Transformational Initiatives in C4I
Geospatial Information Technology in Command & Control

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ABSTRACT: At present, military commanders are aggressively fielding capabilities to support current operations while simultaneously developing future battle command capabilities. Significant investment has been made to modernize the materiel, information technology and doctrine used to equip, train and deploy the current force. A manifestation of these advances can be seen in the way information technologies are being designed and developed in conformance with standards and to operate in a common environment. The C4ISR, M&S and Geospatial Information domains make up three operational stovepipes that directly impact the effectiveness and efficiency of Battle Command processes. Efforts are underway to further integrate these processes through the use of a common foundation based on Geographic Information Systems (GIS).

For such an effort to be successful, geospatial information must conform to doctrine and be directly applicable to operations. The Army Geospatial Center (AGC) has focused on this challenge and developed processes that generate Tactical Spatial Objects (TSO) that can be referenced in both C2 and M&S systems. In order for these products to become fully integrated with battle command, they must be linked to a common C2 data model. With the evolution of the Command and Control Information Exchange Data Model(C2IEDM) and the Joint Consultation, Command and Control Information Exchange Data Model (JC3IEDM), such standards now exist to support a direct link between core C2 information and supporting geospatial products. By directly integrating geospatial intelligence within the Military Decision Making Process (MDMP), commanders are provided with a greater understanding of the operating environment.

Building a foundation based upon standards, Commercial Off the Shelf (COTS) software and a Service Oriented Architecture (SOA) approach, delivers a component-based capability that can be tailored to meet the needs of every echelon of the force. These capabilities can be fielded quickly and greatly increase the quality, timeliness and efficiency of military operations.

1. Introduction

Military commanders have access to a wealth of technology that can help to inform decision making. Capabilities exist to store and maintain Order of Battle, perform war gaming and simulations, command and control forces, display and analyze terrain, and many other functions. The objective of these technologies is to inform the commander with timely and accurate information on which to base decisions and effectively employ available assets. Battle Command systems provide the ability to effectively consume available information from a wide variety of sources while simultaneously organizing and distilling the inputs into actionable information. These inputs inform the commander and the interpretation of them results in decisions, plans and orders.

A limiting factor to the efficiency and effectiveness of battle command is the ability to manage the vast amounts of available information and develop a coherent plan in a time-constrained environment. One factor affecting the efficiency of battle command is the operational stovepipes that sometimes exist amongst and between Command and Control (C2), Modeling and Simulation (M&S) and Geographic Information Systems (GIS). The functional domains of C2, M&S and GIS involve a range of domain specific data models and interfaces that can result in a complex process of data translation and exchange amongst the various systems. By unifying these disparate operations through the use of a common set of standards and protocols, significant operational efficiencies may be realized. Geospatial technologies can provide a basis for a unified battle command approach that supports interoperability and informed decision making. This paper will review the current state of efforts and technologies relating to the transformation of battle command capabilities.

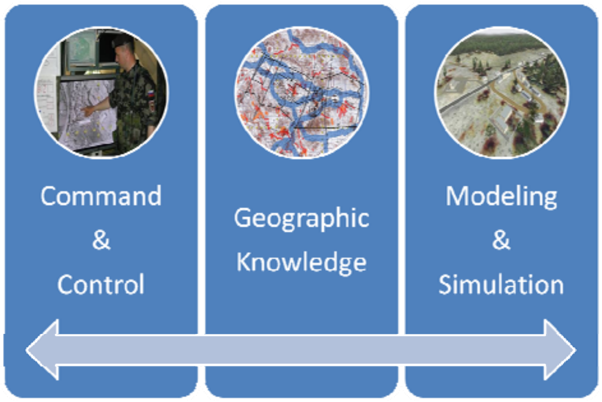

Figure 1. A Common Geospatial Information Basis for C2 and M&S

1.1. Battle Command Perspective

In order to effectively accomplish a mission, a well structured battle command process must allow receipt of orders, consideration of resources and threats, identification and evaluation of options, and onward communication of orders. This process must inform the commander with timely and accurate information on which to base decisions and effectively employ available assets.

Battle Command is the foundation of the Army's present and future command and control architecture. Battle Command delivers a high quality capability of providing seamless interoperability through mission planning, preparation, and situational awareness. Battle Command also enhances Warfighter performance, and reduces system complexity [1].

The primary limiting factor relating to the use of technology in support of battle command is time. Commanders have a finite period of time in which to obtain and analyze available inputs and formulate a plan. If information must be imported, translated and exported from one system to the next, valuable time and resources must be allocated to accomplishing these tasks. Before technology can be fully exploited in support of battle command, significant work must be done to identify the optimal workflows, followed by unification of the disparate systems and functions involved. Commanders often suffer from information overload and time constraints necessitate the development of plans and orders without bringing the full potential of available technologies to bear.

1.2. Improving Value While Reducing The Cycle Time of Planning, Decision And Action Processes

A fundamental skill set required of all military officers is a solid grasp of the Military Decision Making Process (MDMP). The MDMP can be likened to a step-by-step instruction manual to guide decision making and the planning of operations. The full MDMP is a detailed, deliberate, sequential, and time-consuming process used when adequate planning time and sufficient staff support are available to thoroughly examine numerous friendly and enemy courses of action (COAs).[5] In time constrained environments the MDMP process must be abbreviated and parallel planning with subordinate units becomes a higher priority. Situational Awareness (SA) is a vital prerequisite in order for the MDMP to be executed effectively. As a result, timely and accurate SA must be readily available at every echelon of the fighting force. The SA required to support operations cannot be delivered by technology alone, but the technologies available to today's military offer significant potential to enhance the MDMP.

In order to develop an effective plan a commander must first possess accurate and timely knowledge of the Mission, Enemy, Terrain and Weather, Troops, Time and Civil (METT-TC) factors. The vast array of sensor platforms and reconnaissance capabilities deployed on the battlefield provide a wealth of information that is vital to effectively planning an operation. Significant resources are also allocated to the development and maintenance of detailed information relating to the terrain in which our forces operate. All of this information is of little value unless it can be put into the hands of decision makers in a timely fashion.

A GIS capable of consuming the Order of Battle (ORBAT), missions and tasks directly from a C2 system and displaying that information along with terrain reasoning capabilities, fixed and mobile sensor inputs, and available courses of action (COA) can provide the commander with a consolidated, timely and authoritative view on which to efficiently make decisions. In such an environment the number of interfaces is reduced and the use of available information is maximized while reducing the cycle time required to analyze the information.

1.3. Three Communities – Three Stovepipes

Three key enablers of battle command are C2 systems, M&S systems and GIS. The disjointed nature in which these systems sometimes function is evident in not only the data elements and standards involved, but also by analyzing where in the organizational structure and decision making process the various functions are executed. Valuable insight may be gained by evaluating courses of action (COA) in an M&S system, but if the simulation is not directly stimulated from the systems used to derive COA's, and if the results are not linked back to the operational systems, then the simulation system is of reduced value. Geospatial technologies can provide invaluable knowledge relating to the battlefield and the application of combat power, but if the geospatial data is not easily accessed by battle command systems it is of limited value. A C2 system can provide for the efficient creation and communication of orders and other operationally relevant information, but if that information cannot be directly communicated between M&S and GIS systems then operational efficiencies will be reduced.

Widely accepted standards exist within the respective domains and these standards provide a framework for interoperability within each domain. The Multilateral Interoperability Program (MIP) is focused on the development of data standards and system architectures to support C2 system interoperability. MIP includes a data model (C2IEDM becoming JC3IEDM), a message exchange mechanism and a data exchange mechanism. The Open Geospatial Consortium (OGC) develops standards supporting the interoperability of GIS for various types of geospatial data as well as metadata, catalog and discovery services. And the M&S community currently leverages the High Level Architecture and Distributed Interactive Simulation (HLA/DIS) among other standards which allow virtual, live and constructive elements to collaborate in a war game or simulation. The development and widespread use of these standards represents a major step forward and should not be dismissed. Significant fiscal and operational gains have been realized through the use of these standards and the migration away from closed systems and data formats. While facilitating interoperability within the C2, M&S and GIS, these standards do little to enhance the interoperability between the C2, M&S and GIS domains.

In order to maximize the value of available information, C2, M&S and Geographic Information Systems must be linked and made to operate on a common information base. GIS can provide the unifying basis upon which these systems can interoperate and provide maximum value to battle command.

1.4. Geographic Information Systems

Geospatial information plays a fundamental role in C4I and a wide range of capabilities have been developed to meet the needs of the C4I community. In the past, many geospatial capabilities were developed to meet very specific requirements and often resulted in duplicative functionality and costly sustainment requirements. The DoD is migrating to a more structured acquisition environment for their IT capabilities that focuses on the use of commercial technology and standard frameworks. This approach is meant to increase interoperability, reduce costs and support the rapid fielding of capabilities. To support the migration to a standard geospatial framework within C4I, the DoD has adopted the Commercial Joint Mapping Toolkit (CJTMK). CJMTK provides all Command, Control and Intelligence (C2I) programs with an extensible toolkit that provides a solid foundation for interoperability based on commercial software. By adopting CJMTK, C2I programs have access to a rich set of data management, analysis and visualization capabilities and can quickly leverage new developments in the commercial products. The CJMTK represents a major step towards improving operational efficiencies in the C4ISR domain. Through the use of CJMTK, and the Geodatabase at its core, C2I programs have access to the basis for an interoperable information infrastructure.

In order for GIS to be utilized to its full potential within Battle Command, geospatial information must conform to doctrinal procedures and be directly applicable to operations. The Battlespace Terrain Reasoning and Analysis – Battle Command (BTRA-BC) Program has focused on this problem and seeks to distill geospatial information into knowledge that can be used by decision makers. BTRA-BC uses foundational geospatial data such as Theatre Geospatial Database (TGD) to develop geospatial products that are directly related to the planning and execution of military operations. These operationally-relevant geospatial products are referred to as Tactical Spatial Objects (TSOs). Some TSOs are fairly generic and can be produced without knowledge or detail of a specific plan or operation while others apply directly to a specific plan or COA. The size and complexity of TSOs also varies depending upon context and scope. As such, three tiers have been developed to classify TSOs.

Tier 1 TSOs represent the general military value of the terrain and weather based on the doctrinal principles of OAKOC – obstacles, avenues of approach, key terrain, observation and fields of fire, and cover and concealment. These data products can be pre-computed and are generally mission independent. Tier 2 TSOs can be derived from the foundational data and/or from analysis of Tier 1 TSOs. They are more tightly integrated with the tasks that are required to support the unit's mission or operations and are generated when that information becomes available or is further refined. Tier 3 TSOs are increasingly mission and task focused while also accounting for specific friendly and enemy situations [2].

The software used to create TSOs are CJMTK-based processes that generate operationally relevant geospatial data that can be referenced in both C2 and M&S systems. The BTRA Program encapsulates the TSO engines as BTRA CJMTK Extensions (BCEs) and makes them available to the CJMTK community via the CJMTK website. The BCEs represent operationally relevant terrain reasoning capabilities that are directly applicable and available to the warfighter.

In order for BCE products to become fully integrated with battle command, they must be linked to C2 data models (JC3IEDM, BML, etc.) and doctrine. With the evolution of the Command and Control Information Exchange Data Model (C2IEDM), the Joint Consultation, Command and Control Information Exchange Data Model (JC3IEDM), C2 CORE and BML, standards now exist to support a direct link between core C2 information and supporting geospatial products. By directly integrating geospatial intelligence within the Military Decision Making Process (MDMP), commanders are provided with a greater understanding of the operating environment.

1.5. Battle Management Language and Geospatial Battle Management Language

In order to enhance the interoperability of C2 systems and M&S, a capability must exist to automate the exchange and interpretation of the aspects of a plan or order. The five paragraph order contains many inputs required to generate a simulation, but at present it is difficult for a computer system to decompose the contents of an order and significant human interface is required. One of the benefits of the proposed Battle Management Language (BML) is support to communicating orders between C2 and M&S.

The concept is to incorporate the doctrinal base into the C2IEDM/JC3IEDM, which will be used to exchange C2 information in future Army C2 systems. This doctrinal base will include the vocabulary as contained in FM 1-02, Operational Terms and Graphics as data tables. The syntax and semantics as defined through the Army Universal Task List (AUTL) (FM 7-15), the Army Training and Evaluation Program (ARTEP) Mission Training Plans (MTP) and other related Field Manuals will be used to define the relationships of the data tables with respect to specific echelon and type units. This will allow the user of the C4I systems to operationally specify the required actions and behaviors that are to be executed by the subordinate units, either live or simulated, and provides for a detailed mapping to specific execution code within models and simulations.[2]

The concept of GeoBML was developed to support the linkage of TSOs to BML and the language of C2. GeoBML defines TSOs in a doctrinally relevant manner so that they can be clearly understood and referenced by military decision makers. As discussed, TSOs relate to specific aspects of OAKOC and METT-TC and represent required inputs to the planning and execution of missions and tasks. With the current approach to TSO development and GeoBML, the TSOs may be referenced directly within C2 data models such as the JC3IEDM. These references can be queried by planning staffs and the appropriate TSOs can be made easily available for the inclusion in mission planning processes. Should the necessary TSO inputs not be available, GeoBML provides a means to clearly articulate the required information to terrain teams and other staff tasked with providing geospatial support to the planning process.

1.6. Modeling & Simulation

M&S informs how we fight, impacts how we train, how we conduct Command and Control (C2), how we analyze and evaluate our situation and how we select from various courses of action [6]. Due to the complexity of the environments which M&S systems must emulate, and the performance requirements necessary to meet operational needs, most M&S systems leverage proprietary database formats. Capabilities such as SEDRIS exist to provide common meaning and semantics for terrain data and an interchange mechanism between M&S formats, but SEDRIS is not capable of supporting simulations at runtime.

Significant resources are often required to translate operational geospatial information into proprietary data formats for use within M&S systems. To meet performance requirements the source data is often generalized which introduces the potential for inaccuracies based upon a false representation of terrain and other features within the battle space. The disconnect between operational terrain data and proprietary M&S database formats also limits the ability to adapt to changing requirements. As operational data is updated to reflect current conditions or new Situational Awareness (SA) becomes available this data is not directly available for use within many M&S systems. Leveraging the same CJMTK-based data services that are provisioned to C2 systems enhances mission planning processes and situational awareness.

The US Army Topographic Engineering Center has funded efforts to investigate the potential to enhance the interoperability of GIS and M&S. These efforts initially focused on the integration of a specific M&S software from MÄK Technologies and ESRI's ArcGIS (the foundation of CJMTK). MAK developed the GIS-to-SIM extension to ArcGIS to provide the underlying components to enable ArcGIS-based applications to connect to a simulation exercise and visualize real-time data [7]. A similar effort focused on the goal of geospatially enabling M&S software such as MÄK's VR Forces. The Geospatially Enabled Modeling & Simulation (GEMS) effort focused on existing limitations relating to the use of operational geospatial information in simulations. GEMS successfully demonstrated the concept and produced an API allowing direct access to the ESRI Geodatabase to develop and execute simulations. Efforts are now underway to develop more generic interfaces which will support multiple M&S vendors and allow open access to the Geodatabase from within simulation environments.

Integrating C2 and M&S systems has proven no less challenging. As plans and orders are developed within a C2 environment they must be accurately passed to M&S systems in order to accurately develop military scenarios. The Program Executive Office for Simulation, Training, and Instrumentation is engaged in an effort to develop the Military Scenario Definition Language (MSDL) to address this issue. The objective of MSDL is to accurately migrate data from a C2 environment to multiple M&S systems in such a way that each M&S system can uniformly generate military scenarios. The lack of such a capability results in inconsistent definition of the scenario and decreased reliability of the simulations.

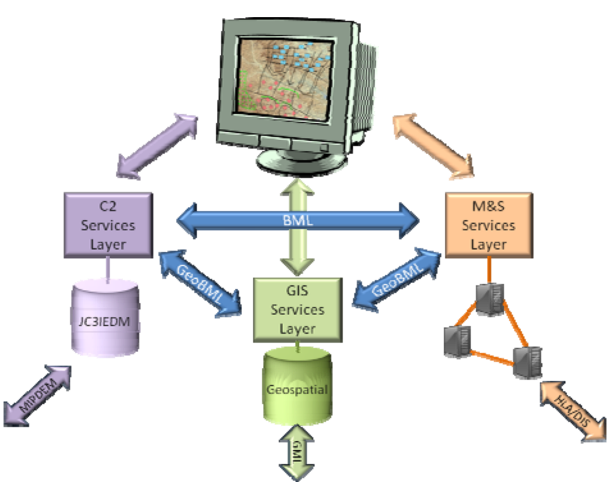

Figure 2. Doctrine-Driven, Integrated Battle Command Framework

2. C2 Transformation

2.1. Network-Enabled Command Capability (NECC)

The current portfolio of C2 systems are transforming to operate in a common framework focused on interoperability. In 2005, the DoD tasked the Defense Information Systems Agency (DISA) to lead efforts to develop a C2 Service Oriented Architecture (SOA) that would modernize existing C2 capabilities and migrate to an integrated C2 framework. The current effort, Network-Enabled Command Capability (NECC), seeks to migrate the Global Command & Control System (GCCS) family of systems to a net-centric C2 framework. A primary focus of this effort is to decouple data from systems and focus on an iterative process to field priority capabilities at a measured pace. The first iteration of NECC development is focused on modernizing capabilities relating to SA and developing a Joint Task Force (JTF) global common operating picture. A priority that will be a focus area in the near term is that of geospatial information. The C2 community currently lacks a fully integrated geospatial capability that supports the access, visualization and analysis of geospatial information that incorporates METT-TC factors and aligns with the MDMP. As defined, the requirements for NECC geospatial capabilities will support the access and display of Joint Intelligence Preparation of the Operational Environment (JIPOE) products, targets, and support automated and scenario-driven flythrough while not degrading accuracy [3].

2.2. Net-Centric Enterprise Services (NCES)

In 2003, the DoD Chief Information Officer published a memorandum outlining the DoD Net-Centric Data Strategy.[4] The key aspects of this strategy are:

- Ensuring data are visible, available, and usable when needed and where needed to accelerate decision-making
- "Tagging" of all data (intelligence, non-intelligence, raw, processed) with metadata to enable discovery of data by users
- Posting of all data to shared spaces to provide access to all users except when limited by security, policy or regulations

- Advancing the Department from defining interoperability through point-to-point interfaces to enabling the "many to many" exchanges typical of a net-centric data environment

The stated goal of NCES is quickly becoming a reality, and its development is following a portfolio management approach that dictates adoption of best of breed technologies and COTS software over the development of costly government off-the-shelf (GOTS) solutions. A key aspect of NCES is that of well-defined and searchable services. These services are accessible to systems via an enterprise catalog supporting Content Discovery Federated Search and a metadata registry containing structured metadata, Web Service Description Language (WSDLs) and Extensible Markup Language (XML) schemas. The availability of discoverable and accessible services has the potential to greatly enhance the MDMP and the interoperability of C2, M&S and GIS.

NCES has the potential to greatly enhance battle command by delivering a framework in which SA and JIPOE/IPB inputs are easily discoverable and accessible in a system agnostic manner. Services that provide key inputs to the MDMP are made available in a way that makes the information understandable and useable by a wide range of systems and processes. NCES supports greater machine to machine compatibility and reduces the man to machine interfaces required to execute IPB. Through NCES, command staffs can discover available services and directly apply them to the MDMP without the need to reach out to multiple functional areas and staff sections.

3. Improve Battle Command

3.1. Improve/Enhance The Communication of Orders (automation of orders)

The most fundamental components of military operations are the development, communication and execution of orders. All military operations begin with the receipt or anticipation of an order and this represents the first step in the MDMP. The orders process has changed very little over time and is almost universal across both US and Coalition armed forces. The key components of an order encompass the Commander's Intent and the Who, What, When, Where and Why of the operation. These components are then organized into a five paragraph document which is approved by the commander.

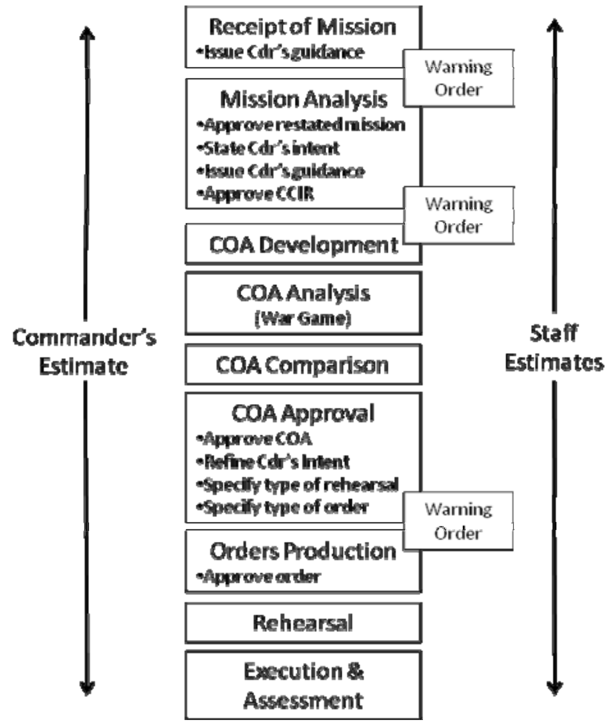

Figure 3. The Military Decision Making Process, Adapted From FM 5-0

The five paragraph order is a document that conforms to a basic structure that is familiar to the reader who is familiar with the language and style used to develop its content. Some knowledge of the author may be required to fully understand certain elements of the order. The use of such documents is limited where computer systems and language barriers are concerned. The document can be transmitted by a computer system, but most C2 systems today lack the ability to understand the free-text content and resolve ambiguity that may exist.

The means by which orders are communicated through the chain of command currently requires a significant amount of human interface. Commanders are required to physically sign orders before they are deemed actionable and subordinate units must manually develop lower-lever orders by distilling the components of orders received from higher echelons. Valuable time and resources are required for this process and limit resources that can be allocated to determining how to execute an order. As orders are passed to lower echelon, knowledge of the style of the originator may be lost resulting in the potential for ambiguity. Style is an important factor since some commanders are far more detailed in their orders than others. One commander may use no more than a sentence to communicate the intent, while others may go into great detail.

The transition to a digital order that is built upon standard schemas that can be understood and decomposed by a computer system offers the opportunity to enhance the speed with which the order can be developed and acted upon by lower echelons and mission partners. Through the use of a standard schema, graphic user interfaces (GUIs) can be developed to streamline the creation of orders as well as allow them to be directly stored in a database for use by other systems. Such an order can then easily be transferred to subordinate units for analysis and reuse via standard protocols.

The transmission of orders and situational awareness is usually accomplished using various messaging formats. Depending upon the C2 systems and domains involved, messages can be transmitted in a number of widely used formats such as United States Message Text Format (US-MTF), ADatP-3 (NATO) and OTH-GOLD (Over the Horizon) that define the structure and content of a wide range of different Message Text Formats (MTFs). In the case of military orders, the ORDER MTF is used to transmit the standard five-paragraph order to subordinate units. Orders that are transmitted in a homogeneous systems environment can be easily translated. Where a heterogeneous systems environment such as might be found in NATO Coalition operations is concerned, mappings are required to translate the content in an unambiguous manner. Although ADatP-3 was derived from USMTF, there are numerous instances were values were changed or have different meaning and therefore mappings must be developed. These mappings can be implemented on a system- by-system basis or through the use of COTS software. One such COTS solution is the IRIS technology from Systematic Software. The IRIS Information Mapping Tool (IMT) permits the efficient creation of mappings between different formats.

3.2. Mission Analysis

In the mission analysis phase of the MDMP, time is the most important factor. A primary role of the commander is to balance the desire for detailed planning with the available time to execution and planning needs of subordinate units. Commanders typically allocate two thirds of the available time to subordinate units and one third to command planning [5]. The issuance of a warning order is extremely important as it provides subordinate units with the ability to begin planning in parallel based upon the core information provided in the warning order. IPB is an area of mission analysis where technology offers significant advantages and opportunities to maximize the time available for planning.

C2 systems allow for the efficient transmission of information such as requests for information, situation reports, ISR taskings, weather reports, terrain analysis and maneuver. The ease with which this information can be accessed, analyzed and acted upon greatly affects the time required to execute mission analysis.

The five-paragraph order contains all of the information required to guide mission analysis and IPB. An order, transmitted in a standardized format, can be used to harvest key inputs to mission analysis and IPB such as the type of mission, specified tasks, constraints, available assets and the area of operations. These inputs can then be provisioned to Army Battle Command Systems (ABCS) and lower echelon forces to further enable efficient parallel planning.

3.3. Order of Battle (ORBAT)

Order of battle signifies the identification, command structure, strength, and disposition of personnel, equipment, and units of an armed force. ORBAT is a key input to mission analysis as it gives the commander a timely and accurate understanding of the forces at his disposal. The means by which this information is documented and maintained varies but many times the ORBAT is maintained as a spreadsheet. The use of a spreadsheet adds another interface required to execute battle command and adds to the resources required to develop and communicate orders. The units contained in the ORBAT must be loaded into the operational overlay for visualization and analysis by the command staff and complex symbology must be applied to allow for accurate interpretation of the graphic.

Since 2004, ESRI has made the Military Overlay Editor (MOLE) available to the battle command community to support the rendering of units and other tactical graphics in operational overlays and other visualization systems. MOLE provides a solution to the issue of rendering graphics that conform to the MIL-STD-2525B and STANAG APP-6 symbology standards.

ESRI, in cooperation with the Army Topographic Engineering Center is currently engaged in an effort to build upon the success of MOLE and deliver a capability that moves beyond rendering symbology and delivers a data model capable of representing information such as dynamic location, Order of Battle, Table of Organization & Equipment, unit capabilities and control measures. These objects can then be modeled within missions and tasks that are executed based upon relationships and parentage. This approach represents a major step forward for GIS and the potential to directly support COA development, IPB and war gaming. This effort is currently coined as the

Military Object Information and Analysis System (MOBIAS).

MOBIAS is being developed on a framework that is fully compatible with enterprise-licensed C2I capabilities within the CJMTK Program. MOBIAS will be able to leverage existing and emerging terrain analysis capabilities such as those being developed by the Battlespace Terrain Reasoning and Analysis, Battle Command (BTRA-BC) Program at the Army Geospatial Center (AGC). Operational restrictions such as those based on space and time are accounted for in the model and will allow for the handling of control measures such as phase lines and objectives as well as temporal restrictions associated with tasks and associated military objects. If MOBIAS is successfully delivered it could resolve a wide range of redundant and inefficient battle command processes and support a geospatially enabled interface to battle command.

3.4. Operational Overlays

An operational overlay uses military symbology to portray the plans, orders and tasks associated with a military operation as well as the friendly and enemy forces involved. Operational overlays are developed based upon the receipt of a certified copy of the OPORD and graphically represent the steps detailed within the order as well as inputs from the G2 and G3. The process of developing operational overlays has largely moved from the use of overlay paper, tape and colored pencils to computer-based systems capable of displaying complex unit and task representations integrated with authoritative geographic information.

Maintaining an operational overlay within a GIS and using the system during the planning process offers greater flexibility and an ability to leverage geospatial analysis capabilities directly within the active overlay. As designed, MOBIAS would offer a streamlined process for the efficient creation of operational overlays and the ability to dynamically analyze a mission and evaluate multiple scenarios without rework or additional graphics.

3.5. Course of Action Development

The development of COAs immediately follows the mission analysis phase of the MDMP. Time constraints impact the number of friendly and enemy COAs that can be developed and evaluated. A commander's guidance can also place constraints on COA development and eliminate sub-optimal COAs. Each developed COA requires a COA statement that articulates how an assigned unit will execute the mission and a graphic that portrays details relating to the forces and control measures involved in the mission.

The development of COAs requires access to a number of inputs that can be coordinated upon receipt of the initial warning order. A series of foundation data products are available to characterize certain aspects of METT-TC. The Theatre Geospatial Database (TGD), Integrated Meteorological System (IMETS) weather data, Digital Terrain and Elevation Data (DTED), and socio-cultural information are all possible inputs to COA development. The characteristics of the mission may dictate which products are required and available.

The AGC has also focused on capabilities to develop mission-specific geospatial products to assist in COA development and mission execution. The BTRA-BC Program has developed a series of software applications that use foundation geospatial data to generate Tactical Spatial Objects (TSOs) that are tailored specifically to mission execution. Upon receipt of an order with a well defined mission and associated tasks, the development of mission-specific TSOs can begin. BTRA-BC is currently focused on migrating TSO engines from desktop and client-server configurations to web services based on OGC standards. The move to web services is in line with the tenets of NECC and NCES and will allow for the discovery and use of the outputs by other battle command systems.

3.6. COA Analysis – War Gaming

COA analysis identifies which COA accomplishes the mission with minimum casualties while best positioning the force to retain the initiative for future operations.[5] COA analysis is both an art and a science. The basis for COA analysis is a geospatial representation of the area of operations, the terrain and both friendly and enemy unit symbols. A complete accounting of combat forces as well as their support requirements and constraints is also required to effectively execute war gaming.

Critical events and decision points are also key aspects of COA analysis. Critical events encompass all potential occurrences that require further action or decision. Decision points are physical locations on the battlefield were decisions are required as the plan is executed. These decision points may affect how the remainder of the COA is executed and evaluated.

The science of war gaming relates to certain known facts relating to the units and equipment involved in operations. Many aspects of war gaming lend themselves well to modeling in a GIS, but limitations do exist. The speed with which a particular unit can maneuver over familiar terrain and the range and capabilities of the weapons systems at their disposal can be accurately modeled in a simulated environment.

War gaming is typically allocated the largest amount of time during the COA analysis process, but it is also limited by the amount of time available before the MDMP must progress. The ability to maximize the efficiency with which COAs can be developed and analyzed offers significant advantages to battle command. If METT-TC and JIPOE inputs can be easily discovered, accessed and incorporated into a COA analysis package, commanders can evaluate the maximum number of COAs in the time available.

Numerous efforts are underway to streamline the process of COA development and evaluation in time-constrained environments. The AGC has focused efforts on the BTRA Battle Engine (BBE) prototype which integrates ORBAT, Modified Combined Obstacles Overlay, terrain analysis, war gaming and visualization into a single framework to support rapid COA development and evaluation. BBE provides a centralized capability allowing the input of enemy and friendly COAs and ORBAT information.

3.7. Development of Order

Once a suitable COA is determined by the commander the process of developing an order commences. Many aspects of COA development can be reused to create the required inputs for an order. The COA statement can be used to define the concept of operations and the graphical representations of the terrain, forces and control measures can be used to generate operational overlays.

4. Conclusion

The common challenge affecting the C2, M&S and GIS domains is the consistent and unambiguous exchange of information. The work of the standards community has done much to alleviate these issues but the landscape of data models, exchange mechanisms and protocols is more complex now than ever. C2 Core and BML are working towards a common and interoperable language for C2 that can be leveraged across all battle command domains. The work of the MIP has resulted in a viable data exchange architecture based on the MIP Data Exchange Mechanism (MIP DEM) that can be implemented to support US and NATO coalition information exchange. HLA/DIS/TENA standards now support distributed cross-platform simulations. CJMTK-based C2 systems can interoperate based upon data and services in GML.

The AGC is currently engaged in an effort to demonstrate a COTS-based capability to support the coupling of actionable geospatial information and C2. The Common Ground Joint Capability Technology Demonstration (JCTD) seeks to implement a discovery and exchange process supporting the creation and exchange of C2 information and associated geospatial information. A common geospatial information base that is directly associated with, and referenced by, C2 standards and systems is a work in progress. These activities align with, and will be directly supported by, the activities of US and Coalition military departments as they implement NECC, NCES and similar loosely coupled frameworks. As the domains of C2, M&S and GIS become more tightly integrated a single operating picture, based upon GIS, becomes more feasible.

References

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