requested in developing areas like the emerging markets in Asia and Latin America and where no general cadastre information is available.

The challenges in doing this are summarised as:

- Restrictions on data collection, for example, restrictions on flying photographic missions, collecting information on roads for in-car navigation and flying UAVs.
- Continued supply of data from earth observation satellites at an affordable price.
- Availability of software which can be used by users unfamiliar with photogrammetry to generate their own specialist information, alternatively to sell photogrammetry as a commodity: users giving data to bureaus to produce the necessary products such as orthoimages and visualisations.
- Responding to emergencies and other urgent needs to provide data in real-time.
- Educating students on the principles of photogrammetry and preventing the reinventing of photogrammetry.
- Expanding the applications of imagery.

We can see that photogrammetry is an essential component in new developments in imagery; the use of UAVs and 3D VGI depends upon accurate rigorous photogrammetric models; many applications using terrestrial laser scanning, such as BIM, require the rigorous processing deriving from photogrammetry and of course there is a universal need for orthoimages and 3D data derived from images.

---

<table>
<thead>
<tr>
<th>Company</th>
<th>Product</th>
<th>Key features</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hexagon Intergraph/ ERDAS</td>
<td>LPS ERDAS Imagine</td>
<td>Leica Photogrammetric Suite (LPS) and ERDAS Imagine are part of the Hexagon range</td>
</tr>
<tr>
<td>Trimble</td>
<td>Inpho</td>
<td>Well developed InPho software, works with ArcGIS, Microstation and AutoCAD. eCognition is also in the Trimble range</td>
</tr>
<tr>
<td>BAE Systems</td>
<td>SOCET GXP</td>
<td>GXP Xplorer data management</td>
</tr>
<tr>
<td>PCI</td>
<td>Geomatica</td>
<td>Includes GXL professional production, geoimaging tools for ArcGIS and GXL Geoimaging Accelerator</td>
</tr>
<tr>
<td>DAT/EM</td>
<td>Summit Evolution Professional</td>
<td>Based on DAT/EM workstation; the software generates data for ArcGIS, Microstation and AutoCAD</td>
</tr>
</tbody>
</table>

*Table 3: The principle photogrammetric software packages*
Effective Multi-Sensor Data Fusion

Although experienced military analysts can develop tactical situation awareness by combining multisensory-derived information fragments, the automation of this process presents significant challenges...

The advent of new information technologies has enabled commanders to know more about the enemy, plan faster, make decisions faster and synchronise sensors and shooters to create desired effects on the battlefield. Network Centric Warfare (NCW) focuses on the combat power that can be generated from the effective linking or networking of the war fighting enterprise.

NCW is executed by means of three vertically linked grids: the sensor, shooter and information grids. All three are interconnected – actions flow from sensors through decision makers to shooters. Tactical data fusion supports effective operational planning and its execution by attempting to provide battlefield commanders with complete and timely situation awareness. Traditionally, much of the sensor derived information has been analysed by humans. As a result of the ever increasing volume of sensor data and the continually shrinking decision making timelines, increased automation of the situation development process is required that involves development of strong algorithms catering to the tactical requirements.

Tactical Battlefield Characteristics

Ideally, tactical situation development systems should be designed using a top down requirements-driven approach. The overall information requirements would first be identified; next, the optimal sensor mix meeting those information requirements would be determined and necessary enhancements to existing systems would be selected. However, due to a wide range of doctrinal, financial and practical considerations, most data fusion systems are actually developed using a more bottom-up approach that focuses primarily on information combination methodologies.

Tactical battlefield characteristics can be classified under two main heads namely, static analysis requirements and dynamic analysis requirements.

Static Analysis Requirements

Sensor Performance Limitations: All practical sensor systems possess performance limitations, including most notably limited range sensitivity and resolution. The use of multiple single-source sensors provides at least three means for overcoming individual sensor limitations.

» Overall system performance can often be improved by using multiple sensors

» Each sensor with overlapping coverage can enhance collection system reliability

» Use of multiple cooperating sensors can often extend the inherent capability of a sensor class

For instance, although SIGNT sensors fundamentally provide azimuth – only target information, multiple cooperating SIGNT collectors using triangulation or Time Difference of Arrival techniques permit range determination, as well as enhanced azimuth resolution. By the same token, target and signal masking by terrain and foliage can potentially be reduced by employing multiple single source sensors operating from significantly different vantage points.

Sensor Capability Limitations: All sensor classes suffer limitations in terms of their ability to measure target attributes. If mapping between target attributes and sensor capabilities for a number of sensor classes is carried out, the two observations are apparent. First, no sensor class provides complete
target characteristics. Second, sensor classes tend to measure overlapping subsets of target attributes. The combinations of information derived from relatively independent measurements potentially generate a more complete target characterisation than if the measurements were highly correlated. Thus, sensor classes that measure relatively independent attributes tend to be the most complementary. For example, since MTI radars measure features associated with the object’s size and motion, SIGNT sensors provide information about a target’s onboard radar and or radios, and imagery (satellite/ UAV) characterises object’s physical appearance, the three sensors provide highly complementary information.

Object Organisations: In addition to detailed targeting level, information against individual tactical objects, effective situation understanding requires a more global evaluation, including the identification and attribution of military units at multiple echelons. Since most sensors provide information about individual physical objects (radar, tanks, command posts, aircraft), multiple object organisations must be recognised based on observed or inferred relationships among objects. Multiple object templating typically relies heavily on historical and/ or doctrinal knowledge.

Physical World Constraints: As the terrain can impose significant constraints on mobility, observability and vulnerability of both individual entities as well as organisations of entities, effective situation development requires that sensor data analysis be sensitive to relevant domain constraints. The sensitivity of fusion tasks to domain context can vary greatly. Strictly, statistical-based algorithms tend to be appropriate for tracking targets that obey well-understood physical motion models like tracking a ballistic projectile or those which are not highly constrained by the environment like tracking ships in the open ocean. Although a ship’s motion is constrained by performance bounds such as its maximum velocity, acceleration and turning rate - such parameters provide very weak constraints on target motion. Ground-based vehicles, on the other hand, exhibit complex behaviours that can be highly constrained by domain features such as roads, rivers and terrain. Consequently, for ground target applications, strictly statistical target tracking algorithms tend to be under constrained.

Real-Time Analysis Requirements: In general, data fusion algorithms need to operate within a time scale appropriate to the applications. Domain sensitive target tracking algorithms for air defence applications, for instance, might require analysis to be completed with less than 1 sec latency, resulting in potentially very demanding algorithm performance requirements. The performance requirements for many higher level fusion tasks, on the other hand, operate on a much longer decision cycle. The identification of a river bridging operation is an example of a considerably less time critical analysis task. Latency associated with both the local processing and distribution of sensor-derived information imposes additional constraints on the timeliness of intelligence generation. Since the computational resources in a tactical environment tend to be limited, achieving real-time performance across all applications can present a significant challenge.

Dynamic Analysis Requirements

Dynamic, Time Varying Situations: In a battlefield, targets may be moving at one instant of time and stationary at another, communicating during one interval and silent during another. The four mutually exclusive target states can be defined as:-

- moving/ non-emitting
- moving/ emitting
- Non-moving/ non-emitting
- Non-moving/ emitting

Since many entities will change between two or more of these four states over time, the situation awareness product must be continuously maintained. As a result, data fusion algorithms require a recursive analysis element. Table I shows mapping between these four target states and a wide range of sensor classes. As can be observed, the ability to track entities through these state changes effectively demands multiple source data.

<p>| Table 1: Sensor Classes vs Four Primary Target Classes |
|-------------|----------------|----------------|------------|----------------|---------------|-----------|---------------|</p>
<table>
<thead>
<tr>
<th>Target classes</th>
<th>MTI Radar</th>
<th>SAR</th>
<th>Laser Radar</th>
<th>COMINT</th>
<th>ELINT</th>
<th>FLIR</th>
<th>Optical</th>
<th>Acoustics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moving/ Emitting</td>
<td>**</td>
<td></td>
<td>**</td>
<td>**</td>
<td>**</td>
<td>**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moving/Non Emitting</td>
<td>**</td>
<td></td>
<td>**</td>
<td>**</td>
<td>**</td>
<td></td>
<td></td>
<td>**</td>
</tr>
<tr>
<td>Non-moving/ Emitting</td>
<td>**</td>
<td>**</td>
<td>**</td>
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</tr>
<tr>
<td>Non-moving/Non-Emitting</td>
<td></td>
<td>**</td>
<td></td>
<td>**</td>
<td>**</td>
<td></td>
<td></td>
<td>**</td>
</tr>
</tbody>
</table>
Complex Behaviour of Individual Objects: In general, individual targets exhibit complex patterns of behaviour that can help discriminate object classes and identify activities of interest. Consider the scenario of the movement of a missile transporter/erector/launcher (TEL) vehicle between the two time intervals, that is, time t0 and time t6 as under:

» At t0, the vehicle is in a location that makes it difficult to detect.
» A t1, the vehicle is moving along a dirt road at velocity V1.
» At t2, the vehicle is moving and begins communicating with its support elements.
» At t3, the vehicle is travelling off-road at velocity V3 along a minimum terrain gradient path.
» At t4, the target has stopped moving and is beginning to erect its launcher.
» At t5, just prior to launch, radar emissions begin.
» At t6, the vehicle is travelling to a new hide location at velocity v6.

Table 2 identifies sensor classes that could contribute to the detection and identification of the various target states. At the lowest level of abstraction, observed behaviour can be interpreted with respect to a highly local perspective as indicated in column 6. By assuming that the object is executing a higher level behaviour progressively more global interpretation can be developed as listed in columns 7 and 8.

Coordinated Behaviour of Groups of Objects: Since individual battle space objects are typically organised into operational or functional-level units, observed behaviour among groups of objects can be analysed to generate higher level situation awareness products.

Limited Sensor Assets and Sensor Availability: Due to sensor resource limitation, available collection assets must be effectively and efficiently managed. Even as the generation of unnecessary or redundant information can overwhelm the data analysis and information dissemination process, ineffective collection management may prevent more important information from being collected and utilised. Once adequate information about a particular target has been obtained, the utility of continued collection may be low. Thus, collection requirements must be constantly re-evaluated based on both the commander’s guidance and the current situation awareness product short falls. Because only a limited number of the supporting assets might be locally controllable and only a subset of these assets might be available for re-tasking, collection management will necessary be sub-optimal. Further, complicating the collection management process are latencies associated with onboard sensor analysis and reporting.

Deception: In general, the use of extensive problem domain knowledge and the fusion of multiple source data can minimise the impact of intentional deception on the situation development process. Deep problem knowledge permits

<table>
<thead>
<tr>
<th>Status/ Class</th>
<th>Emission</th>
<th>Velocity</th>
<th>Contributing Sensors</th>
<th>Interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 NM/NE</td>
<td>0</td>
<td>SAR, Imagery Video FLIR</td>
<td>Light Foliage Concealment Hide</td>
<td></td>
</tr>
<tr>
<td>1 M/NE</td>
<td>V1</td>
<td>MTI, FLIR Video</td>
<td>Road association High speed mobility</td>
<td></td>
</tr>
<tr>
<td>2 M / E</td>
<td>Comm. Type I V2</td>
<td>MTI, Video FLIR,COMINT</td>
<td>Road association, C2 Network active High speed mobility Coordination</td>
<td></td>
</tr>
<tr>
<td>3 M/NE</td>
<td>V3</td>
<td>MTI, FLIR Video</td>
<td>Off Road Good mobility Local Goal Seeking</td>
<td></td>
</tr>
<tr>
<td>4 NM/NE</td>
<td>0</td>
<td>SAR, Imagery Video, FLIR</td>
<td>Open, Flat, Good Mobility &amp; Visibility Tactical Activity/ Staging area</td>
<td></td>
</tr>
<tr>
<td>5 NM/E</td>
<td>Comm Type I &amp; II, Radar 0</td>
<td>SAR,FLIR Imagery Video, SIGINT</td>
<td>Coordination, Pre launch Tx Launch Indication</td>
<td></td>
</tr>
<tr>
<td>6 M/NE</td>
<td>V6</td>
<td>MTI, FLIR Video</td>
<td>High Speed travel Road Seeking Move to Hide</td>
<td></td>
</tr>
</tbody>
</table>

M, Moving, E: Emitting, NM: Non Moving, NE: Non Emitting
the identification and exploitation of inconsistencies in sensor-derived measurements. Although single sensor deception is relatively easy to perpetrate, effective multisource deception can be considerably difficult. For example, while inflatable rubber tanks might be indistinguishable from real ones when based strictly on overhead imagery, the consideration of SAR and/or FLIR imagery may reveal that the targets do not process either the electromagnetic signature or thermal properties of operational tanks. Thus, complementary sensors can play a key role in identifying deliberate deception.

**Situation Awareness Requirements**

Based on the above tactical battle space characteristics, three high-level situation awareness development requirements can be identified. Each of these requirements is discussed in the succeeding paras.

**System Level Requirements:** Three classes of system level requirements exist - adequate input information; adequate communication bandwidth and computational capability, and effective collection management. Performance and capability limitations of individual sensors can be at least partially offset by employing multiple single-source sensors as well as multiple-source sensors. High performance hardware and adequate communication bandwidths are required to support real-time operational requirements of situation awareness development. Based on the commander’s guidance, collection plans must be developed for all organic assets that optimally support the information needs of the situation development process. In addition to identifying the optimal spatial coverage of the sensor suite as a function of time, effective control requires the selection of individual sensor parameters such as mode, frequency band and resolution. Due to the dynamic nature of the battle space, dynamic re-planning is an integral part of the collection management process.

**Algorithm Requirements:** Based on the aforesaid discussion, four primary algorithm requirements can be identified which are robustness, context-sensitivity, efficiency and recursive update potential. In general, achieving robust performance requires model-based reasoning that employs deep problem domain knowledge. This ability to generate multiple level of abstraction characterisations of the battle space is a critical aspect of effective situation awareness development. In many real-world applications, the use of non-context sensitive fusion algorithms tends to generate ineffective, inaccurate and inconsistent products. Strictly statistical based tracking of ground vehicles might exhibit extensive track association and fragmentation errors. On the other hand, the consideration of non-sensor derived context such as local, natural and cultural features, provide constraints that can focus the reasoning process as well as specialise the fusion product. The potentially valuable, context-sensitive reasoning can require the maintenance of extensive domain databases and support for sophisticated spatial reasoning. Due to real-time performance requirements and the limited computational resources available in a tactical environment, the computational efficiency of fusion algorithms is an important consideration. Problem-solving approaches that possessed large state space representations and rely on global optimisation, for instance, tend to generate high computational requirements. When fusion tasks do not lend themselves to efficient closed form solutions, algorithm efficiency can often be enhanced by problem decomposition, the use of powerful heuristics and/or top down reasoning. Top down reasoning, in turn relies on multiple level of abstraction and multiple resolution representations that support the determination and hierarchical refinement of global solutions.

Due to the time varying nature of tactical situation and latencies associated with both the analysis and dissemination process, dynamic truth maintenance is an underlying requirement in many data fusion applications. As additional information becomes available, refinements or even significant corrections in interpretation may be required. Viewed from the perspective, truth maintenance is really a special form of temporal reasoning.

**Support Function Requirements:** Data fusion automation requires two general classes of infrastructure support, database management system and generic functional software. Database requirements include support to algorithm development and efficient access and manipulation of potentially extensive non-sensor derived domain knowledge bases. At a minimum, fusion algorithms can require support for spatial, temporal and hierarchical reasoning. The database management system, in turn must provide efficient support to these reasoning classes.

**Conclusion**

An effort has been made to present a brief view on the requirements of the tactical situation development process. Based on this, a matrix depicting relationship between the characterisation of tactical problem domain and fusion requirement can be drawn which can lead to effective multi-sensor data fusion.
New Challenges for Sensor Simulation

How to incorporate the real world into the virtual one? This is the challenge facing the military sensor simulation industry throughout the world. And the advancement of technology is only making things tougher...

High-fidelity, real-time sensor simulations have always been constrained by the cost, capability and availability of technology. In the past, the imagination of simulation engineers often exceeded that of widely-available equipment, resulting in hardware-based solutions that were costly to build and difficult to maintain. Thus, in the early days of simulation, the primary challenge faced by engineers was cost-effectively modelling a particular sensor.

With the advent of affordable PC, computing technologies, engineering professionals soon developed the resources needed to implement complex models of various sensor systems. But, while they found it difficult to model a specific sensor in the past, advancement in technology has shifted the challenge of simulation from modelling a sensor to modelling the environment.

Challenges of the Past: Modelling the Sensor

One of the earliest radar simulations was designed in late 1950s by R. K. Moore at the University of Kansas. It was an acoustic simulation using a water tank and piezoelectric transducers to simulate the transmission, delay, reflection and reception of a radar signal. The device could generate a representative radar range trace and thus was useful for research, and aided in radar system design.

By the mid-1960s, glass plates with flying spot scanners were routinely used to generate reasonably good radar displays. The glass plate was a photographic positive of a radar image; when backlit with a uniform light source, a photodiode could be rapidly scanned on the front side to produce a voltage proportional to the radar return. Unfortunately, this system had numerous shortcomings, including the inability to accurately represent angle resolution effects or terrain shadowing due to changes in aircraft altitude.

3D terrain boards were used in 1970s. A vertical video probe was used along with a directional light source, positioned according to the encounter geometry. The light source illuminated a monochrome-coloured terrain model in a manner that created pseudo-radar imagery with fairly accurate shadowing. The system worked, but was cumbersome and inflexible. And while this could represent the occultation effects of altitude change, it lacked the ability to simulate complex effects such as angular resolution.

Another difficulty with early radar simulation was the lack of adequate source data from which to build an accurate landmass database. This problem was abated in the early 1970s with the introduction of the Defense Mapping Agency (DMA) Digital Landmass System (DLMS), the forerunner of Digital Terrain Elevation Data (DTED) and Digital Feature Analysis Data (DFAD). It was not long before these data sources provided the foundation for new simulation methods. By 1980, hardware-intensive radar simulators comprising 800-900 printed circuit boards stuffed with small-scale integrated circuits were common. While unprecedented in capability, they were big, expensive and nontrivial to maintain.

By mid-1980s, several radar simulators were built with minicomputer front ends and array processor back-ends. Unfortunately, these systems shared many of the undesirable characteristics of their predecessors. Hence, simulation pioneers like Dr George Bair of Merit Technologies (and later Cambor Corporation) developed software-only solutions using high-speed, single board computers on a VME bus. This approach proved to be successful, and as computing technology improved, so did the software sensor models.

By 1990, general-purpose computer workstations were powerful enough to replace VME systems, thus setting the stage for steady migration across platform architecture - from large consoles such as Silicon Graphics machines to PC workstations. Over the years,
this trend continued and now, in 2013, it is not uncommon to see high fidelity sensor models running on tablet systems or single board embedded systems.

Challenges of Today and Future: Modelling the Environment

While the simulation industry has dramatically increased the fidelity of software sensor modelling through the use of faster multi-core processors, high speed interfaces such as Gigabit Ethernet, and high-capacity memory and storage devices, the industry is facing a new set of challenges. The advances in hardware technology essentially levelled the playing field for high-fidelity sensor simulations, with low-cost hardware providing an ever-widening array of software developers, a platform upon which complex software-based simulations could run.

While in the past the fidelity of the environment was secondary to modelling the sensor, the tables have now turned; modern complex sensor models are only as realistic as the fidelity of the simulated environment in which they operate. In the training and simulation world, this simulated environment generally includes terrain and cultural databases, atmospheric and weather phenomena, and independent target models.

Challenge 1: Acquisition and Incorporation of High-Resolution Satellite Imagery

Prior to the commercialisation of satellite imagery, which began with the launch of the IKONOS satellite in 1999, the incorporation of imagery in sensor simulation was largely limited to the use of geo-typical textures. These representative samples provided artificial detail across areas of interest, but were not accurate representations of any real region. These techniques worked for a while, but as the fidelity of radar and visual sensors such as Electro-Optical (EO) and Infrared (IR) systems increased, so did the need for high-resolution, geo-specific imagery. Simulating state-of-the-art sensors, such as EO/IR imaging systems that can achieve zoomed-in narrow field-of-views or Synthetic Aperture Radar (SAR) systems that can render high-resolution ground images, require accurate source imagery of comparable resolution. Unfortunately, satellite imagery at needed resolutions are often cost-prohibitive over large areas and either unavailable for many regions of the Earth or are not ideal for simulation use.

Satellite imagery must be processed before incorporation into sensor databases. Typically, it is captured as a high-resolution, panchromatic image (grey-scale captured from all visible colours) and multispectral band images at lower resolutions. Since the multispectral images are obtained at resolutions lower than desired, they are merged with the panchromatic image to produce a single, high-resolution, colourised image. This colorisation process is known as pan-sharpening. Additionally, the satellite imagery must be orthorectified to warp the imagery so that it can be accurately

SAR images generated by Camber Corporation’s Radar Toolkit® incorporating geo-specific satellite imagery
Satellite imagery must be processed before incorporation into sensor databases. Typically, it is captured as a high-resolution, panchromatic image and multispectral band images at lower resolutions. Before labour associated with post-processing is accounted for. Thus, smaller areas of interest are usually identified for which high-resolution imagery would be required. This pre-set designation of interest areas represents a particular inflexibility in a training environment for which an urgent, real-world need for training in a new area can quickly arise.

**Challenge 2: Incorporation of Cultural Data and Material Classification**

In order to accurately simulate the characteristics of various sensor systems, a more thorough representation of the environment is required compared to a typical out-the-window scene, to sufficiently simulate the rendered sensor scene. Material classification is the process of assigning a combination of materials with sensor attributes to each pixel in imagery.

This can be achieved by maintaining an extensive library of material characteristics, and by accurately cross-referencing the materials present in the multi-spectral satellite imagery to those in the library. For each material classification, there is an attribute table that includes spectral reflectance and temperature throughout the diurnal cycle as a function of season, weather and surface azimuth and slope. Through this classification, for example, an IR simulation would be able to determine whether to classify a particular kind of material as hot or cold.

The first challenge of achieving accurate material classification is that it requires source data that includes multispectral imagery covering the spectrum of the sensor to which the database will be applied. For performing material classification of imagery to be incorporated into a radar sensor database, no such multispectral imagery is widely or commercially available. While some level of classification can be performed on colour (RGB) imagery, its resultant fidelity will be limited. Camber has developed database tools specifically for performing material classification for radar sensor databases.

The second challenge of achieving accurate material classification involves the resolution of the multispectral imagery or other commercially available source data. In general, commercially available multispectral imagery is provided in resolutions much coarser than resolution of the visible imagery that would be rendered by the sensor simulation. Alternative sources of data, such as land use/land cover GIS data are only available in even coarser resolutions than multispectral imagery. In addition, it has been found that since land use/land cover data is collected using the human element, numerous errors exist in such data.

The third challenge of achieving accurate material classification involves the process itself. Commercial image mapping tools are available that utilise algorithms to automatically analyse satellite imagery and perform material classification based on a reference materials library. But, in practice, these tools have limited accuracy and the resulting mapping must be carefully and ardously reviewed by human eyes and tuned manually. Alternatively, image mapper tools are available for man-in-the-loop classification on per pixel basis which is a labour intensive and time-consuming process.

**Challenge 3: Accurate Correlation across Multiple Sensor Databases**

High-fidelity landmass databases incorporating high-resolution terrain (that is, elevation) data, cultural and natural features, coastline and inland vector data, and high-resolution, multispectral satellite imagery are essential to the modern military readiness trainer. A further...
requirement is that these individual databases be cross-correlated across the sensor simulations ensuring 100 per cent correlation between each sensor’s rendered scene and operation. Furthermore, to support training operations for rapidly-changing scenarios, these databases including high-resolution areas of interest insets, must be generated and quickly made accessible.

To address cross-sensor correlation, a database toolset has been developed to generate run-time sensor databases directly from the visual polygonal representation. These tools use an industry-standard OpenFlight format as an input. Most visual-based databases are available in this standard polygonal format, thus ensuring that the non-visual and sensor simulation runtime databases are generated from a common source.

Camber has pioneered efforts to completely eliminate the schedule impact and labour costs associated with generating separate sensor databases for each sensor system application, by providing its simulation applications, beginning with its flagship Radar Toolkit® product, as a plug-in to major Image Generation (IG) application providers. Such a configuration allows the IG application to provide the sensor application in run-time with required radar-relevant data to support accurate sensor simulation.

To eliminate the need to generate run-time versions of visual and non-visual sensor databases, the simulation industry is moving towards software products that can render visual and sensor scenes ‘on-the-fly’ in run-time. Labour costs required to generate separate databases are eliminated. And most importantly, the time required to provide a customer with the capability to train time-critical scenarios is greatly decreased. We have developed plug-ins allowing our sensor simulations to support the same rendering methodology.

**Challenge 4: Modelling and Correlation of Simulated Live Actors**

In modern training scenarios, the inclusion of unconventional forces is becoming more prevalent as the scope of military combat operations widens. Twenty or thirty years ago, the scope of actors required to be supported in a training scenario was generally limited to conventional weapon platforms such as surface and sub-surface targets, ground-based vehicles, and airborne fixed-wing and rotary-wing platforms. Physical modelling of these entities was not a time-consuming or costly process as polygonal models supporting such a limited set of entities were widely available to the simulation industry. Additionally, simulation of the reactive behaviours of these entities due to entity-to-entity interaction and resulting weapon modelling was limited in scope and usually well-defined within commercially available data.

With the incorporation of unconventional forces into today’s training scenarios, that scope of entities to be supported has greatly widened to include individual human beings and a wide array of ground and surface targets and weapons. Polygonal models supporting such a wider scope of entities are not as commercially available and require more labour to generate. Additionally, the behaviours of such an array of entities often requires the use of higher-fidelity and costlier simulations such as Computer Generated Forces and Special Automated Forces.

Cross-sensor correlation is also a challenge when generating target models used by various visual and non-visual sensor simulations. We utilise the same design approach as in our terrain database generation process in order to ensure correlation. This approach is based on the use of a common data source when generating individual target models to support each of our sensor simulation applications.

**Conclusion**

As we head into the future, the military community requires cost-effective, high-fidelity trainers that support simulation of sensors that are greatly enhanced in range, resolution and capacity, the correlation and synthesis of track information from multiple sensors, simulation of unconventional forces exercising unconventional behaviours and quick turnaround on the generation of training scenarios that reflect the rapid-response required for modern operations. These needs reflect new challenges to the military sensor simulation industry. These will be met through the innovations of the computing industry providing even faster processing with greater throughput, the entrepreneurship of various customers and the data collection community providing larger and even more accurate data to a competitive international market. And these challenges will be overcome by the sensor simulation industry leveraging the advancements of these partner industries and implementing innovative solutions.

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Although OGC’s current standards can meet many of the emerging markets’ interoperability requirements, much work remains to be done to make heterogeneous sensors and sensor data stores useful for diverse applications...

Wikipedia defines a ‘sensor’ as “a converter that measures a physical quantity and converts it into a signal which can be read by an observer or by an (mostly electronic) instrument.”

A sensor network is a computer accessible network of many spatially distributed sensors to gather information/monitor conditions at different locations, such as temperature, sound, vibration, pressure, motion or pollutants. A Sensor Web refers to web accessible sensor networks and archived sensor data that can be ‘discovered’ and accessed using standard protocols and Application Program Interfaces (APIs).

There are hundreds of millions of Internet/web enabled sensors on, in and around the earth, and the number is growing rapidly.

Standardisation is the key requirement for communicating information about sensors and sensor data and for comparing and combining information from different sensors. The OGC’s Sensor Web Enablement (SWE) standards meet this requirement in the most complex as well as very simple applications. Sensor location is usually a key piece of sensor or sensor data information, and SWE standards make it easy to integrate...
this information into thousands of geospatial applications that implement OGC’s other standards.

Critical Needs and Challenges

Internet-connected sensors are proliferating at a phenomenal rate. Apart from the traditional CCTVs and IR sensors used by security agencies, smartphones typically include a gyroscope, accelerometer, GPS, Wi-Fi, bluetooth, cell, sound, light, magnetic force, time, near-field communications (NFC), compass and a camera. Tiny, inexpensive, network-connected sensors like these are rapidly making their way into vehicles, buildings, transportation networks and many other applications. To produce useful information, such data often needs to be ‘fused’ with map data and/or computer-aided design (CAD) building data, and also text, image, video or sound.

Current standards from the OGC can meet many of these emerging markets’ interoperability requirements, but much work remains to make heterogeneous web-resident sensors and sensor data stores useful to diverse applications that have been developed. Integrating sensors involves semantic understanding of the sensors.

OGC standards provide an important framework for addressing semantics, but more work needs to be done to enable fusion of data from diverse sensor types. Data quality and quality of service are important issues to address in sensor web standards development activities. Indoor location and indoor/outdoor location integration represent significant challenges for many sensor web applications such as energy management and the smart grid. None of these challenges can be met without further standards work. No single company or technology-biased industry association can meet these challenges.

OGC’s Contribution and the Vital Role of Domain Working Groups (DWGs or WGs)

The OGC is inviting technology users and providers to collaborate in promoting SWE standards in new market domains, inviting contributed specifications for possible adoption as OGC standards, and reaching out to other Standards Development Organizations (SDOs). The challenges of ubiquitous computing and sensing require broader participation by SDOs, technology users and providers, and inter-SDO coordination on an unprecedented scale to avoid costly duplication of effort and unintended new standards stovepipes. Here, a key role is played by the DWG. These provide a forum for discussion on key interoperability requirements and issues, discussion and review of implementation specifications, and presentations on key technology areas relevant to solving geospatial interoperability issues.

The SWE DWG members are specifying interoperability interfaces and metadata encodings that enable real-time integration of heterogeneous sensor webs into the information infrastructure. Developers will use these specifications in creating applications, platforms and products involving web-connected devices such as flood gauges, air pollution monitors, stress gauges on bridges, mobile heart monitors and webcams as well as space and airborne earth imaging devices.

The OGC’s SWE Initiative

Planetary scientists first proposed the concept of standardised description files for sensor location in the early ’90s. Subsequent work by NASA, the University of Alabama Huntsville and CEOS (Committee on Earth Observation Satellites) was brought into the OGC in 2001 for prototyping, testing and promotion as its SWE activity. OGC took on the task of standardising sensor communication because every sensor, whether in situ (such as a rain gauge) or remote (such as an earth imaging device), has a location, and the location of a sensor is highly significant for many applications.

In the SWE initiative, OGC members have defined and documented a unique and revolutionary framework of open standards for exploiting web-connected sensors and sensor systems of all types. SWE presents many opportunities for adding a real-time sensor dimension to the web. This has a high level of significance for defence and security, disaster management as well as in other areas like environmental monitoring, transportation management, public safety, facility security, Supervisory Control And Data Acquisition (SCADA) operations, industrial controls, science and facilities management.

The resulting suite of SWE standards – now being widely implemented around the world – enables developers to make all types of networked sensors, transducers and sensor data repositories discoverable, accessible and useable via the web or other networks. OGC standards are downloadable at no charge, for use by anyone.

High Level Architecture

The models, encodings and services of the SWE architecture enable
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Implementation of interoperable and scalable service-oriented networks of heterogeneous sensor systems and client applications. In much the same way that HTML and HTTP standards enabled the exchange of any type of information on the web, the SWE initiative is focussed on developing standards to enable the discovery, exchange and processing of sensor observations, as well as the tasking of sensor systems. The functionality that OCG has targeted within a sensor web includes:

» Discovery of sensor systems, observations and observation processes that meet a user’s immediate needs

» Determination of a sensor’s capabilities and quality of measurements

» Access to sensor parameters that automatically allow software to process and geo-locate observations

» Retrieval of real-time or time-series observations and coverage in standard encodings

» Tasking of sensors to acquire observations of interest

» Subscription to and publishing of alerts to be issued by sensors or sensor services based upon certain criteria

Within the SWE initiative, the enablement of such sensor webs and networks is being pursued through the establishment of several encodings for describing sensors and sensor observations, and through several standard interface definitions for web services. SWE standards that have been built and prototyped by members of the OGC include the following standards:

» Observations & Measurements Schema (O&M) – An OGC adopted standard that defines conceptual models for encoding observations and measurements from a sensor, both archived and real-time.

» Observations and Measurements XML (OMXML) – XML encoding of the O&M conceptual model.

» Sensor Model Language (SensorML) – An OGC adopted standard that defines standard models and XML Schema for describing sensors systems and processes; provides information needed for discovery of sensors, location of sensor observations, processing of low-level sensor observations, and listing of taskable properties.

» Sensor Observations Service (SOS) - An OGC adopted standard that specifies a standard web service interface for requesting, filtering, and retrieving observations and sensor system information. This is the intermediary between a client and an observation repository or near real-time sensor channel.

» Sensor Planning Service (SPS) – An OGC adopted standard that specifies standard web service interface for requesting user-driven acquisitions and observations. This is the intermediary between a client and a sensor collection management environment.

» SWE Common Data Model - The standard defines low level data models for exchanging sensor related data between nodes of the OGC SWE framework. These models allow applications and/ or servers to structure, encode and transmit sensor datasets in a self-describing and semantically enabled way.

» SWE Services Common – This standard currently defines eight packages with data types for common use across OGC SWE services. Five of these packages define operation request and response types. These packages use data types specified in other standards.

» PUCK Protocol Standard - This standard defines a protocol for RS232 and Ethernet connected instruments. PUCK addresses installation and configuration challenges for sensors by defining a standard instrument protocol to store and automatically retrieve metadata and other information from the instrument device itself. PUCK is the newest addition to the SWE standards suite.

» Sensor Alert Service (SAS) – An OGC discussion paper describing a web service interface for publishing and subscribing to alerts from sensors. This is not an OGC standard.

» Web Notification Services (WNS) – Standard web service interface for asynchronous delivery of messages or alerts from SAS and SPS web services and other elements of service workflows. This is not an OGC standard.

The goal of SWE is to enable all types of web and/ or internet-accessible sensors, instruments and imaging devices to be accessible and, where applicable, controllable via the web. The vision is to provide a standards foundation for ‘plug-and-play’ web-based sensor networks. SWE standards, therefore, have been harmonised with other OGC standards for geospatial processing. The SWE standards foundation also references other relevant sensor and alerting standards such as the IEEE 1451 ‘smart transducer’ family of standards and the OASIS Common Alerting Protocol (CAP), Web Services Notification (WS-N) and Asynchronous Service Access Protocol (ASAP) specifications. OGC works with the groups responsible for these standards to harmonise them with the SWE specifications.

Advances in digital technology are making it practical to link
virtually any type of sensor or locally networked sensor system with wired or wireless connections. Such connections support remote access to the devices’ control inputs and data outputs as well as their identification and location information. For both fixed and mobile sensors, sensor location is often a vital sensor parameter. A variety of location technologies such as the GPS and Cell-ID with triangulation make mobile sensing devices capable of reporting their geographic location along with their sensor-collected data.

SWE standards have been implemented in hundreds of applications by private sector, government and university developers. For example, US National Ocean and Atmospheric Administration (NOAA), Integrated Oceans Observing System (IOOS); German Indonesian Tsunami Early Warning System (GITEWS); Asian Institute of Technology, Thailand - Nepal Wireless Project for Monitoring Climate Change in the Himalayas; Japan National Institute of Advanced Industrial Science & Technology (AIST): Earthquake Monitoring and Warning System (QuiQuake); Europe Emergency Response: (http://www.ess-project.eu) an infrastructure based on SOS, SPS and SES to provide real-time information to crisis managers during abnormal events to improve the management between forces on the ground (like police and fire fighters) and the control centres; US Department of Homeland Security (DHS) Unified Incident Command and Decision Support (UICDS).

Conclusion

Standardisation is the key requirement for communicating information about sensors, its data and for comparing and combining information from various sensors.

OGC recognises this challenge and is working actively with other agencies, industries and users for building standards.

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EVENTS

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AUVSI 2013
August 12-15, 2013
Walter E. Washington Convention Center
Washington DC, USA
www.auvsishow.org/auvsi13/public/enter.aspx

MAKS 2013
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MSPO 2013
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October 22-25, 2013
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Military Survey and GIS

Military Survey is responsible for providing the forces with maps of border areas. The author argues that not only is the agency not focussing on its primary task, but is also continuing to use outdated methods and technology to prepare maps...

Military Survey of the Indian Army and Survey of India (SoI) both owe their origin to the erstwhile British Indian Empire. Map Policy of India lays down that mapping within the country is the responsibility of SoI. However, Military Survey continues to be involved more internally rather than focussing on trans-border mapping. Technology adaptation in SoI has gone way ahead of Military Survey, whereas, it should have logically been the other way around. Presently, Military Survey is some 30 years behind in meeting even existing routine mapping requirements of the military, whereas large scale mapping requirements of say 1:5,000 and below is practically not being met at all, which are vital to Operational Information Systems being introduced into the military, particularly the Army.

The development of a specific methodology for preparation of 1:10,000 scale or larger maps with the use of advanced technologies such as remote sensing, GPS and GIS in an integrated way, is the need of the hour.

Military Survey was formally raised under Military Intelligence during World War II. It was later brought...
landings were eventually possible. which luckily was not required as air was planned on a tourist map, even the paradrop on Male airfield only offer a tourist map. As a result, Ironically, the Director R&AW could Survey had no maps to offer. went into Maldives on request by same. Also when, the Indian Military 30 years more or less remains the found to be superior to those with the Sri Lankan Military were When the Indian Peace Keeping from the Ministry of Home Affairs. In addition, it also provides maps to the paramilitary forces, central armed police forces and police organisations on demand from the Ministry of Home Affairs. When the Indian Peace Keeping Force went into Sri Lanka, maps with the Sri Lankan Military were found to be superior to those with the Indian Army. The situation after 30 years more or less remains the same. Also when, the Indian Military went into Maldives on request by the Maldivian President, Military Survey had no maps to offer. Ironically, the Director R&AW could only offer a tourist map. As a result, even the paradrop on Male airfield was planned on a tourist map, which luckily was not required as air landings were eventually possible.

Recent Times

In May 2004, Military Survey was brought under the newly created Directorate General of Information Systems (DGIS) under express sanction of the Defence Minister to ensure inclusive development and deployment of Operational Information Systems (OIS), Management Information Systems (MIS) and GIS. The need to shift from Platform Centric Operations to Net Centric Operations had brought into focus vital issues. Net Centric Warfare (NCW) has the critical requirement for integration of operational and tactical information and knowledge with reference to terrain for precise targeting. Battlefield management requires coordination between units, formations, other services and multiple government agencies. Real-time geographical visualisation of the battlefield scenario on a network is required, and that is possible through the exploitation of geospatial data obtained from multiple sensors located in space or on aerial, ground, sub-surface and other platforms. Commonality of data and standards for defence services is an imperative. The tasks assigned to Military Survey include trans-frontier mapping, updating maps with satellite imagery, creation of GIS, creation of digital topographical database, preparation of Defence Series Maps (DSMs), large scale mapping, training on GIS and attribute data collection, photogrammetric survey and RS, and the like. For Military Survey, the requirement to introduce an Enterprise GIS became paramount, as also did the requirements of large scale mapping in meeting increasing demands of the upcoming OIS. Trans-frontier mapping responsibility that was earlier up to 300 km depth across the border was increased to a depth of 5000 km by Headquarters Integrated Defence Staff (IDS) apparently to meet requirements of the Strategic Forces Command.

As we move closer towards operating in a fully automated digitised battlefield, there is a need to review the way digital maps and imagery need to be organised and processed for seamless functionality at both strategic and operational levels. All battlefield management systems are inherently dependent on a robust GIS. The GIS applications require geospatial base data in terms of digitised maps, imagery, attributes and so on, before it can deliver results to the user. This base data can be considered as the blackboard on which users create their mission-specific overlays. In a GIS environment, the user should be able to carry out a number of 2D and 3D analysis functions purely using the base data. Therefore, the quality of the base data in terms of spatial accuracy and the level of attached attribute data, the structure and format of the digitised data and in case of topographical maps, the datum and projections used, assume great significance.

Technology, policies, standards and resources are necessary to acquire, process, store, distribute and improve utilisation of geospatial data for military purposes. Therefore, the need to establish a Defence Spatial Data Infrastructure (DSDI) is never so urgent especially when a National Spatial Data Infrastructure (NSDI) has already been established though its integration with concerned government ministries and agencies is still a long way off. Military Survey had expanded over the years with Centre for Automated Military Survey (CAMS); Army Digital Mapping Centre (ADMC), Defence Institute for Geospatial Management and Training (DIGIT), a Field Survey Group and a Ground Air Survey Liaison (GASL) platoon, latter providing aerial cover for survey.

Functioning Under DGIS

Merger of Military Survey with DGIS brought out a host of shortcomings, some of which were: techniques used for production of maps were archaic; Google Map downloading was being resorted to as base data; there was more focus on the own side of the border rather than trans-border; the organisation and entire focus (following the British legacy) was on physical survey within own borders, however, even this had not been done for decades in counter-insurgency areas of J&K and in the north-east despite presence of army in all such areas; demands for satellite imagery were forwarded
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Output of Military Survey’s archaic mammoth organisation, with an authorised strength of 112 officers, 319 Junior Commissioned Officers (JCOs), 1,033 other ranks and 89 civilians, in no way met military requirements.

With an aim of introducing an Enterprise GIS, a tri-Service study was ordered in 2007 to examine nuances for establishing an Enterprise GIS for the Military, which took more than a year because of turf battles. On conclusion of this study, a GIS Policy with common symbology for the three services had been evolved; there were sustained voids of survey trained officers in Military Survey spanning over a decade.

2009 but was not followed up. More importantly, considering the organisational and output oriented shortcomings of Military Survey, an Army Study for Reorganization of Military Survey was ordered, which was headed by Major General K Surendranath, then Additional Director General, Mechanized Forces at Army HQ. Study members included representatives of the Military Secretary, Military Intelligence, Engineers Branch, Military Survey, PMO Battlefield Surveillance System (BSS) under DGIS, DIPAC, Naval Intelligence and Air Intelligence. Main issues to be addressed by the study were: reorganisation of Military Survey units in the backdrop of available global technology and modern techniques; examine existing system of mapping, map updating, digitisation and how updating can be speeded up through reorganisation; examine the role of Military Survey in attribute data collection; officer management; rationalisation of existing manpower; changes in present trade structure; human resources development and present training capability, need for establishing DSDI and road map for proposed restructuring. Some of the findings and recommendations of this study were on the following lines:

» Output of Military Survey's archaic mammoth organisation, with an authorised strength of 112 officers, 319 Junior Commissioned Officers (JCOs), 1,033 other ranks and 89 civilians, in no way met military requirements.

» DIGIT was functioning on ad hoc basis with very limited capability.

» Existing units of Military Survey were functioning on different structures with varying capability, which need to be addressed.

» With same roles, there was considerable duplication of manpower and equipment between the GIS cells of Military Survey at command, corps and divisional headquarter levels and the IIITs working under General Staff Branch of respective HQs.

» GIS Cells at Formation HQs were no more than storekeepers of printed maps.

» Amalgamation of the GIS and IIIT cells was warranted and would accrue in considerable savings in manpower, equipment, and costs besides improving efficiency.

» There was a vital requirement to change Military Survey into an All Arms organisation.

» There is a definite need to replace the Military Survey officers at the field formation level by All Arms officers.

» Numerous trades in Military Survey could be reduced to two.

» Military Survey must visualise future operational requirements and cater for infusing new survey equipment and technology.

» Emerging technologies like digital photogrammetry using digital aerial photo/ high resolution imagery/ UAV inputs, mobile data capture in field using PC tablets, gravity and geo-magnetic surveys, Airborne Laser Terrain Mapping (ALTM)/ LiDAR survey, online data transfer for updation/ web enabled services, GIS applications and services, digital cartography and hi-tech digital planning need to be incorporated.

» Periodicity of updating of maps should be increased to 2-3 years instead of the current 10-15 years.

» Large scale mapping is a must for future NCW requirements.

» Establishment of the DSDI is an essential operational requirement, which should be preceded by an Enterprise GIS.

The study made operationally vital
reorganisational recommendations and the study report having been approved, was sent to concerned directorates for implementation. However, vested interests have apparently managed to put this into the freezer because implementation of the report meant: induction of All Arms Cadre officers in Military Survey; Military Survey officers in field formations replaced by All Arms Cadre officers; amalgamation of GIS Cells and IIIIs at formation HQ level would curtail the Military Survey's empire. As it is, the lopsided arrangement continues - the GIS Cell functioning at Formation HQ level is not under the GS Branch but continues to be under the local Engineer unit.

Current Scene

In 2011, Military Survey was reverted to Military Operation for some inexplicable reason. More significantly, in June 2013, a fresh study for Reorganization of Military Survey has been ordered, Lt Gen K Surendranath (who had done the previous study) having superannuated from service on May 31, 2013. The current scene is:

» Military Survey has washed off its hands from progressing the GIS/Enterprise GIS on the plea that it is a General Staff (GS) issue. This is despite the fact that that it should actually be their bread and butter since they are now part of Military Operations which is the topmost GS Branch and Military Survey itself mans MO (GS GS).

» Non-establishment of an Enterprise GIS despite the RFP for it in 2009 is adversely affecting development and fielding of Operational Information Systems. Military Operations located in South Block has little time and inclination to push Military Survey into progressing the Enterprise GIS.

» Military Survey activity is back to the confines of paper maps and continues to lag behind military requirements even in this.

Requirement

The MoD and the military need to take a call on the following:-

» The 'reverse deputation' of the British era should be replaced with a simple three years deputation with SoI. The circumstances under which the British started this process do not exist anymore. There should be a vertical split between the Military Survey and Ministry of Science and Technology, with former brought under the MoD through Integrated HQ MoD (Army).

» The army study on Restructuring of Military Survey which was approved in 2009 should be implemented, reasons for its non-implementation in last four years examined and the second study ordered in June 2013 scrapped.

» Not only should Military Survey be made an All Arms organisation, it should be headed by a General Cadre officer.

» Military Survey should be placed under the DGIS without further loss of time, as was envisaged and approved by the Defence Minister in 2004.

» Development and fielding of an Enterprise GIS and establishment of DSDI needs accelerated focus.

» Vision for Military Survey must include provision of real-time and accurate geospatial data and services for network centric applications across the entire spectrum of conflict.

» An in-depth analysis should be done to meet the mapping (including large scale mapping), digitisation, imagery and GIS requirements of the military keeping in mind the fielding of OIS and enhanced missile ranges, and a road map worked out to leapfrog large mapping voids.

As we carry out transition from the platform centric approach to a network centric, it is essential for us to understand the strengths and the limitations of the available technology to harness its full potential. Geospatial data and its exploitation remain central to any battlefield management system and as such, understanding the complexities of various elements of this type of data becomes imperative. Organising the base geospatial data is in itself a major task. Its further exploitation would remain a major challenge unless all users come to a common framework. Development of any common geographic reference framework is essentially a triservice responsibility and can only be undertaken in conjunction with agencies responsible for production of geographic data. In our case too, the three services are using maps based on differing datums and projections. Even within individual services, standardisation with regard to maps, imagery and user generated symbology is yet to take place. Issues regarding procedures to be adopted on zone boundaries between the zones of our projected coordinate system have to be worked out. Unless these aspects are addressed collectively by the three services, results from applications developed for C4I2 systems will remain unpredictable, especially during joint operations. It is therefore imperative that the issue of common reference framework for geospatial data is addressed on priority. Military Survey has a major role to play in all this and needs to get its act together.

Lt Gen PC Katoch (Retd)
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Describing timely availability, integrity and security of information as a major challenge before the security agencies, Admiral DK Joshi, Chief of Naval Staff, Indian Navy, said, “There is a need to harness the potential of geospatial information by developing applications in the military domain,” adding, “The challenge is to integrate the data produced by different organisations and create applications in the military domain.” Admiral Joshi was speaking at the seventh edition of the annual defence conference GeoIntelligence India 2013, held in New Delhi recently.

Acknowledging that geospatial technology is a great facilitator of network centric operations, both at the operational and tactical level, Lt Gen Anil Chait, GOC-in-C, Central Command, Indian Army, recommended a geospatial framework for the country. However, he said to facilitate and support such a framework, India needs a national communication network that can leverage on a national information grid to harness national power.

Sharing the industry perspective, Kaushik Chakraborty, Vice President, Hexagon India said that for the first time in the history of warfare, there is no excuse for taking a wrong decision citing the lack of information at the right time. In this period of transition and partnerships, it is important to take advantage of the legacy systems, work on them to build new platforms with the right use of technology.

**Plenary Sessions**

India plans to create three new tri-service commands, headed by three-star generals or equivalent, for Space, Cyber and Special Operations. The plenary sessions for the conference were thus structured accordingly.

**Weaponisation of Space**

Cp Capt RK Singh, IAF, Senior Research Fellow, United Service Institution of India, observed that “China’s aggressive posturing against India necessitates review of security implications of our space assets and development of space weapons to protect them,” with space weaponisation becoming both urgent and a necessity. Brig (Dr) Arun Sahgal (Retd), Director – Forum for Strategic Initiative, deliberated upon militarisation versus weaponisation. Calling space ‘the new frontier,’ he said that militarisation of space implies developing and deploying assets in space, and is aimed at enhancing military surveillance and target acquisition. The session was chaired by Air Marshal SB Deo, DG Air (Ops), Indian Air Force, who explained the relative advantages and disadvantages of kinetic kill vs electronic kill in ASAT.

**Cyber Warfare**

Prof. V.S. Subrahmanian from Center for Digital International Government, Computer Science Dept. & UMIACS, University of Maryland, presented his views on the concept of vulnerability where in an attacker takes advantage of a code to exploit technologies related to monitoring networks for known attacks, unknown attacks and social media attacks. Lt Gen Gautam Banerjee, (Retd), former
Chief of Staff, Central Command, described the rational interpretation of the terminology ‘Cyber Warfare’ in Indian context. He focussed on finding appropriate definitions, identification of the nature of the threat and courses of action to secure own cyber-space. Presenting his views on geolocation in cyberwar, Cdr Mukesh Saini (Retd), Former National Information Security Coordinator, Government of India (GoI), recommended inclusion of cyberwar in national cyber security policy; evolution of cyber warfare doctrine and development of capacities to implement such doctrine and penetration tools indigenously. Chaired by Lt Gen Rajesh Pant, Commandant MCTE, the session witnessed one of the most interactive question and answer rounds of the conference.

Special Operations

“Special forces cannot succeed unless they have the intelligence that geospatial technology provides,” said Maj Gen RK Malhotra (Retd), National Security Council Secretariat. His views were echoed by Christopher K Tucker, who represented OGC at the event. He said, “Geospatial technology helps build trust,” adding, “Special forces are the highest users of geointelligence.” Wg Cdr Satyam Kushwaha, National Security Council Secretariat, talked about the requirements and challenges of security agencies, “We need a 3D system that is capable of handling all kinds of maps, is designed for Indian conditions and can be used by all the three forces,” he said. “GIS is not about maps, it is about what we can do with maps,” said John Day, Director-Global, Defence Esri, USA, who talked about the need to build intelligent systems which can communicate with each other. Lt Gen PC Katoch (Retd), former DGIS, Indian Army, who chaired the session, stressed upon the need for India to build its capabilities in the geospatial sector to support special operations.

Guest Address

Shambhu Singh, Joint Secretary – North East, Ministry of Home Affairs (MHA), GoI, spoke about the importance of geotech in internal security and explained how the technology helped solve insurgency in Tripura.

The role of GIS in crime analytics was highlighted by S. Suresh Kumar, Joint Secretary – Centre States, Ministry of Home Affairs (MHA), Government of India, who discussed the initiatives taken by the MHA in implementing GIS in crime analytics.

Technical Sessions

Internal Security and Border Management

Chair: Lt Gen NB Singh, Director General, Electronics and Mechanical Engg., Indian Army

“Conflict is all about people,” said Brig Xerses Adrianwalla, Chief of CIS and Group Security, Mahindra & Mahindra, who explained the importance and limitations of humans in the collection and analysis of geointelligence. Speaking about the increasing use of geotech by terrorists in planning their attacks, Lokhnath Behera, Inspector General of police (Intelligence, Operations, Policy and Coordination), NIA, emphasised the need of use of geospatial technology for internal security. While Manoj Agarwal, IG, Gujarat Police, explained how satellite imagery was successfully used to stop intrusion at Harami Nala in Gujarat; Dr Sandeep Goyal, Advisor, MPCOST, drew the attention of the gathering towards security challenges facing the state of Madhya Pradesh like illegal migration, red corridor etc, and said that the state police is planning to develop a geoint decision support system in the state. Prof
VS Subrahmanian, meanwhile, introduced audience to the new field of ‘geospatial abduction,’ in which geospatial technology is being used to predict locations of IED weapons caches and/or high value targets (HVTs) associated with IED attacks.

Maritime Security

Chair: Rear Admiral DM Sudan, ACNS (Air), Indian Navy (IN)

Space-based surveillance forms the backbone of Maritime Domain Awareness (MDA). This was the message that was strongly communicated by one and all present in the session dedicated to maritime security. Prof Guy Thomas, Advisor, C-SIGMA Centre; Chairman, Global Maritime Awareness Institute for Safety, Security & Stewardship, explained in detail how space-based Automatic Identification System (S-AIS) enhances the MDA in his talk on “Collaboration in Space for International Global Maritime Awareness.” His views were echoed by Cmde Ranjit Rai (Retd), Former Director, Naval Operations & Vice President, Indian Maritime Foundation, who talked about the advantages of technology in context of Indian Navy. He praised the Navy for the way it has enhanced India’s coastal security following 26/11 attacks. Talking about the role, responsibilities and challenges faced by IN, Captain Rajiv Ashok, Director, Naval Operations, IN, said that the force is looking at building capabilities in S-AIS, NCW, mine counter-measures, etc.

Maritime Survey

Chair: Rear Admiral KM Nair, NM, Joint Chief Hydrographer, National Hydrographic Department

Speaking about the application of hydrography as an effective tool for national development, Cdr Sajeev K Nair, National Hydrographic Office, Dehradun, said that there is an urgent need to produce accurate nautical charts on which navigation and other related activities are dependent. K M Sivakholundu / Project Director, Coastal & Environmental Engineering Group, National Institute of Ocean Technology gave a presentation on ‘co-tidal model’ for Gulf of Gujarat, and briefed the listeners about the methodology of preparation of a model along with the challenges faced in case of a difficult terrain. While presentation on applications of high resolution bathymetric mapping of the Indian exclusive economic zone was given by Abhishek Tyagi / Scientist-B, National Centre for Antarctic and Ocean Research, Goa, Dr V V L N Sarma, National Hydrographic Office, Dehradun, dwelled on the significance of electronic charting standards and interoperability issues in Marine GIS environment.

Image Interpretation and Terrain Modelling

Chair: Maj Gen Girish Kumar, Commandant Army Digital Mapping Centre (ADMC), Bengaluru
The importance of imagery in enhancing ISTAR (Intelligence, Surveillance, Target Acquisition and Reconnaissance) capabilities of security agencies was the crux of the presentation of Neeta Trivedi, Head – Aerial Image Exploitation Division, ADE, DRDO. She briefed the audience about the work done/ongoing work in this direction by ADE. Her presentation was followed by Shailesh Shankar, Manager-Sales Engineering, Asia Pacific, DigitalGlobe, who spoke about the company’s capabilities in image interpretation. Explaining the importance of terrain for soldiers, Murali Mohan of Mobiterra Solutions introduced the audience to the solutions developed by his company which help forces in developing accurate 3D models of terrains.

Geointelligence Enablers

Chair: Lt Gen SM Mehta, Commandant MCEME

The session witnessed speakers talking about various sensors and sensor platforms - Maj Gen T M Mhaisale, (Retd), Senior Advisor Electronics MNC and Former Commander HQ Technical Group EME, deliberated upon networking sensors and platform weapons; Lt Col Sarvanan of Indian Army spoke about the importance of satellites in national security and search and rescue; and Anand Santhanam, Director Sales – Asia Pacific, Geospatial eXploitation Products Group, BAE Systems, deliberated upon the role of UAVs in aiding tactical warfare. Dr Rakesh Malhotra of Fayetteville State University and USGIF observed that social media is a great leveller of information and it can be extended with “geo” to derive “GeoSocial.” While Brig Rahul Bhonsle (Retd), Director - Security Risks Asia, discussed exploitation of geointelligence in the Indian operational environment, Dr Narayan Panigrahi, Scientist ’F’, CAIR, spoke about the robust computational techniques for computation of geospatial data registered temporally and geometrically.

Product Lifecycle Management

Chair: Brig Raju K Subramani, Indian Army

Brig Raju elaborated upon the relevance of geointelligence to product lifecycle management, saying, capturing geoinformation during the exploitation stage will impact everything else. Balaji Rangachari, Vice President – Business Consulting Group, Ramco Systems, discussed the integration of GIS and analytics with MRO for effective decision making, and how GIS can be used for a number of purposes like mission planning, peacekeeping operations, modelling, etc.

Network Centric Warfare (NCW)

Chair: Brig AS Nagra (Retd)

Brig Nagra spoke about the advantages of NCW like information dominance, shared battle space awareness, lock out of enemy’s options, etc. The challenges, that need to be addressed, according to him, include overestimating human capacity, underestimation of enemy’s capabilities, in sufficient situational awareness, and so on. Anil Pant, Sr DGM (D&E/NCS), BEL, elaborated on how situational awareness can be ensured through net centric operations. He described the need to deliver right information to the right place at the right time as the fundamental requirement for carrying out an effective operation.

Data Infrastructure - Interoperability and Security FWof Data

Chair: Maj Gen (Dr) R Siva Kumar, CEO, NSDI

Lt Col Anupam Tiwari, HQ IDS, Indian Army, talked about spatial big data and challenges like security, data storage and input validation. While Dr M K Munshi / Chair, OGC India Forum, focussed on OGC’s approach towards the propagation and implementation of open standards, Chris Tucker, CEO, Map Story Foundation, talked about the growing agreement on standards in defence and intelligence, and Adimulam Vinay Babu, Sr. Manager Defence and Public Safety, Intergraph, spoke about interoperability and commonality in systems.

Organised by Geospatial Media and Communications, the seventh edition of the two-day conference revolved around the theme, ‘Geospatial – Force Multiplier for Modern Warfare.’
Uttarakhand is one of the most famous tourist destinations in India. The state is not only popular for its mountains and natural beauty, but also for its Char Dhams (four religious places of followers of Hindu religion). Kedarnath is one of the most frequented Dhams. It is located in the snow-clad area of the Himalayas at a height of 3,583 m (11,755 ft) above the sea level in the Mandakini valley of Rudraprayag district.

On June 16 and 17 this year, the state experienced heavy rainfall which triggered floods and landslides in the area resulting in the death of thousands of people and a massive damage to infrastructure. Areas in and around Kedarnath Dham have been completely destroyed. Satellite images obtained show dramatic alterations in the region’s topography. For example, earlier, only one stream used to flow in the background of Kedarnath shrine, which used to split into two after coming down the hills. But post-disaster, images show that a new (third) stream has been formed in the region.

**Pre-disaster satellite imagery**

1 & 2: Images show that water moves along in thin channels

3: Settlements around Kedarnath temple

**Post-disaster satellite imagery**

1 & 2: The channels of water have become broader

3: The town has almost disappeared by debris flow from both the east and west valleys
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Conference Takeaways
- A comprehensive overview on the applications of geospatial technologies for national defence & security
- Opportunities for interaction and networking with the stakeholders of the GeoIntelligence community
- Business development platform for the industry to showcase latest technologies to decision makers