Requirements of Geospatial Intelligence for Tactical Networked Systems

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Introduction

During the First Gulf War in 1991, the world watched with abated breath the dawn of a new era of warfare. The impact of Revolution in Military Affairs (RMA), along with the emergence of smart Information & Communication Technologies (ICT), took war fighting into a new domain. This new era of warfare has been christened as the Network Centric Warfare (NCW). This term was not in use when the First Gulf War happened, but was coined later to showcase the dawn of a new era in warfare.

Today, militaries the world over are in various stages of development or implementation of various 'networked systems'. These 'networks' will fight the wars of the future, as is being propagated by the protagonists of NCW. The Indian Army (IA) too has taken up this tectonic shift from the platform centric method of war fighting to war fighting in the NCW domain. Since the Geographic Information Systems (GIS) will form the backbone of all networked systems, Geospatial Intelligence (GeoInt) will assume great importance for waging and winning wars in the NCW domain.

A Typical TNS Architecture

In the NCW domain, networks are the building blocks of any army's network centric war fighting capability. These networks include a gamut of stakeholders on the battlefield – from the individual soldier to the strategic/national level decision makers. In any networked army, all the components of the Tactical Networked System (TNS) will interact with each other for waging wars in the NCW domain. The components of any TNS will vary from nation to nation and

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will be tailor-made to serve the military doctrine of that nation. As I see it, every TNS will have the following main components:-

(a) **Network Security Layer.** The data being used in the network will be classified, as it will pertain to the operational matters. Hence, there is a requirement of having a security layer wrapped around the network to cater for the security aspects of the TNS. This layer will incorporate various cryptographic technologies to ensure the security of flow of information.

(b) **Combat Components' Sub-Networks.** Each combat component of the army (like infantry, artillery, armour, etc) will have a network of its own, which will be a sub-network of the overall TNS. These sub-networks will mesh together at various hierarchical levels – from a fighting unit to a divisional or corps headquarters.

(c) **Logistics' Sub-Network.** Logistics form the bedrock of sustenance for any military operation. To meet the logistic needs of the army in war, there will be a logistics sub-network catering for operational logistics. The data in this sub-network will aid the decision makers in planning the logistics in support of the operations.

(d) **Decision Support System (DSS).** In order to aid the decision makers at various hierarchical levels to optimally perform their role in a NCW environment, it is imperative to have a DSS. This DSS will incorporate various decision support aids like soft computing techniques, algorithmic iterations, mathematical functions, etc to constitute the decision making cycle of the user.

(e) **GIS.** The GIS will be the core of all the other sub-systems. As all military planning is done on maps, in the NCW domain, all military planning will be done on digital maps aka GIS. Therefore, GIS will be the essential ingredient of any TNS. Ergo, the data granules comprising the GIS will assume critical importance. These data granules will comprise the GeoInt.

(f) **Control Hub.** This hub will be the control centre of the TNS. All the communications and data flows will pass through (logically, not physically) this hub. The decision makers of the TNS will work through this hub. Ergo, this part of the network will become crucial to military operations. Other networks of the nation may be connected to the TNS through this Control Hub.

The TNS will therefore encompass all the components of the army. The virtual world of NCW will, therefore, be a mirror image of the physical world. The only difference being that the, 'combat power' – of the army in the NCW dimension will be an exponential factor of the information flowing through its veins. Therefore, information - and hence axiomatically GeoInt – will become the critical factor for success in battle. After having seen a typical TNS, let us now understand GeoInt.

Meaning of GeoInt

GeoInt has been defined as "the exploitation and analysis of imagery and geospatial information to describe, assess and visually depict physical features and geographically referenced activities on Earth".[1] GeoInt can also create a Common Operational Picture (COP) of a specific area by effectively using multiple and advanced sensors, multiple types of data and information (including operations, planning, logistics, etc), as well as multiple intelligence disciplines to present a comprehensive visual depiction.[2] GeoInt also includes information on weather, order of battle, intelligence reports and other forms of intelligence.[3] The term has been used widely throughout the world interchangeably with the term Geographic Information (GeoInfo) without any major change in its import.

Importance of GeoInt in TNS

In any military operation, credible and actionable real time information is a vital ingredient of planning. The same holds true in NCW also. And since the GIS forms the heart of any TNS, therefore a good GIS will result in a good system and vice versa. GeoInt, being the atomic granule of GIS, thus assumes critical importance. Any GIS of any TNS will have Geoint at its core. The quality of the data in the core – GeoInt - will determine the efficacy of any geographical intelligence. In TNS, all the plans will invoke the GIS on a regular basis. There will be linkages in the Data Base (DB) between textual data and GIS data. Data will be traded as per the queries/operations performed by the user. The quality of the GeoInt will, therefore, have a great bearing on operational planning. GeoInt will help the user in the following:-

(a) Unmasking the enemy's intentions.

(b) Formulation of sound responses by own forces.

(c) Fructification of sensor-to-shooter concept.

(d) Provision of decision support to commanders at all levels.

(e) Maintenance of DB of enemy terrain and to decipher any changes in his operational plans.

(f) Sharing of real time information with other national agencies in times of natural disasters.

Requirements of GeoInt for TNS

There are a number of features available in any commercial GIS today. Apart from these inherent features – like buffering, network analysis, geo-referencing, 3D fly through, etc - in order to ensure a high quality operational planning and to meet the users' aspirations, the GeoInt and GIS will need to have the features as given in the succeeding paras.

Large DB For Various Operational Exigencies. In order to fight a victorious and short duration war using networks, any TNS should have a large DB of the orbats, doctrinal templates, satellite imageries and Unmanned Aerial Vehicles (UAV) clippings of the geographical regions of the adversaries, to ensure the availability of requisite data for operational planning. In the case of IA, as it is getting involved more and more in operations that are likely to fall in the realm of Fourth Generation Warfare (4GW), with ongoing insurgencies in Kashmir, Northeast India and the rise of Naxalism, the involvement of IA in more and more of these kinds of operations is only likely to increase. Therefore, it is imperative that a major portion of the GIS DB of TNS of the IA should have adequate DB for fighting such wars (i.e. it should have DB for internal geographical areas as well). Again, in the present geopolitical situation, operations of the IA are likely to be restricted to the sub continent only. However, in the near future, operations with allies or under the aegis of the UN cannot be ruled out. Hence, adequate geographical data about areas where such operations are likely, must be gathered. This will transform the DB into "Knowledge Bank".

Met and Almanac Data. The TNS will be used to arrive at operational plans and, will therefore, need to have a DB of met and almanac data of the envisaged areas of operations. This DB will indicate mundane but critically important questions like the moon phase on a particular date at a particular place, wind patterns in a given area, onset of spring and neap tides on shores, chances of rainfall/storms during a particular time period, et al. This data will need to be regularly updated. This data will be utilised for selecting the time of attack, areas of nuclear fallout based on wind patterns, and other such military decisions/analyses.

Accurate and Authentic Dynamic Data. Dynamic data is the data which is fed by the users and is regularly updated by them. This data is the basic user data present in the GIS, the onus of which is on the users. The dynamic data has to be accurately fed into the DB, first initially and then as and when the changes occur, to keep it updated. This DB has, therefore, to be updated on a regular basis, by the users. Inaccuracies will lead to faulty planning and resultant avoidable setbacks on the battlefields. In order to ensure fruitful data updation in the DB, suitable software algorithms have to be used to ensure that the user gets what he wants for his operational planning.

Multi Sensor Data Fusion (MSDF). As the TNS of any nation gets enlarged in its scope, in due course of time, there will be a plethora of sensors/agents who will be giving such information. These sensors will be in the form of electro optical sensors, acoustic sensors or visual or electronic line of sight sensors. Therefore, there is a need to have suitable algorithms for fusion of data from multiple sensors. This fused intelligence will then be displayed on the GIS to ensure better decision making by commanders and staff. MSDF, therefore, assumes critical importance in any TNS.

Preclude Information Overload. With a plethora of electro optical reconnaissance and surveillance devices mushrooming on the battlefield, all future wars will have more transparency in real time. These sensors will send their feed to their respective owners. However, it will also lead to information overload at various hierarchical levels of the TNS. GIS of the TNS should, therefore, have adequate in-built flexibility to sift through mountains of information to provide real time decision support to the commanders at various levels. This implies having strong algorithms with apt human interfaces in the overall workflow of the GIS.

Incorporation of Doctrinal Templates. If the TNS is designed to handle intelligence problems, then the system should have suitable Intelligence Preparation of Battlefield (IPB) modules in-built. Therefore, there is a requirement to have doctrinal templates of the enemy/insurgents being stored in the DB of the system. This will enable better decision support to commanders at various levels. Again, the regular updation of these templates based on the enemy's changing thinking and dispositions assumes vital importance.

Enhanced Data Mining Techniques. There is a need to incorporate enhanced data mining techniques to analyse apparently inconsequential activities of the enemy in an area and then throw up a possible pattern in its doctrinal or operational thinking. This will enable the users to identify the relationship between any changes in the enemy's deployment patterns in the exercises and actual operational concepts of the enemy and modify own operational plans accordingly. Presently, in many a GIS, this facet is neglected. But this facet is of immense importance during peace time for operational planning. A strong data mining algorithm is, therefore, obligatory in any TNS.

Data Reuse and Preservation. As the volume of data being generated will increase due to prolonged usage over a period of time, there will be a need to preserve this data and reuse it intelligently at a later stage. Therefore, there is a dire need for data reuse and preservation. With the data being acquired so quickly, there is a tendency to ignore or postpone the creation of metadata or indexing of the source material.[4] Therefore, the GeoInt being used in the TNS should have adequate algorithmic checks incorporated to ensure cataloguing, indexing, preservation and reuse of data.

Interoperability. To meet the specific demands of the various components of any army – combat and logistics – it becomes imperative that different platforms are used for respective sub-networks. As these sub-networks get meshed together in the TNS and have to communicate with each other, interoperability of data assumes critical importance. This interoperability is of three types:-

(a) **Semantic Interoperability.** This will ensure that when the one user queries "list all the jungles in the area X" and the other user queries "list all the forests in the area X", the system throws up the same answer. As the scope of the networks is enlarged with other players becoming stakeholders in the network, this will assume vital significance.

(b) **Structural Interoperability.** This will imply uniformity in the metadata (like coordinate system, resolution, etc) and the schemas involved. Suitable programming techniques should be adopted to solve the problem of structural interoperability. Various software solutions already exist in the market to incorporate this capability.

(c) **Syntactic Interoperability.** This deals with the file formats, data formats etc. If two subsystems store the same data with different syntax, then there will be a problem when they try to exchange that information. There is thus a need for the development of specific GeoInt ontologies and standards. Open Geospatial Consortium (OGC) standards are a step in this direction.

Change Detection Module. This is complementary to the temporal queries being performed by the system. As various sensors will gather data about an area over a period of time, it becomes imperative to have change detection software being incorporated in the GIS to ensure that subtle changes in terrain features (natural or man-made) – if missed out by humans – are detected by the software. A powerful change detection software incorporated as the integral part of the GIS module will have exponential payoffs in the DSS of any TNS.

Common Symbology. In order to depict the same data on the GIS, there is a requirement of having a common symbology platform for different types of users. In the absence of a common symbology, exchange of marked overlays between disparate systems or within the different sub-networks will be problematic and will hamper smooth operations.

Automate Routine Cognitive Tasks. A lot of routine tasks that presently require human interface should be automated by the GIS of the TNS. These will include, say, selection of helipad sites, selection of suitable radar and gun deployment areas, etc. Most of these problems are based on the terrain features and a given set of parameters. Hence, a powerful GIS will have adequate tools to ensure automation of such routine cognitive tasks. These then should be bundled together in a module of the GIS for better user-interface.

Dynamic Maps. Presently, only digital maps are being incorporated in the GIS. However, there is a need to depict spatial and visual data through animated symbology and cartographic designs. This assumes importance in the light of the fact that many clients will have variable connectivity, dictating the amount of information that can be efficiently delivered and visualised. Hence, the need for middleware that performs optimised filtering of GeoInt for content delivery, based on the end user's connectivity and visualisation environment[5] – from any hierarchical formation headquarters (say a corps HQ) to a battalion – becomes imperative.

Scalability + Zoom. Ideally, the scale and clarity of the map should remain the same when the user zooms closer, with the point of zoom staying in focus. This would entail a large amount of metadata and attributes being captured and is thus a highly painstaking, but imperative, work. Current systems, however, merge the two features and therefore, when the user zooms closer to the point of focus, the view scale also changes.

Predictive Interaction. Presently, the GIS opens the same type of GIS map for all the users. However, there is a need to incorporate interactive models to include implicit predictive interaction based on a user's past activities over a period of time[6]. This will ensure that, for e.g., a map of scale say 1:50,000 is opened (as a default by the system) for the artillery user; of scale 1:10,000 for infantry user operating in urban terrain; of scale 1:250,000 at corps level; and so on.

Miscellaneous Issues

Apart from the integral requirements of the GIS of the TNS as discussed above, there are a plethora of other issues which if addressed suitably by the appropriate policy making or designing authorities will go a long way in ironing out the wrinkles of the GIS enabled environments of any army including IA. These are highlighted as under:-

(a) **OGC Compliance.** The GIS being selected by various sub-networks of the TNS should be OGC compliant to ease interoperability issues at a later stage.

(b) **Standardised Attribute Tables.** The attribute tables being used should be standardised to a common format to ensure seamless integration of various networks.

(c) **Metadata Repository.** A metadata repository needs to be created to store the metadata of the data being used in the sub-networks. This will enable authentic data updation on a regular basis. Again, in the case of India, National Spatial Data Infrastructure (NSDI) Metadata Standard should be complied with for creation, formatting and storage of all metadata of the GIS being used in the TNS.

(d) **Conform To Policies.** The softwares, data and maps being used should conform to various policies – like map policy, GIS policy, etc - being laid down by the Government and/or the IA.

Questions GeoInt aka GIS Will Answer

We see that the requirements may appear as all encompassing today and all may not be available in the systems of today. However, with emerging technologies and evolution of TNS, it is better for us to crystal gaze in the near future to cover the silhouettes of the TNS, say five years hence. For a military user, the GIS could answer many questions and aid in decision support. Some of these questions are as under :-

(a) What are the details of the terrain in my area of operations?

(b) Based on the movement of troops and convoys during adversary's mobilisation practices, exercises, etc has his doctrine undergone any major changes?

(c) What are the road and railway routes available for mobilisation? What are the choke points en route and the detours available?

(d) Where are the likely helipads, gun areas, dropping zones?

(e) What is the moon phase on a specific day?

(f) Where are the mobility corridors and avenues of approach in the area of operations?

(g) What is the dead ground or blind areas for my guns and radars?

(h) What is the line of sight from place X to place Y?

(j) What are the villages and towns with a specified set of parameters?

(k) Where are the defiles and forested areas along a route / in an area?

Conclusion

In order to win the future wars, in the backdrop of NCW, GeoInt (and thence GIS) becomes an important ingredient of combat power. Hence, identification of the correct requirements of GIS today will enable a better TNS for any army tomorrow, thereby leading to a quick victory in a 'virtual' war. It is, therefore, morally obligatory for any military user to fulfill the requirements of GIS to obtain optimum benefits from the TNS. Once these are identified and thereafter, implemented in the TNS, victory in the NCW domain will have inched closer.

As various networks are mushrooming in the IA as well, it is an operational imperative to have apt designs of the varied GIS enmeshing with the correct GeoInt data, to ensure that we have battle winning systems in our inventory, a few years from now.

Endnotes

1. Geospatial Intelligence Basic Doctrine, Publication 1-0, published by National Geospatial-Intelligence Agency (NGA), September 2006, page 5.

2. Ibid, page 5.

3. "Priorities for GEOINT Research at the National Geospatial Agency", published by National Geospatial Agency (NGA), February 2009, downloaded in PDF format from http://www.nap.edu/catalog/11601.html, accessed 03 June 2009, page 10.

4. Ibid, page 49.

5. Ibid, page 41.

6. Ibid, page 45.