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FUSING IMINT: DRONES, MANNED ASSETS AND SATELLITES

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Abstract

Imagery Intelligence (IMINT) is one of the important intelligence collection disciplines required for preparation of an Intelligence Product for military operational planning. Due to technological evolution, there is a huge proliferation of imaging resources at various levels. The article details the evolution of IMINT and the present day IMINT functions of UAVs, drones, manned assets and satellites. The IMINT users in India and evolving IMINT needs at tactical, operational and strategic levels and Military IMINT Process are also highlighted. The IMINT fusion needs, IMINT fusion challenges and suggested ways to Achieve IMINT Fusion are then discussed. The article concludes with the way forward to include organisational changes, joint training, evolution of IMINT human resources, strengthening of IMINT sharing mechanism and integration of Drone Intelligence in IMINT matrix at all levels, underlining that effective IMINT fusion will result in economy of effort, prevention of duplication of information and discarding of unreliable inputs, which can facilitate in creation of better and reliable Intelligence Products for operational utilisation.

INTRODUCTION

Since the dawn of warfare, a commander's ability to visualise the battlefield and direct his or her forces has often meant the difference between victory and defeat.[1] Such visualisation of battlefield is possible through timely

intelligence products, derived from numerous intelligence collection disciplines, to include Human Intelligence (HUMINT), IMINT, Signals Intelligence (SIGINT, which comprises of Communication Intelligence and Electronic Intelligence) and Open Source Intelligence (OSINT).[2] These days, certain new and evolving intelligence collection disciplines, such as Measurement and Signature Intelligence (MASINT), mostly used by Western Intelligence Agencies, Cyber Intelligence and Geospatial Intelligence (GEOINT) also form part of intelligence collection disciplines.

IMINT

IMINT is an intelligence collection discipline, which collects information obtained by imaging, via satellites, aerial photography through manned assets, drones and/or any similar platform. As a means of collecting intelligence, IMINT is a subset of intelligence collection management, which, in turn, is a subset of intelligence cycle management. IMINT is especially complemented by non-imaging MASINT, electro-optical and radar sensors.[3] GEOINT is the analysis and visual representation of security related activities on the earth, produced through an integration of imagery, imagery intelligence and geospatial information.[4]

EVOLUTION OF IMINT

Early attempts to capture scenes of the earth's surface consisted of observers and artists going aloft in hot air balloons. However, the true birth of IMINT came with the invention of the camera. During the American Civil War, the US Union Army used hot air balloons for observation and photography, where soldiers were sent up in balloons to gather intelligence about their surroundings. The Germans too experimented with both kites and rockets as platforms in the late 1800s. However, their early efforts met with little success. During the First World War, cameras were used on aircraft, but usually only for front line tactical applications. Rapid advances were made in both cameras and aircrafts between the wars. In the Second World War, around 80% of the intelligence gained was derived from aerial photography,

which was used mainly against strategic targets such as industrial complexes, lines of communications and population centers.[5] Possibly, due to these practices, IMINT used to be earlier referred as Photo Intelligence (PHOTOINT).[6]

Having proved its worth in two World Wars, aerial photography was thereafter extensively used world over in every major conflict. During the last 30 to 35 years, the UAVs have also proved itself as a valuable IMINT tool for the tactical commanders.[7] In the recent past, IMINT has evolved rapidly to help satisfy most of the intelligence requirements. These days by allowing everyone to see the map and understand pertinent details about the enemy and terrain in time and space, the commander's and staffs' visualisation of the battlefield are enhanced.[8]

IMINT is possibly the only discipline that allows the commander to see the battlefield in real time as the operation progresses.[9] There are multiple resources to image a territory and derive intelligence out of it to prepare a significant IMINT Product for military and non military use at tactical, operational and strategic levels. The advancements in numerous manned assets, developments in the field of space, satellites, satellite imagery, proliferation of drone technology and its evolving innovative usage makes the images and videos available in real time, which if, collated, interpreted, synthesised, analysed, fused and disseminated swiftly to the users of IMINT Products in real time can facilitate a successful intelligence based warfare.

UAVs AND DRONES FOR INTELLIGENCE AND MILITARY APPLICATIONS

UAVs make significant contributions to the war fighting capability of operational forces. They greatly improve the timeliness of battlefield information, while reducing the risk of capture or loss of Manned Assets. In addition, they are cost effective and versatile systems. While Reconnaissance, Intelligence, Surveillance and Target Acquisition (RISTA) are the premier missions of UAVs, they also provide substantial support to Intelligence Preparation of the Battlefield, Situation Development, Battle Management,

Battle Damage Assessment and even Rear Area Security.[10] The images and videos captured by UAV RISTA missions form a significant component of IMINT Products.

Drone technology, now less expensive and accessible, is rapidly advancing to provide more robust and advanced drones, accommodating longer flight times and heavier loads, which are being put to several military and commercial uses around the world including for operational and tactical level imaging.[11] The remote and dual-use technologies offered by drones, is essential in any conflict to address asymmetry. Ukraine has very effectively used these "homemade kamikaze drones" against Russian forces for numerous military operations including tactical imaging. In fact, Ukraine had also put out a general request for the donation of commercial drones and crowd funded for the purchase of military drones for these purposes.[12]

Some of the evolving Intelligence (including IMINT) and Military Applications of drones include the following:

- Geographic Mapping to acquire very high-resolution data and download imagery in difficult to reach locations, such as higher reaches, coastlines, islands and so on.
- Creation of 3D maps and contribution to crowd sourced mapping applications.
- Aerial photography to capture footage and its live broadcast that would otherwise require helicopters/other air assets.
- Surveillance and Reconnaissance, which is augmented by presence of thermal sensors with drones and provides them with night vision.
- Post Strike Damage Assessment.
- Drop equipment, material, food, water and supplies to difficult locations during war, before Reinforcements reach.
- After a natural or man-made disaster, drones have the capability to provide a quick close-up view of areas, gather information and navigate debris and rubble to look for injured victims. The high definition cameras, sensors and radars with drones may give rescue teams access to a higher field of view, saving the need to spend resources on manned helicopters.

Drones can drop the supplies to unreachable locations, before rescue crews reach there. They are able to discover the location of lost persons and unfortunate victims, especially in harsh conditions or challenging terrains.

- Drones may be used to monitor dangerous and unpredictable weather. Since they are cheap and unmanned, these can be sent into hurricanes and tornadoes, so that scientists and weather forecasters acquire new insights into their behaviour and trajectory. Its specialised sensors can be used to detail weather parameters, collect data and prevent mishaps.[13]

MANNED ASSETS

Manned Assets such as Aircrafts, Helicopters carry Aerial Sensors, employed to conduct both reconnaissance and surveillance missions. Reconnaissance is performed over specific targets at specific times, while surveillance is performed over typically larger areas over long periods of time. During Reconnaissance and Surveillance Missions, Tactical IMINT could be obtained from various means to include Visual, Photography, Infrared (IR), Radar and Electro-Optical (EO).[14]

Use of Aerial Photography for IMINT from manned assets offer advantages in collection of evidence across the Forward Line of Own Troops, provisioning of high resolution images to identify objects in more detail and provisioning of permanent record, which can be later used for change detection in the target area. Photo missions prove most successful when cross-cued from other intelligence disciplines. Many limitation, which apply to visual observations also apply to photograph, such as limitations caused by enemy defences, weather, darkness, masking of the target by terrain and so on, which may be reduced by careful mission planning. Timeliness is perhaps the greatest limitation of photography. Information on the imagery may have perished by the time the analyst sees it. Different sensor format (camera positions - Vertical, Oblique and Panoramic), if specified allows to see the earth's surface from different views.[15]

IR sensors detect energy that is emitted or reflected from an object. IR imaging systems detect electromagnetic waves that are outside the visual spectrum as they lie just passed visible light and just before microwaves. IMINT products obtained through IR imagery have the same properties as visible light images, as IR is near the visual spectrum and therefore it closely resembles photo images. These images are produced by recording the amount of heat released by an object onto the ground. During the day, objects absorb solar energy and release it after the sun set. Some objects release energy faster than others. IR however has a limited capability to penetrate camouflage. IR can be used during day or night, but night IR images provide better contrast. It is a passive system that does not emit signals and therefore cannot be jammed. IR imagery is degraded by severe weather and terrain and affects it the same way as conventional photo images.[16]

Imaging radar operates by emitting an electromagnetic pulse, which illuminates or paints the target area. The emitted energy after reflection from the target, gets back to the aircraft, where the signal is recorded. The amount of energy that returns and the time it takes that energy to return is calculated to produce a radar image and determine the size and location of the target. All radar imaging systems today are data linked to ground stations, therefore the information is near real time. The system uses its own energy to illuminate the target and this makes it day and night capable. The system is near all weather. Severe thunder storms degrade the image. Radar provides images of fixed targets. This is useful for terrain analysis, change detection and pattern analysis. Perhaps its greatest capability is to detect moving targets. A moving object produces a Doppler shift and is displayed as a dot on radar imagery. With the sophistication of today's systems movers, speed and direction can be determined. The limitations of Radars are that the Resolution (impulse response) is poorer than with other systems and interpretation is more difficult and requires higher levels of training and skill. Radar is an active system that emits signals which can be jammed and is therefore susceptible to Electronic Counter Measures.[17]

EO Imagery collects imagery in the visual range using an array of detectors that sample light at fixed points. EO can be manipulated using digital techniques. The human eye can detect about 30 shades of gray. An EO system can detect 256 shades of gray. The individual pixel value of the image can be changed to identify targets that otherwise cannot be seen by the human eye.[18]

SATELLITE IMAGERY

Satellite Imagery involves obtaining photographs or the images of the Earth by Imaging Satellites. Satellite images offer numerous military applications (mostly in intelligence and warfare) and non military applications, such as in cartography, geology, meteorology, fishing, agriculture, biodiversity, conservation, forestry, landscape, regional planning and so on. Satellite Images are available in visible colours and in other spectra. There are elevation maps, usually made by radar images. Satellite Imagery is at times supplemented with aerial photography (which has higher resolution) and can be combined with vector or raster data in a GIS. Types of resolution in relation to Satellite Imagery are spatial, spectral, temporal, radiometric and geometric, which vary, depending on instrument used and altitude of the satellite's orbit. Types of images available in satellite imaging are panchromatic image (acquired by satellites, transmitted with the maximum resolution available) and the multispectral data (transmitted with coarser resolution, usually two or four times lower). At the receiver station, the panchromatic image is merged with the multispectral data to communicate more information.

SYNTHETIC APERTURE RADAR (SAR) IMAGES

SAR images can be obtained from satellites, such as RISAT. As radar images are formed by coherent interaction of transmitted microwave with the targets, it suffers from the effects of speckle noise. Special care has to be taken when interpreting SAR images, as it often requires some familiarity with the ground conditions of the areas imaged.[19]

IMINT USERS IN INDIA: CIVIL AND MILITARY

The three services are the premium IMINT users in India for their operational and intelligence purposes, closely followed by the other intelligence and security agencies. The reliance on IMINT is evolving at such fast pace that it is increasingly being adopted for innovative usage by most of the government services, to include various bodies dealing with the disaster management, forest, cartography, oceanography, conservation, geology, meteorology, agriculture, fishery, town planning and so on.

EVOLVING IMINT NEEDS AT TACTICAL, OPERATIONAL AND STRATEGIC LEVELS

With the advent of technology, world over the technical intelligence collection disciplines are increasingly gaining primacy over conventional HUMINT. Further, amongst technical intelligence collection disciplines, the ones less prone to deception have more credibility. IMINT being such discipline provides maximum evidence value to any Intelligence Product. While at the Strategic and Operational levels, the relevance of IMINT had always been at premium, the proliferation of drone technology, live feed phenomenon and nature of warfare evolving to quick and short wars have rapidly enhanced the significance of IMINT at the tactical levels of military operations. To be effective, interpreted IMINT acquired through various means needs to be collated and fused appropriately in the current intelligence product to facilitate interpretation, synthesis, analysis and dissemination and make the intelligence product valuable for military operations. This process needs to be continued during the entire cycle of operations, throughout the intelligence cycle and even subsequent to such military operation.

MILITARY IMINT PROCESS

In order to effect fusion of IMINT obtained from the above mentioned resources, it is essential that the Military IMINT Process is understood. At the

strategic level, the services demand the imageries through their Intelligence and IMINT channels to DIPAC/Defence Space Agency, which based on the capability and availability, is met from the domestic or foreign (even commercial) imagery resources. Likewise, the air photos are demanded from the Indian Air Force and operation level aerial intelligence needs, such as through UAVs, Helicopters are mostly met out of the integral resources available with the services. These days availability of drones at the tactical levels provides a quick IMINT option to the commanders. Depending on the capability, resources, priority and availability, the available images are disseminated to the demanding force in near real time. The interpretation of these images occurs at various levels by dedicated Imagery Interpretation Teams and IMINT reports are disseminated across the concerned force depending on its area of operations.

FUSING IMINT

IMINT Fusion relates to congregation of all the important information from multiple images and their inclusion into smaller number of images, preferably on a single image, which may be more informative and accurate. Fusion reduces the quantity of data and constructs more appropriate and easily understandable images, by the IMINT Operatives and for machine perception. Image fusion methods are Spatial Domain Fusion and Transform Domain Fusion.

IMINT FUSION CHALLENGES

- Different IMINT software used by different agencies at various levels may not be able to talk to each other. Therefore, it may be difficult to obtain appropriate still image from video and achieve the desired fusion of video footage with the still image, mostly at operational and tactical levels, which besides difference in software, could also be due to use of different formats at various levels, lack of resources, lack of expertise and lack of time owing to operational needs and constraints. Lack of standardisation of formats and software is not peculiar to

IMINT, but to all the existing and evolving intelligence collection disciplines, however, in case of IMINT, it attains more importance as any incoherence in this system tends to complicate the IMINT Process at every functional stage of the IMINT Process. This is the most critical challenge to fusion of IMINT, as inappropriate discretion adopted by any IMINT user may complicate the IMINT Process and impede collection, analysis, dissemination of IMINT and its integration into the Intelligence Product.

- Different image fusion algorithms may be needed due to proliferation of space borne sensors. Some image processing situations need high spatial and high spectral resolution in a single image, which many available equipment may not be able to provide.
- Interpretation and fusion of huge amount of data received over a short period of time from multiple IMINT sources and agencies, especially when such data is raw and not interpreted is another serious IMINT fusion challenge. These days the heavy inflow of drone footage further complicates such fusion needs.
- There are difficulties in fusion of images obtained from various imagery means with Manned Assets. It is not really easy to fuse a photographic image with IR, Radar or EO image.
- Fusion of Air Photos of different sensor formats and camera positions is difficult due to variance in focal length and field of view. Various methods are used to calculate the height, length and distance of the object captured by the air photos. Such fusion needs detailed efforts.
- There are practical difficulties, such as different timings of the image received, which require appropriate image fusion to achieve correct IMINT timelines in multiple IMINT missions. At times, images of different resolution cause fusion bottlenecks.
- Some agencies have a tendency to share only PDF format or power point of their IMINT Product with a very little scope for the receiver to undertake any fusion at their level. There are also instances of wrongly

interpreted images shared. All these functional difficulties waste a lot of time, especially at the operational and tactical levels.

- Perhaps the most important function of IMINT is its fusion with inputs obtained from other intelligence collection disciplines, where it has an evidential value for the final Intelligence Product, which needs to be applied for the operational planning and intelligence based warfare. This is the most important feature of the Synthesis Stage of the Intelligence Cycle and should not be ignored. Tendency to rely only on IMINT for operational planning needs to be avoided.
- There have been procurement difficulties faced by some IMINT agencies, leading to supply of not the most advanced systems. Further, both civil and militarily IMINT agencies rely heavily on foreign equipment, which may create some functional discomfort, due to lack of desired support and services.

ACHIEVING IMINT FUSION

- Image fusion techniques facilitate integration of different information sources, with the fused image having complementary spatial and spectral resolution characteristics. Various commercial software solutions are available to combine images to video and extract relevant image from the video. In fact, certain advanced software provide the facility of turning photos into videos, which may facilitate appropriate fusion of videos. The difficulties faced due to lack of resources, lack of expertise at operational and tactical levels need serious considerations as during operations, an unskilled IMINT operative may prove to be the weak link, which may impose an adverse time penalty on intelligence and operational staff. The need is to have availability of optimum IMINT specialists.
- In order to harness the IMINT resources at all levels, it will be a good idea to commence IMINT Specific War Games/SATs at the tactical and operational levels in the three services to assess efficiency and generate new IMINT fusion ideas.

- Integration of IMINT specialists of civil government and commercial organisations may be made to make up any shortfall in Military IMINT resources. However, for them to be useful during war/operations, it is essential that they are suitably integrated during training, exercises and war games.
- Multi sensor data fusion could meet the more general formal solution demands of a number of application cases, as well as overcome the constraints of the instruments, which are not capable of providing such information either by design or because of observational constraints.
- Artificial Intelligence (AI) applications may be used for interpretation and fusion of a large volume of images received over a short period of time. However, for such AI Applications to be effective and efficient, optimum training of AI systems on similar images/videos is essential.
- In case more than one radar image of an area of different time periods is available, they can be combined to give a multi-temporal colour composite image of the area.[20]
- Fusion of SAR imagery with IR imagery can be achieved through pixel level fusion, feature level and decision level fusion. The Pixel level fusion is good for visualisation and suitable for homogenous sensors, but it requires sub pixel time/alignment. Feature level fusion has powerful feature vector, but it needs pixel/time alignment. Decision level fusion does not need pixel/time alignment and is suitable for heterogeneous sensor (SAR/IR), but it can be less accurate compared to a feature level. Decision level fusion therefore emerges as the best choice.[21]
- There is an inescapable need of all IMINT stake holders in the country to train together to facilitate working jointly and sort out functional level teething problems, to achieve desired fusion when needed. This is especially desirable in view of evolving IMINT technology, software resources, data management, evaluation and analysis tools and their proliferation at a very high speed.

- It is essential that the procurement process is smoothened and the Indian industry is made capable to offer indigenous IMINT equipment and provide the desired services for such equipment.

THE WAY FORWARD

- A National Level Apex IMINT Authority/Agency responsible for all IMINT functions in the country (including all civil and military IMINT functions) needs to be considered. This will help in understanding and evolving national level IMINT needs, appropriate imaging and fusion.
- For civilian IMINT personnel to understand military IMINT needs and vice versa, joint institutionalised education and training are essential. To achieve this, creation of National IMINT College needs to be considered, which may help in achieving IMINT synergy at various levels.
- The Human Resources of IMINT agencies need to evolve. Based on evolving technological and operational thresholds, certain unique talent/experts may be inducted with liberal service conditions. Amongst IMINT personnel also, there is a need to create Sub Specialists. Inter agency posting of IMINT personnel by deputations must be encouraged. This will help in proliferation of best practices amongst all IMINT stake holders.
- Strengthening of IMINT Sharing Mechanism is essential to achieve transmission of images in real time. The film must be returned to a processing site and developed before analysis is possible.
- Integration of Local Drone Intelligence in IMINT matrix at all levels is critical. The evolving importance of drones in Intelligence and IMINT functions needs to be continuously studied and desired infrastructure should be built to test and utilise their services across it.

CONCLUSION

To make our present IMINT apparatus capable of delivering the goods and becoming an effective part of a seamless organisation, fusion of IMINT obtained from various sources and agencies is essential. Effective fusion

of IMINT from all resources will result in economy of effort, discarding of unreliable inputs, corroboration, effective IMINT analysis, which can facilitate in creation of better and reliable intelligence products for operation utilisation for the national security. Such IMINT fusion will be achieved better if the civil and military IMINT agencies through some reliable mechanism, achieve the highest level of integration to prevent the duplication of efforts and achieve the desired IMINT objectives.

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