# Methods of Practical Spatial Data Modeling forArmed Forces

Mr PVGS Jayaram[1] Dr T. VijayaLakshmi[2] Mr Ramesh Chandra Padhi[3]

[1]MrPVGS Jayaram, General Staff Officer (Software & GIS),Project Management Organisation, Directorate General of Information Systems, Integrated Headquarters of Ministry of Defence, New Delhi, jayaram777@gmail.com
[2] Dr. T. Vijaya Lakshmi, Assistant Professor, Centre forEnvironment, Institute of Science and Technology, JNTUH, Hyderabad tatiparti@yahoo.com
[3]Mr Ramesh Chandra Padhi, Additional Surveyor General & Head, Indian Institute of Surveying and Mapping, Hyderabad rcpadhi@gmail.com

----------ABSTRACT----------

The Geospatial data sharing is the prime tool in the hands of Military leaders to fight all conventional battles including the information warfare. Timely updation of data is very critical for successful planning of operations and taking decisions in realtime. The interoperability between various military agencies at the national level is only a part of the challenge, while the integration of systems of both military and civilian agencies is the crucial and other part of the challenge.Most of the solutions that were propagated by various governmental and private agencies in dealing with this challenge are through encouraging use of Spatial Data Exchange Format. Indian National Spatial Data Infrastructure (NSDI) has come out with National Spatial Data Exchange (NSDE) format, which if used by all agencies, the exchange of Spatial data could be made contiguous. The approach is positive for most of the civil agencies adopting the Geospatial resources for planning, but the same approach will not be sufficient for Armed Forces, towards achieving interoperability. The challenge for inter service data exchange for Armed Forces pegs from indifferent data models attempting to interchange data in a conflict situation. The data models need to be logical and base their framework on the prevailing operational art. Each system in every service follows a proprietary data model. The need for a uniformly adoptable data model is the necessity for the Armed Forces. There have been innumerous attempts of model generation attempted with partial success at the institutional level;the issues noticed as complex even after such attempts in providing seamless integration are because of the nature of functioning within Armed Forces. The approach and planning that should be focused in undertaking the development of a logical data model for Armed Forces are different from what are followed in creation of data model for civil agencies. Unless these are addressed, the creation of data model for Armed forces will be not wholesome and will fail to achieve its very aim.

***Keywords*** *–Data modeling, Armed Forces, Framework for logical data model, context based process analysis, command control and operational elements.*

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## 1. INTRODUCTION:

The domain of defense and the ambit of Geospatial technology have witnessed an ideal mix in the military, over the past decade. The necessity of Geospatial data to augment national security has been recorded in all operational forums of defense as an inescapable way forward.The collection, storing and management of Geospatial data have gained momentum post realization of the operational importance of the spatial data. Defense has not been any exception in bringing forth its need for Geospatial technology thathas witnessed unorganized growth in the civil already. The huge Geospatial intelligence gathered with individual defense establishments has to be managed effectively in order to gain strategic benefits to full potential. The lack of seamless interoperability surfaced as the major hurdle for smooth data transfer. The syntactic and semantic interoperability issues have been successfully addressed by defense, as the understanding of each other's domain was sound. However, the schematic interoperability has been most challenging of all. While hardware, software based commonalities have been addressed to a large extent with focused approach, the practical data model has been identified as the most essential pre-requisite for seamless interoperability. This paper attempts to bring out the major strategies that one needs to adopt in undertaking the task of designing a logical data model for the Armed Forces. It will also highlight the gaps, reasons and shortcomings, the data modeling approaches have been

noticed with, so far, while attempting to create a data model.

## 2. Data Model Creation Procedure:

### 2.1 Basic:

The technologists responsible to create a practical data model are the critical link between the creation and execution of it. These developersof data model need clear understanding of the database, the size of it, the complexity of RDBMS (Relational database management systems), the abstraction associated with the data, the accurate interpretation of the operational needs and most importantly the manner in which the Geospatial data is to be presented to the military leaders. These are understood, though, with frequent interviews and interactions with the users, the domain is not interpreted by the developers correctly. The gap between technical understanding and the tactical realization continue to figure in the data model created. The approach adopted with military precision in arriving at a pragmatic, practical and logical data model needs to have a team with blend of domain knowledge and technical expertise.This paper focuses on areas that need renewed attention to see the most effective and logically apt data model for the Armed Forces.

### 2.2System of Studying Existing Models:

For creating any new system, it is essential that the existing drawbacks in the prevalent systems are analysed, corrected and modified to suit the end system. In the case of military, the study of models is not possible, as the existing models are confidential in nature. The evolution of Geospatial technology is also not very old; hence not too many robust systems are available for study in open domain. This situation results in the technologists studyingdata models employed in the civil systems, which do not match the military needs. Hence the system study does not really lead to the development of practical data model.Hence a model development plan for Armed Forces needs to be attempted from the scratch. The following crucial questions that precede a new model development must be addressed:-

[01] Why is current system of data model development not ideal for the desired results in the Armed Forces?

[02] What are the issues that are not in the acceptable format or not to the desired level of satisfaction?

[03] Are proposed model specifications likely to improve and automate the currently implemented system?

[04] What are the critical weaknesses of the existing system?

[05] Can a feasibility study be initiated to overcome existing problems in the prevalent models?

### 2.3 Governing Dimensionsand Preparation of a Framework for Planning a Logical Data Model:

Planning is very crucial for any project development. Information systems are no different. While the information is vital for decision making in military, the Geospatial information will assist systems in becoming more intelligent. Huge hardware and software resources, which are part of information systems, are spent in eliciting accurate Geospatial information. Hence it is mandatory to have a formal team having clear understanding of the hardware and software in use in the systems. The application, the operating system and the database in use are crucial in designing effective model. The role played by the operational systems in the automated systems, must be thoroughly studied by the team. A framework having these basic details must be prepared, which would act as a driving forces for further planning of the model. The strategic planningprocess of the systems and execution model in the networked environment under tactical command control and communication systems as part oforganisation's overall GIS plan must be clearly documented separately under the framework document. These will be formed subsequently as governing rules and regulations for GIS based implementation in the operational information systems. The underlining data model will logically be based on the framework document.It must be clearly understood that unlike any MIS (Management Information Systems) planning, GIS based planning and data modeling needs to be undertaken at managerial, operational and execution levels simultaneously.

### 2.4 Link Between System Development and User Requirements:

The physical level framework creation will be followed by the process of identifying system requirements to streamline and record user requirements. The GIS technology keeps changing; accordingly the concepts of system development and the manner of operations in the military also vary, the pattern of which must be noted, accordingly the questionnaire for collecting user requirements must be framed. Hence a link between users and technologists should never be discontinued. Every meeting with the user should be considered as a new learning. While the collection of requirements of users is a well formulated and standard process in the

civil, it is a kind of an iterative process for Armed Forces.

## 2.5 Interpretation of the Problem:

The users see a problem in generic terms and will expect the qualitative outcome from the solution. No more than generic requirements can be expected from them, whereas the system developers expect the problem definition in terms of input, output, processes and structured form of data. The system design tends to get generic due to either misinterpretation or failing to elicit and assimilatefull details of user needs, due to intentional holding of inputs by users due to security concerns, or lack of adequate understanding with the users. Three well documented strategies namely '*Kitchen sink strategy'*, '*Smoking strategy'* and '*Same thing strategy'* are adopted by users in the Armed Forces even when system developers approach them.

**2.5.1 Kitchen Sink Strategy:**The users describe everything into the demand definition – Exaggeration of needs such as overabundance of reports, exception processing, and the like. This approach usually reflects user's lack of experience in the area.

**2.5.2 Smoking Strategy:**The users set up a smoke screen by requesting several system features when in reality only one or two are needed. The excess requirements are used as bargaining power. This strategy usually reflects the user's experience in knowing what he/ she wants.

**2.5.3 Same Thing Strategy:**This strategy indicates users' slothfulness, casual attitude or lack of knowledge. "Give me the same thing but in a better format through the computer" is a typical statement. Here the analyst has little chance of succeeding because only the user can fully discover the real needs and the problems.

## 2.6 Long Term Historic Perspective:

The human perspective is generally short term, hence the requirements tend to be influenced by recent data necessities, and the historic needs are left out. This is mostly applicable to Armed Forces, as the users are generally stay for a short term at an appointment and at a location. The influence,hence, of recent events, as against necessity of all the important events, tend to overshadow the long term historic perspective. Hence the user requirements for a data model should not be merely based on user submitted document. The system developers should studyother existing information systems, analyse the manual procedures in vogue and execute a continuous discovery approach capturing the information system requirements.They may have to adopt a prototyping approach, considering the historic perspective of military requirements.

## 2.7Information on Work Flow:

The information about the organization and the manual procedures may not suffice, as the information about the manner in which the procedures are executed at formation, unit or sub-unit level are required to be recorded as a work flow. Workflows in the Armed Forces are mostly different than that exist outside, as the operations vary from context to context. The focus, hence, should not only on where the data is emanated from, but also on what happens to it while it passes through various access points in a system. This should get represented as a data flow diagram with each processing point in the system being exhibited with direction.The difference between simple system flowchart and the workflow diagram must be understood. The mere representation of physical systems with flow depicted in a one-sided direction is not sufficient. Generally flowcharts fall in to this category, whereas the workflow diagrams give out the source of generation and location of processing points through a clear depiction of start and end points.Without preparing the workflow diagrams, the model generation will not address all the operational aspects.

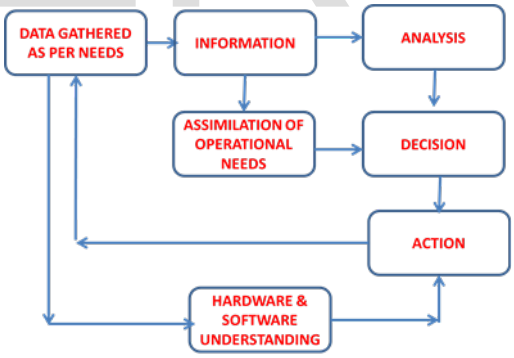


**Fig 1 – Sample workflow diagram**

## 3 Context basedProcess Analysis prior to Creating a Data Model:

The existing data models in the civil industry do not apply to the operational information systems. This situation resulted in creation of multiple adhoc data models for Armed Forces, without considering all the operational aspects, which are implemented in individual systems in silos. The models have so far been created taking certain pre-conceived conditions applicable to a particular context. However, when the same model is executed between disparate systems, in different context, the system will not facilitate

seamless interoperability. The model needs to be flexible, context dependent, modular, logical and of course user friendly. All the situations arising out of operational needs of Armed Forces need to be assessed before designing the data model. The sample context based situations given below can throw some light on the context based design:-

Context 1 : Defensive operations
1.1: Enemy forces attacking by foot.
1.2: Enemy forces attacking by air.
1.3: Enemy forces attacking by water route.
1.4: Enemy mechanised forces attacking.

Context 2 : Offensive operations
1.1: Own forces attacking enemy by foot.
1.2: Own forces attacking enemy by air.
1.3: Own forces attacking by water route.
1.4: Own mechanised forces attacking enemy.

**Fig 2 – Sample Context based situations**

## 4 Data Modeling Process Focus Areas:

### 4.1 Data Abstraction:

A certain amount of abstraction is linked to the data, which is used as framework for modeling. The data assists developers think deeply about the way a model has to be designed. The criticality of data in the Armed Forces grows because of its enhanced abstraction levels. The data is assimilated differently in different situations, which is the main cause of its increased abstraction. In the civil, the data is equally critical, though the data definition is clear, which does not alter with changing situations. Even if it changes, the situations are conceivable.The abstraction for Armed Forces, since is huge, when multiple systems with different data definitions, are to be considered for an integrated data model, it becomes difficult to assess and quantify the abstraction. The construction of the data model hence would be prone to errors. The object based database will obviate handling problems of data at database layer.Any successful project implementation towards creation of a data model in Armed Forces can be attributed to the success or failure of the accurate process of data design based on quantification of the abstraction.

### 4.2Precise Data Modeling:

The importance of the contexts, historical perspective of the data is highlighted in the preceding paragraphs, but the process of undertaking data modeling to the precise degree will now be considered in succeeding paragraphs. The data model for Armed Forces must be based on complete understanding of the operational principles. The level of detail should include suitable entities along withattributes and relationships with relevance to the operational principles.The data types along with full constraints must be developed as part of the data model. The process also should focus on the level of finesse and the degree of integrity. The suitability of the model must bear in mind the application of it in the operations. The necessity at the enterprise level, applicability of it for futuristic systems and the need for its employability in the networked environment are very critical. Though certain generality is essential to maintain flexibility, the level of detail must be very specific and precise.The operational, control and command elements depicted below should form the main entities towards consideration of workflow dissemination and data modeling:-

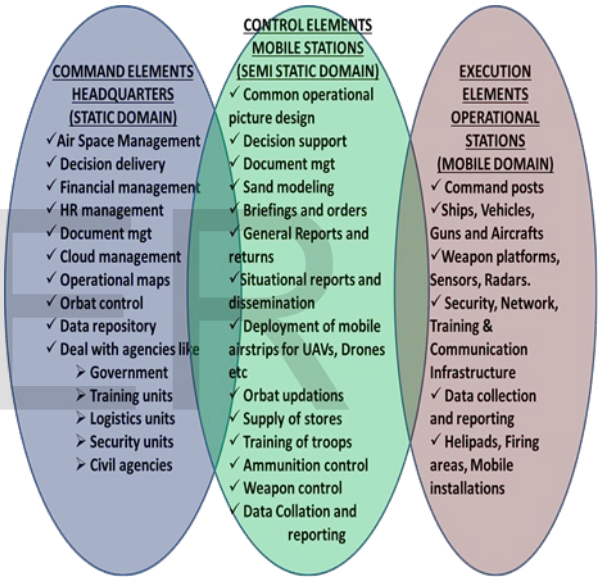


**Fig 3 – Command, Control and Operational Elements**

### 4.3Iterative Development of Model:

As described in preceding paragraphs, the data modeling for Armed Forces should be iterative in nature. The problem definition of the Armed Forces is not similar to any modelin the civil agencies. Hence no firm definition or level of detail can be obtained in one instance and no such details are available on public domain. The process is not limited to one form of warfare or operational parameters. Figure 2 describes the contexts in two forms of warfare, however the warfares vary with each type of terrain. The weather conditions and the resources available also dictate the kind of situational awareness desired in the system in field. Hence, the parameters to be assimilated vary from context to context, from terrain to terrain, from situation to situation and from weapon availability to weapon availability. The parameters may vary from airforce to navy

and navy to army. Hence the combinations of situations in an iterative manner must be assessed and finalised. It is axiomatic to quote in this context that only iterative form of logical data modelthrough prototype submission to users, the model's practicality can be assessed.

**4.4Avoid Ambiguity in Modeling:**Asunderstood, unlike the civil agencies, the situation in the Armed Forces cannot be assessed. Most of the situations tend to emerge as response to Geopolitical realities exists at that point in time during operations. Hence the model will have to consider such situations with a strategic approach. The speculations and the assumptions that are recordedprior to creating a data modelshould not be rigidly fixed as the norm. It can help in creation of a prototype, however the speculation prevention must be attempted at each stage of data modeling. The data definitions can be defined clearly based on the operational status. The entities need to be defined both for topographical elements and for operational objects. No entity should be included, which has no role in the way Armed Forces operate.The attributes with each entity must also be simple and close to reality, rather than theoretical in nature.The relationships between entities besides including the topology must be given heightened state of priority.

**4.5 Combination of operational and Analytical Data Model:** By far it is evident thatthe data model for Armed Forces must be simple, unambiguous and easily executable, by defeating the uncertainties through robust analysis of situations. The data use in Armed Forceswould have direct bearing on the operational effectiveness of the application. Hence the data model would have to be created on operational functionalities included in the application domain. However, the analytical capability of each application in military clearly an indication on the way forward for the data modelers. Merely addressing the operational functionalities may result in partial successin creation of a logical data model, as the analytical practicalities have to be considered for effective data modeling. The operational functionalities concern the regular modus operandi and operations in military domain. These are routine in nature and can be modeled with ease through clear understanding of the domain. In contrast, analytical practicalities emphasize complex queries that import and uselarge quantities of data to enable military leaders towardstaking strategic decisions in real time.

**4.6 Redundancy of Entities and Attributes:**While data modeling for Armed Forces, the entities must be designed unique as is the norm, however special attention is warranted to avoid unnecessary redundancy of entities and attributes. The attributes must be simple and should be matching the operational and analytical functionalities within applications. The duplicates can bring in avoidable inefficiencies, which can become a reason for subsequent failure of the model. The process of optimization should commence at the time of entity and attribute finalisation.

**4.7Asymmetric development of Topological Relationships for Entities:**

The entity relationship at the database level must be designed to keep the connectivity between them intact. As the terrain entities and the operational entities are going to be large in number in the data model for Armed Forces, it must be ensured that the data structure and topology development is simple and normalized. In absence of proper optimization, the symmetric planning of relationships can lead to heavy and impractical data model. The symmetrical form of entities will set inefficiencies in the systems, which should be carefully avoided while designing data for Armed Forces. The asymmetric form of entity relationship must be retained for optimized spatial analysis. The under given example clarifies this issue:-

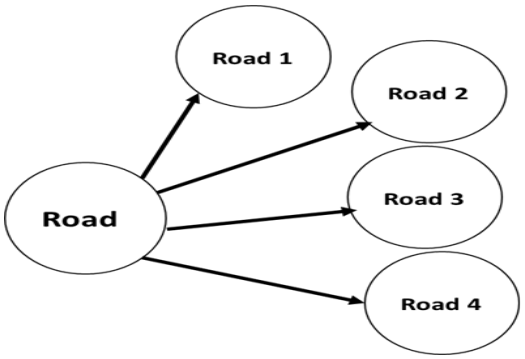


**Fig 4 - Symmetric Entity elationship (Should be Avoided)**

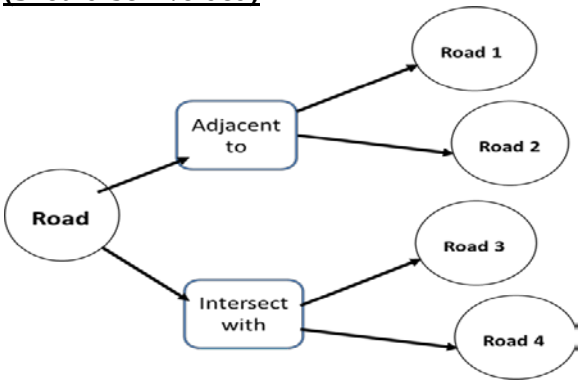

**Fig 5 - Asymmetric Entity Relationship (Should be Adopted)**

## 5 Summary of Issues to be borne in mind for designing a Practical and Logical Data Model:

Any prospective developer of data model for Armed Forces prior to undertaking the process, must bear in mind the issues highlighted above. These can summarized as given under:-

[1] Database design has to precede the data model development. Object based database is the most suitable form of database.
[2] Understanding of the GIS planning and rules set for GIS implementation at the organization level is essential.
[3] Data flow diagram more important than a mere flow chart of events.
[4] Clear understanding of the domain isquintessential. Continuous interaction with domain experts must be maintained.
[5] Entities and attributes with operational principles. Data integration and constraint based data types with deployability at enterprise level is essential.
[6] Iterative form of devp of data model.
[7] Precision and geopolitical precision with a strategic view point is order of the day for modeling in Armed Forces.
[8] Combination of operational and analytical application.
[9] Redundancy reduction and optimization from the beginning of finalizing entities and attributes.
[10] No Symmetry for entity devp.
[11]Information planning is everything. Information is a critical asset.
[12] Historic perspective.
[13] Requirement of understanding various operations of warfare.
[14] Understanding of the GIS planning and rules set for GIS implementation at the organization level is essential.
[15] Study the civil models but build from the scratch.
[16] Situational assessment is mandatory prior to model design.
[17] Entities and attributes should be linked closely with operational principles.

## 6Conclusion :

The inter service data exchange will efficiently be undertaken only with a pragmatic and logical data model. National spatial data exch format of Indian NSDI will not suffice to attain seamless interoperability amongst disparate systems. The data modeling needs to be undertaken by technologists keeping the practical functionalities of the Armed Forces. The aspects that are necessary to be considered while creating a data model for Armed Forces are highlighted in the paper. If the guidelines are followed on creating a data model, a very logical and user-friendly data model could be created. This approach can be effectively adopted for any defense force at the international level.

## References:

**Books:**

[01] S Atre, (*Discussion on Normalisation*), *Data Base: Structured Techniques for Design, Performance, and Measurement, (*John Wiley & Sons, 1980).

[02] Mr. George Tillman,*A practical guide to logical data modeling, Systems design and implementation series*.(McGraw hill, 1993).

[03] MrTony J Teorey,*Database modeling and design: The Entity Relationship Approach*, (Morgan Kaufman Publishers, Inc 1990).

**Journal Papers:**

[04] MrEric Hartunian and Wade A German,*Data Integration to explore the dynamics of conflict, Program for Culture and Conflict Studies at nps.edu* (Dec 2008).

[05] MrCodd E, *A Relational Model of Data for Large Shared Data Banks*, Communications of the ACM (1970).Normalization as a data modeling technique is advocated in this paper.

[06] Mr Witt, G.C., "*The role of metadata in data quality*", published in Journal of Data Warehousing Vol 3 No 4 (Winter 1998).

[07] Reiner K. Huber, Lynn F. Jones, EgilReine, *Military Strategy and Tactics: Computer Modeling of Land War Problem*, Plenum Pub Corp (Jan 1976) presented during Otto Conference on Modeling Land Battle Systems for Military Planning.

[08] Reiner K. Huber,*Modeling and Analysis of Conventional Defense in Europe*, Springer (May 1986).

[09] *National Spatial Data Exchange (NSDE) format* issued by NSDI, Ministry of Science, Government of India.