A Framework for Integrating Command and Control Systems, Geographic Information Systems and Simulations

Dr. Michael R. Hieb
Dr. J. Mark Pullen
Center of Excellence in C4I
George Mason University
4400 University Drive
Fairfax, VA 22030
USA
(703) 993-1538
mhieb@gmu.edu
mpullen@gmu.edu

David Swann
Gary Scoffield
ESRI
380 New York Street
Redlands, CA 92373
USA
(909) 793-2853
dswann@esri.com
gscoffield@esri.com

Kay Pedersen
James Muguira
Systematic Software Engineering A/S
Soren Frichs Vej 39
DK-8000 Arhus C
Denmark
45-8943-2000
klp@systematic.dk
jam@sseusa.com

Michael W. Powers
US Army Engineer Research and Development Center
Topographic Engineering Center
7701 Telegraph Road
Alexandria, VA 22315
USA
(703) 428-7804
Michael.W.Powers@erdc.usace.army.mil

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ABSTRACT: In this paper, we present a framework for integrating Geospatial Information with C2 and M&S information. Common services are identified and specific Geospatial, C2, and M&S standards are utilized, where appropriate. Currently, these are three domains where the applications and services only minimally interoperate.

A new development is the emergence of Geographic Information Systems (GIS) as the foundation for US defense-wide enterprise services. One example of this is the Commercial Joint Mapping Toolkit (CJMTK), which provides a standardized geospatial information and application infrastructure within the US DoD. This infrastructure is capable of supporting the powerful terrain reasoning capabilities needed by both M&S and C2 systems. Interoperability between C2 and M&S systems is substantially improved when both are using the same geospatial data sets and the same display.

Recent work has shown the relevance of working with standard C2 data models, using the current NATO standard Command and Control Information Exchange Data Model (C2IEDM) to interface to C2 applications and services. In order to utilize Geospatial Information, a Geospatial Battle Management Language (geoBML) can be used where Spatial Objects (SOs) that have tactical significance are generated using terrain reasoning and are referenced within the C2IEDM. Examples of SOs are mobility corridors and engagement areas.

The framework is supported by case studies using CJMTK, the C2IEDM, and geoBML. The strength of this framework is that a C2IEDM-based C2 System becomes the foundation for a more sophisticated terrain reasoning environment and is significantly extended with a capability to emulate and analyze Courses of Action (COAs) using M&S capabilities. The chosen COA in the C2 System can then produce a consolidated plan that conforms to C2IEDM. This sophisticated analysis is then available to all C2IEDM compliant partners.

1. Introduction

The purpose of this paper is to propose a new framework for the integration of C2 with GIS and simulations. As more defense systems are converging upon GIS, there is a need to define the interface between these functional domains. These domains need to share common representations of the Battlespace environment. GIS formatted data and information has the capability to enable both C2 and simulations to perform consistent, interoperable planning, wargaming, and C2 rehearsal. As more geospatial information becomes available and accessible in the future, both Command and Control applications and Modeling and Simulation systems will need to take advantage of the geospatial capabilities (i.e. GIS) to realize the potential of interoperability and enhanced execution within both critical domains.

1.1 Why Geospatial data, information and systems should provide a common framework for Developing Defense Systems

First and foremost, geospatial data and information provides a ubiquitous, critical basis for understanding the environmental context impacting the full spectrum of military operations. Geospatial data and information is both an enabler and a constraint on operations and needs to be comprehensively and consistently addressed in the domains of both C2 and simulations.

In addition, there is a growing frustration about the lack of source data and the expense of creating custom terrain databases for stovepiped C2 and M&S systems. The problem is particularly acute for simulations, as each simulation has its own terrain data base format. This greatly limits the fidelity of terrain used in simulations, and causes great, and often insurmountable, interoperability problems in using simulations to support C2 systems due to terrain disconnects (e.g. format, syntax and semantic consistency).

As geospatial systems have evolved to the current generation of commercial GIS tools and enterprise GIS solutions, such as CJMTK, there is a growing feeling that the next generation of net-centric C2 systems should make increasing use of these geospatial systems and tools.

With the advent of capable desktop, server, enterprise and services-based GIS solutions, there is no technical reason why all C2 and simulation systems could not use the same terrain framework. In particular, there needs to be a commonly understood methodology for how Geospatial, C2 and M&S systems will be used. In this paper, we argue that the C2 and M&S domains can be treated as the same from a geospatial perspective. The use of separate terrain formats for C2 and M&S in the future will perpetuate basic interoperability problems as net-centric systems are developed.

Note: In the rest of the paper when we refer to Terrain, we are referring to the broad class of environmental data that includes representations of the physical environment to include terrain, weather, and similar concepts.

1.2 Need for a clear Conceptual Framework

Within the US Army, the domains of Geospatial, Command and Control, and Simulations are traditionally treated separately from requirements validation through material development. There is a US Army Training and Doctrine Command (TRADOC) Program Integration Manager (TPIO) for Terrain and a TPIO for Battle Command (the current US Army term for C2). Simulation requirements have emerged both from the grass roots level in the TPIO's, as well as centrally from a program office. Also, the material developers have been separate program offices. This has led to a completely different set of Terrain and C2 requirements in the US Army. Consequently, Terrain data and information is produced and consumed in totally separate contexts in the C2 and Simulation domains.

This same situation exists in other services and countries. The result is not only a lack of interoperability, but a limited understanding about the common dependencies of Terrain upon the two domains, as well as of the fundamental Terrain concepts, processes and Information Technology (IT) infrastructure that is common between the C2 and Simulation domains.

The existence of stovepipes has encouraged the development of specialized terrain products and tools as well as C2 systems for various functional areas. Decoupling these areas may have been necessary in the past, but, given the more general standards and net-centric concepts and technology, this is neither necessary nor desirable in the future.

What is needed is a general framework that can guide integrated development of both C2 and Simulation uses of Terrain Services and functionality for the Warfighter.

1.3 The Effect of the Proliferation of Terrain Capabilities and the Objective of a Conceptual Geospatial Framework

The emergence of stove-piped systems within and between each domain has led to challenges and solutions. One solution to interoperability within the terrain domain has been to look at standardizing the *data* formats so that all systems can use the same terrain. Another successful approach is to use a mediation/translation architecture as in the SEDRIS (Synthetic Environmental Data Representation and Interface Specification) standard.

The conceptual framework proposed takes advantage of the use of data level services and capabilities of commercial GIS. In doing so we can take advantage of the mediation services already developed, while at the same time being able to adopt the rich set of data supported by commercial GIS and standards bodies such as the Open Geospatial Consortium (OGC). Thus, we do not need to weigh the merits of one terrain data format over another. Additionally, the proposed framework will be shown to allow common solutions through well-engineered abstraction from the data level up to that of actionable geospatial information. In this extension, the framework exposes a second, arguably richer basis for interoperability between the C2 and Simulation domains. Finally, the framework addresses the potential of common GIS management and analytic tools and IT implementations.

1.4 Roadmap to Rest of Paper

The remainder of this paper is organized as follows: Section 2 gives a background on the relevant standards for the Geospatial, C2 and M&S Domains. Section 3 reviews several relevant projects, which show how C2 applications use products generated by a GIS. Section 4 presents an initial framework along with recommendations on how future development should proceed for the Defense Community. Section 5 concludes with recommendations for an open community framework in this area.

2. Building Blocks

Successful frameworks are based upon open standards. The success of standards in C2, GIS, and M&S pave the way for specifying a new approach to the use of geospatial information.

2.1 MIP and C2IEDM

Despite the fact that C2IEDM is only an interim step in an evolving standardization work of the Multilateral Interoperability Programme (MIP), it already creates a solid foundation for the industry to build C2 systems that support the strategic and tactical needs of coalition forces. The C2IEDM is constantly evolving and the next version will be called the Joint Consultation, Command and Control Information Exchange Data Model (JC3IEDM).

The C2IEDM has become a trustworthy standard through bi-annual multilateral test runs that document which nations are interoperable with one another. The ongoing test activities may seem exhausting to the industry, but are necessary to ensure the continuous validity of the evolving MIP standardization work.

A few nations have already chosen to deploy their C2IEDM-based systems into international operations, which is a clear indication of the fact that C2IEDM has moved away from the test lab and into the battlespace, as the interoperability provider.

2.2 CJMTK and Geospatial Markup Language (GML)

The Commercial Joint Mapping Toolkit (CJMTK) is a National Geospatial-Intelligence Agency (NGA) Program that provides the required geospatial information management, analysis, and visualization functionality for command, control, and intelligence (C2I) mission applications running in the Common Operating Environment (COE) and the emerging Network Centric Enterprise Services (NCES).

The CJMTK provides common, commercially-based, geospatial tools, while enhancing their capability and performance. Commonality of platforms, software tools, and processes is a critical factor in assuring interoperability across C2 Services. Also, adoption of commercial industry standards reduces overall integration costs for the various DoD Mission Applications.

The CJMTK is based on a single scalable open architecture, with open development environments, incorporating industry standards, where significant research and development costs are borne mainly by vendors, offering regular software upgrades, extended functionality, and standard, regular training. The primary component of the CJMTK is the ESRI Geographic Information System (GIS) software called ArcGIS.

ESRI's ArcGIS platform is an integrated collection of software products for building a complete geographic information system (GIS). ArcGIS is used for the creation, management, integration, analysis, display, and dissemination of geospatial data. The ArcGIS platform enables you to deploy GIS functionality and business logic wherever needed—in desktops, servers, custom applications, Web services, or mobile devices. (ArcGIS Main Website - <http://www.esri.com/software /arcgis/index.html> and "What is ArcGIS 9.2?" - http://www.esri.com/library/books/what-is-arcgis92.pdf).

The ArcGIS platform embraces a wide range of IT, Defense and Geospatial standards to ensure a permissive approach to standards in that developers are able to choose the standards needed to deliver interoperability in their specific circumstances. A key geospatial standard that is supported in ArcGIS is Geography Markup Language (GML).

GML is an XML encoding for the modeling, transport, and storage of geographic information including both the spatial and non-spatial properties of geographic features. The key concepts used by GML to model the world are drawn from the OGC Abstract Specification (available online: http://www.opengeospatial.org/specs/). The GML specification defines the XML Schema syntax, mechanisms, and conventions that:

• Provide an open, vendor-neutral framework for the definition of geospatial application schemas and objects;

• Allow profiles that support proper subsets of GML framework descriptive capabilities;

• Support the description of geospatial application schemas for specialized domains and information communities;

• Enable the creation and maintenance of linked geographic application schemas and datasets;

• Support the storage and transport of application schemas and data sets;

• Increase the ability of organizations to share geographic application schemas and the information they describe.

Implementers may decide to store geographic application schemas and information in GML, or they may decide to convert from some other storage format on demand and use GML only for schema and data transport.

2.3 M&S Standards – HLA and DIS

The M&S community predominantly uses two standards: the High Level Architecture (HLA) for M&S and Distributed Interactive Simulation (DIS). Each of these was developed to enable multiple simulations to interoperate in a distributed fashion.

Of the two, DIS is the more basic. It represents objects and their interactions by fixed-format messages, and represents time implicitly, in that time is presumed to be the same at all points in the distributed simulation, with latency of communication neglected.

HLA is considerably more sophisticated. It provides for explicit management of simulated time, as well as other critical aspects of the distributed simulation: federation management (execution control), declaration management (publish/subscribe/control data), object management (definition/location/interaction), ownership management (privilege to update), and data distribution management (routing data to processes based on interest). HLA is based on a set of formal rules and has built up complex definitions of federation, simulation, and management objects that form the basis for interoperation of a wide variety of simulations.

These simulation standards, while quite useful for their intended purposes within the simulation community, generally are seen by outsiders as too specialized for use outside of the M&S Domain.

3. Investigations into Incorporating Actionable Terrain Information into the C2IEDM

We first examine some application-level lessons learned with existing commercial products and innovative research projects.

3.1 A C2IEDM Compliant C2 System's (SitaWare) use of GIS (ArcGIS)

Modern C2 systems such as SitaWare [17] consist of many components that, as a whole, establish an environment for the creation of complex orders such as Five-Paragraph-Orders. Figure 1 demonstrates the range of SitaWare and its integrated parts. It is significant that the geospatial representation of planning (e.g. Annex C/OPLAN) is the preferred environment to get an overview of these orders; not just for situational awareness, but also for planning activities. This is not just an outcome of digitization, but rather a historical precedence that the focal point of a Headquarters is the map board. The integration of ArcGIS Engine, Military Overlay Editor (MOLE) and Geodatabase from ESRI (shown in Figure 1) enables SitaWare to represent military geospatial aspects in a C2 context.

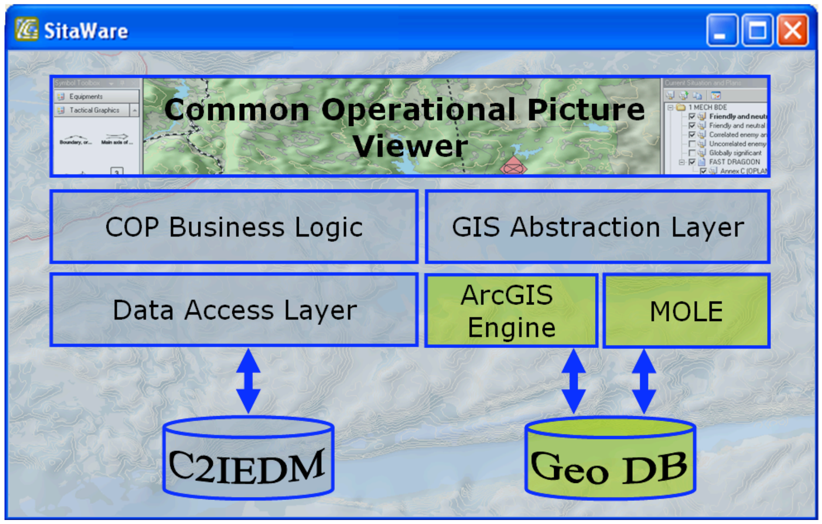

Figure 1: SitaWare utilizes the ESRI components ArcGIS Engine, MOLE and Geo DB to build a Common Operational Picture.

When trying to understand the predominant advantages of digitizing geospatial data, there are three obvious benefits to the warfighter:

1) *Editorial flexibility*. Drawing the first draft of a plan on a paper map is as fast as on a computer, but making adjustments and making copies for all relevant parties is time consuming and typically involves a larger staff. A digital process is much more flexible and can be performed 'as you talk' by a single person.
2) *Working with map overlays*. In modern C2 systems, there is no upper limit to the number of layers that can be applied and the layer concept is essential when grouping geospatial information to keep the overview intact. A key part of MIP compliance requires the ability to handle designated layers named Operational Information Groups (OIG's) – shown in Figure 2. By defining OIGs, the sending party is ensured that the recipient will organize the information in the same layers intended by the sender.
3) *Distribution speed*. Once a plan has been authorized and released by the commander, the latency until action starts at the subordinate echelon is highly dependent on the time needed for distribution to all involved parties. When digitized, this latency is reduced to seconds and becomes negligible.

With these three benefits realized, Systematic's research activities are moving toward an even more geospatially oriented planning process. The emerging concept (illustrated in Figure 3) is to support the user in a focused geospatial and digital workflow to build the Five-Paragraph-Order:

1) draw each stage of the plan on a map layer
2) assign units from the Task Org.
3) view the specified timing in a GANTT view and add sequencing dependencies
4) add additional tasks in the GANTT view
5) export the GANTT data to the Plan Manager that holds Five-Paragraph-Order.

Defense projects are moving more and more towards a situation in which it is a prerequisite that a substantial portion of the solution is based on COTS components. The ability to benefit from COTS products is dependent on the flexibility and capability of the product as a component within a larger solution. A good candidate for a COTS component is an encapsulation of the C2/JC3IEDM and the combined complex business rules ensuring interoperability with other systems. A generic C2/JC3IEDM Data Access Layer (DAL) component should offer services for high and low level abstractions of the data, since different solution providers would have different requirements for access to the data model. It would also be required that a generic component is capable of handling the network communication with allied systems.

An example of an already available COTS implementation of such a C2/JC3IEDM DAL component is SitaWare Services. It offers Data Model Services that allow direct access to the C2/JC3IEDM, as well as Domain Services that aggregate the model and implement the strict domain specific logic required for compliance with the Multilateral Interoperability Programme (MIP).

The Domain Services group data objects into operational

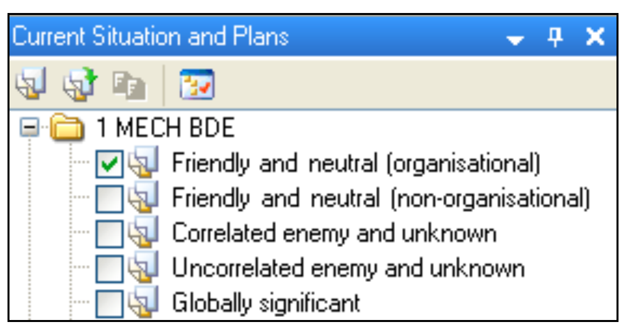

Figure 2: SitaWare is showing the five MIP defined OIG's for 1st Mechanized Brigade.

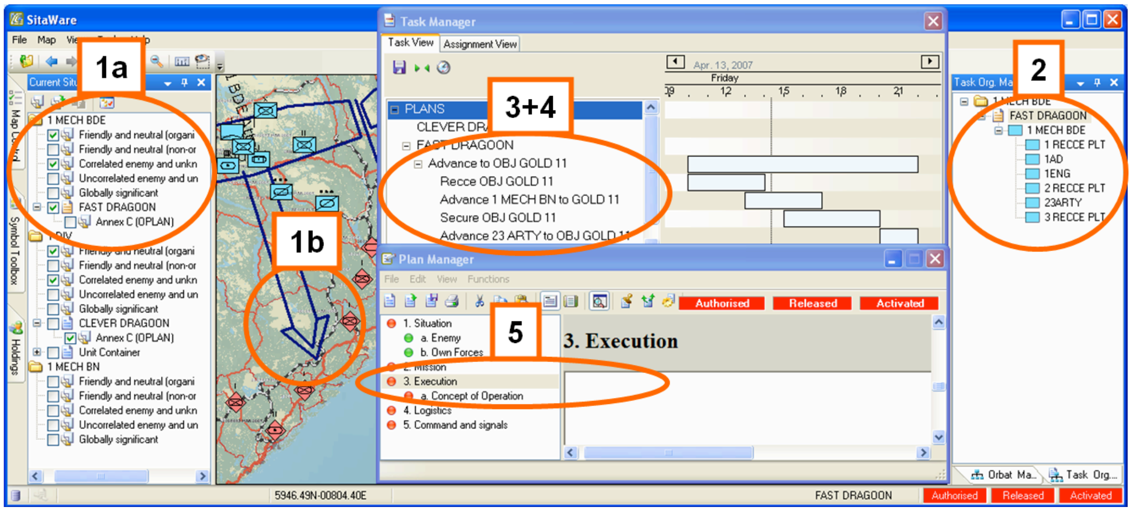

Figure 3: Geospatial planning workflow in SitaWare [ref. 17]

information, which can be used by C2 business logic built on top of the SitaWare Services. An example of such an object is a military unit (e.g. a platoon) represented in a single map overlay. The unit information such as geographical position, status, and type is stored in twenty different tables in the C2IEDM model. The Domain Services aggregate this information into four objects, which are all accessible though one single unit object. Another example is the definition of a map overlay, which is represented in half a dozen tables in the data model. The Domain Services reduce the map overlay to one object only. This well-defined interface simplifies the usage of the data model to system integrators.

3.2 Investigations with geoBML

The C2 Community has evolved a concept of a Battle Management Language (BML) to ensure explicit meaning and context between commanders [Carey et. al., 2001, 2002; Hieb et. al., 2004a, 2004b]. The explicit meaning (semantic) provides a common context through which two or more commanders (in different locations) could effectively and accurately communicate and collaborate on the state of the battlespace. The effectiveness of any communication between two or more elements is directly related to the shared, commonly defined context. BML provides the precision of context required for accurate shared awareness between commanders.

Current work on BML has focused both on developing standard web services for common C2 messages (Joint Battle Management Language or JBML) [Pullen et. al., 2007] and developing a formal grammar based on Computational Linguistics (Schade & Hieb, 2006a, 2006b, 2007)

Initially, when BML was developed, its formalism did not include an *explicit* geospatial, terrain, weather, or other environmental data component. Geospatial BML (geoBML) addresses this and identifies geospatial products relevant to missions, as well as enabling terrain reasoning with mission information. GeoBML is described in [Hieb et. al., 2006, 2007a, 2007b]

An example of geoBML providing power to the edge can be seen in the following Operation/Tactical vignette:

A coalition/multi-national corps has been tasked with a mission to enter a disputed territory and be prepared to conduct defensive operations to secure the area; offensive operations to restore previously established borders; and humanitarian relief and nation building operations in order to stabilize the area.

Within this organization and operational mission structure, there will be a plethora of diverse units and missions all functioning at the edge and demanding very specific sets of information and tailored knowledge to support their tactical missions and tasks. Within the standard military construct of Mission, Enemy, Terrain and Weather, Troops and Support Available, Time Available and Civil Considerations (METT-TC), information and knowledge pertaining to Terrain and Weather will be of critical importance to virtually all decision-making that needs to occur.

In the past, most of this information was gleaned locally from low fidelity sources such as maps, limited reconnaissance, long range forecasts, or generalized descriptions of terrain and cultural features. Current systems now allow for the rapid development of significantly higher fidelity and more current and accurate technical products to support the diverse decision making requirements presented above. The problem is, however, that many of these products, in their raw form, are very technical in nature and do not transmute directly into the vocabulary of or form of the decision maker's processes. Additionally, they also consist primarily of data and facts rather than the information and knowledge a decision maker at the edge requires to have a thorough understanding of the situation and make well-informed, timely decisions. GeoBML provides the conduit that will now put tailored, actionable knowledge in the hands of commanders at the edge.

Underlying geoBML is a concept of Spatial Objects (SO's) that are arrayed in three tiers.

- Tier 1 constitutes those SO's which are based exclusively or primarily upon the terrain and can be pre-computed without being informed by the other factors of METT-TC. Examples include:
    - Cross County Mobility; Obstacle; Cover and Concealment SO's
    - Maneuver Networks
    - Mobility and Choke Point SO's
    - Fields of Fire and Dead Space SO's
- Tier 2 SO's are those that might support a certain mission or tactical task, but are based upon a strong set of terrain attributes and for which candidate SO's can be pre-computed. Examples include:
    - Indirect Fire Firing Positions
    - Assembly Areas
    - Battle Positions
    - Engagement Areas
- Tier 3 SO's are very specific objects that have been selected to support a specific Course of Action (COA) and are associated with a plan or order. In many cases they have been chosen from the Tier 2 candidate SO's and been further refined based upon METT-TC. They may also include graphic control measures and other items that are often associates with or influence the perception of terrain.

Some of the Tier 1 SO's are composed primarily of facts and data, and are used to compute other Tier 1 products – e.g. the maneuver network and obstacle graph are used to produce the Mobility Corridor and Choke Point SO's. The Tier 1 products are then often used to compute Tier 2 products and refine them into Tier 3 products.

GeoBML allows for these SO's to be defined, described and stored (either as objects or representations of the objects) in the C2IEDM, and made readily available to the diverse set of decision makers. GeoBML is being implemented using a state-of-the-art terrain reasoning system called Battlespace Terrain Reasoning and Awareness (BTRA).

3.3 Investigations connecting GIS with HLA/DIS

In previous generations of information technology, in order to meet the information needs of a specific domain, every aspect of the computing platform generally had to be specifically tailored. So, in order to satisfy the rich visualization needs of a simulation, the visualization, business logic, and data structures ended up looking very different to those of other domains, such as C2.

Advances in processing power and graphics acceleration now enable specific information needs to be satisfied using a general purpose computing infrastructure. This has been illustrated by investigators at ESRI and MÄK Technologies who have collaborated on a product called GIS2SIM that enables a GIS (ESRI's ArcGIS) to subscribe to a simulation using HLA or DIS.

This takes advantage of a basic construct of a GIS – 'layers' of information. A layer is a visual representation of a geographic dataset in any digital map environment. In programmatic terms it can define a custom connection to a dataset in terms that include performance and visualization definitions. This permits geographic entities (features in GIS parlance) to be represented according to the information needs of the user. An example of this would be the display of the location of a battalion headquarters (a point feature) in a C2 system as a correctly rendered MIL-STD 2525B symbol.

In GIS2SIM, developers at MÄK Technologies created a custom layer that subscribes to HLA/DIS. It parses location information from the simulation in order to place features in the GIS display. This is the same GIS display used in CJMTK and Systematic's SitaWare.

This represents a considerable breakthrough, since it permits one visualization environment (the GIS display) to simultaneously connect to three separate domains: C2, GIS, and Simulation. This is proving exciting for developers and users, as it provides real impetus for investing in the more important step at the heart of this paper: establishing strong information exchange between these domains.

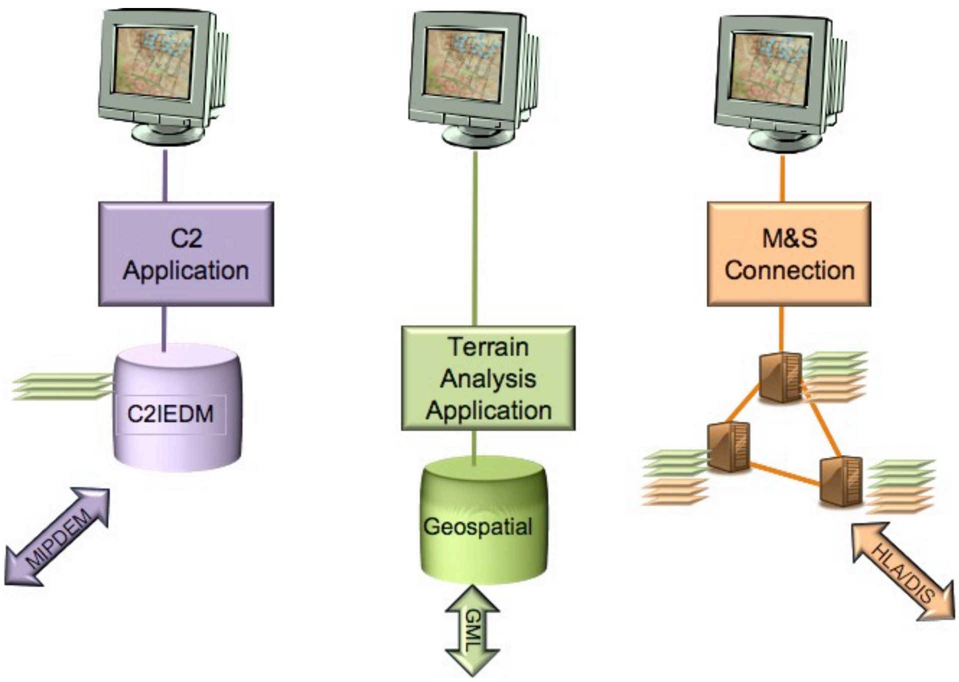

Figure 4: Stovepiped Integration of Geospatial and C2 Information

4. Defining a Common Infrastructure for C2, M&S and GIS

The advent of enterprise geospatial implementations, such as CJMTK, defines a framework for integrating C2 applications and Geospatial tools.

4.1 Traditional Integration of Stovepiped Systems

Previous generations of defense systems have focused interoperability efforts on like systems with powerful single-domain standards like MIP and HLA/DIS. The C2 community has developed the strong MIP standards to ensure that coalition C2 systems can interoperate; the M&S community has developed the HLA/DIS standards to join M&S systems together; and the Geospatial community has developed various geospatial standards, such as GML

This like-systems approach to interoperability creates a number of significant challenges illustrated in Figure 4. If a user needs to access C2, Terrain Analysis and M&S functionality, three separate systems will be involved that are fundamentally different in almost every respect:

- The visualization environments are all different – the user needs three operational pictures, often on three separate monitors.
- The applications are all different – even if a program is created to merge the applications, this will involve GIS, C2, and M&S software engineers working with three different software application programming interfaces. This is risky, expensive, and time consuming – the source of many integration failures in the past.
- The data stores are radically different - if any transfer occurs between the systems it is by a time-consuming transfer of files that have to be manually imported and often lose data integrity through the translation between domains.

Perhaps the biggest challenge concerns the geospatial information. Current systems use three different representations of the battlespace: the C2 applications use geospatial data supplied as products from the defense mapping organization; terrain analysis systems use geospatial data that is often considerably denser and enriched; and, M&S systems use synthetic terrain definitions that might only be loosely based on the real battlespace. This replication is costly as geospatial information of whatever kind is hugely expensive to produce. Since the geospatial information is supposed to be a representation of the single battlespace, this replication is also illogical. In current systems, the geospatial information isn't just in different formats, it has different content: thus there are inconsistencies.

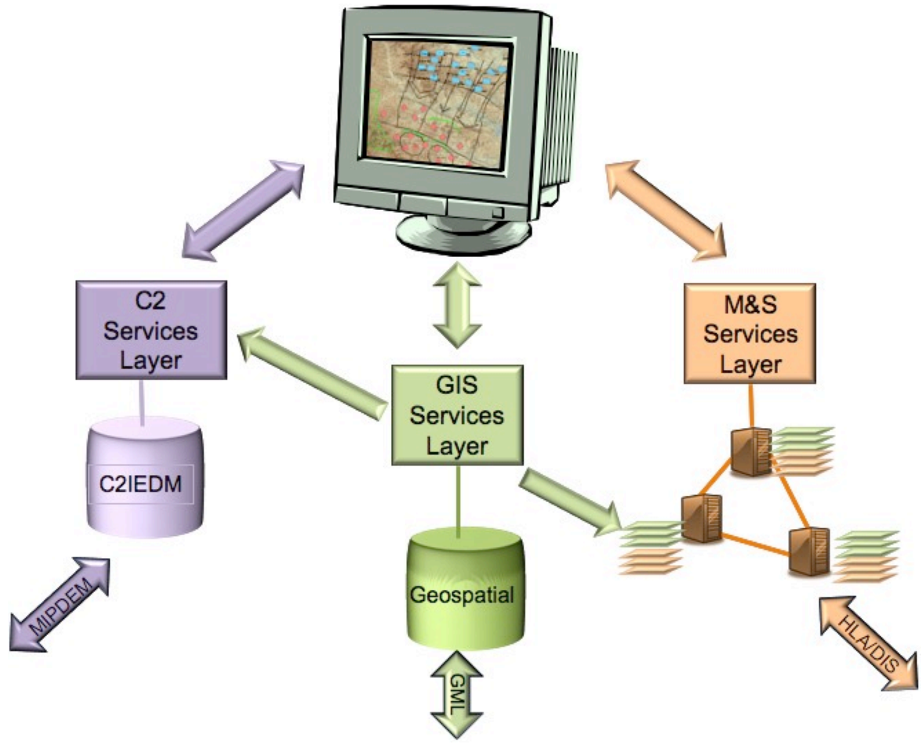

Figure 5: Integrating Geospatial and C2 Information Today

4.2 Better Integration through using SOA Principles

Network centric operations demand connectivity definitions that go beyond like-systems. There is a real need to enable interoperability between disparate systems, such as C2, GIS, and M&S systems.

As shown in Figure 5, Service Oriented Architectures (SOA's) are permitting easier connectivity between systems at the syntactic level. We can connect a common visualization application to C2, GIS, and M&S systems, simultaneously. This is a dramatic step forward for the user since a wealth of information can be accessed from a single application – a common user interface can serve the information needs of C2, GIS, and M&S users.

This is important progress that is already being deployed in Commercial-Off-The-Shelf (COTS) software products such as Systematic's SitaWare, ESRI's ArcGIS, and MÄK Technologies' GIS2SIM as described in Section 3.

The true power of a Service Oriented Architecture is beginning to emerge in the ability to use geospatial services to integrate common geospatial information into C2 and M&S systems.

4.3 A Framework for the Future

There remains much to be done, though. The syntactic connections are comparatively easy to establish since the principle challenge is technical in nature. BML is addressing a much more significant and important challenge in establishing common semantics between these disparate domains. This goes far beyond common visualization and establishes consistent information bearers between these systems.

We recommend, based on the work described in Section 3, a technical approach as shown in Figure 6. In this approach, the information bearers do not interfere with domain-specific standards such as MIP and HLA/DIS. The like-systems interoperability is preserved since the interface between the standards is achieved through a service layer. The domain-specific service layer will accomplish the mapping between the common BML standard and the domain-specific standard. This approach offers defense developers an opportunity to pursue the strengths of BML, while respecting the single-domain standards.

GeoBML is particularly interesting in this respect, since it may need to bear richer semantics than the C2 domain

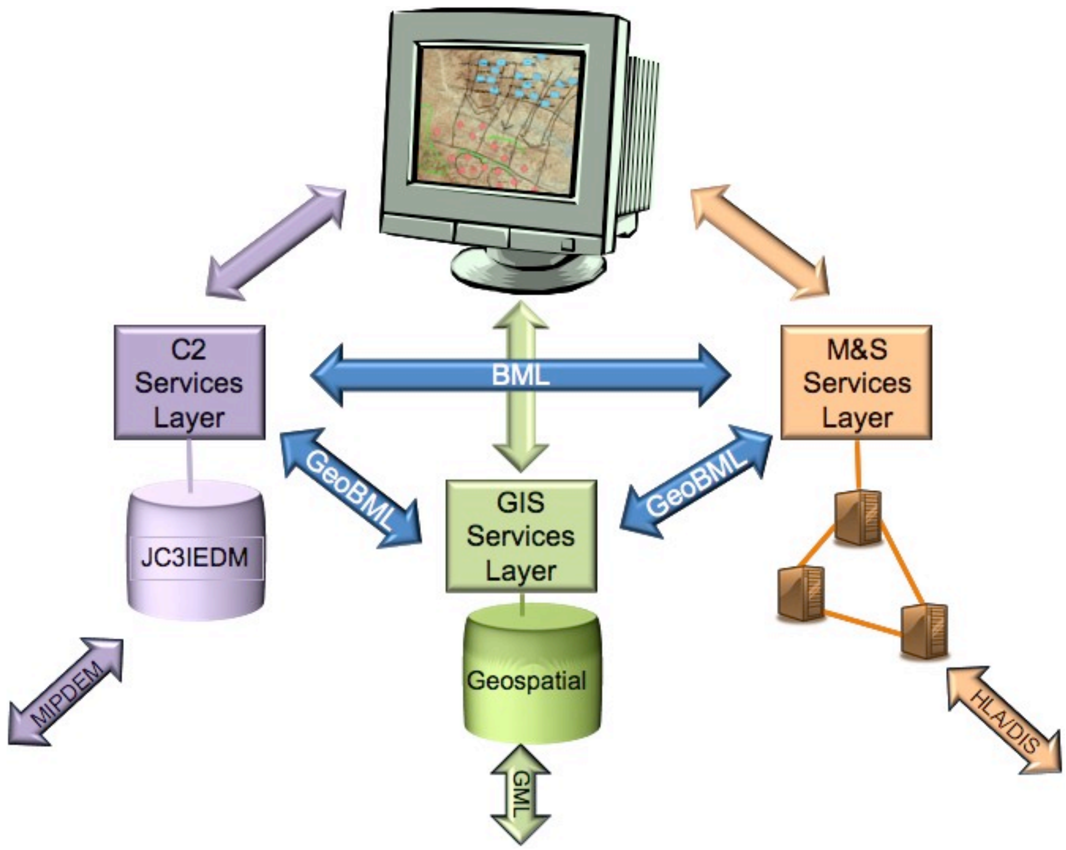

Figure 6: A Framework for Integrating Geospatial and C2 Information

might be able to contain within the JC3IEDM construct. The C2 service layer provides a mechanism to translate from the rich geoBML semantics to the simpler geospatial content demanded by JC3IEDM without diminishing the ability of the C2 system to make use of the geoBML content.

5. Benefits and Recommendations

We conclude with a discussion of the benefits of formalizing relationships between Geospatial and C2 information. While some of the ideas presented are dependent upon technology, most of the conceptual framework is not, and thus we expect it to remain relevant as technology evolves. We also present some recommendations that follow from our work.

5.1 Benefits of formal relationships between Geospatial and C2 Information

As uncovered in our findings and discussed above, most military plans and orders are significantly impacted by the environment – Terrain and Weather. However, Terrain and Weather information is often conveyed as raw data and facts, and is not readily usable by commanders, especially at the Edge. Terrain reasoning can combine this information with other C2 relevant data and distill it into Spatial Objects, which have actionable context to commanders. Encapsulating or referencing the SO's in the C2IEDM using geoBML will allow for the replication of this information along with the other C2 data in the model and will ensure commanders have timely access to relevant environmental data to make the right decisions faster. Integration of M&S services with the GIS-enabled C2 System will empower the commander to use these capabilities to analyze courses of action and perform mission rehearsal. This also creates an environment in which commanders "train as they fight", since they will have embedded training capabilities in their C2 environment.

5.2 Recommendation to explore geoBML in C-BML Effort

Within the Simulation Interoperability Standards Organization (SISO) there is already a standardization activity for Coalition Battle Management Language (C-

BML) [Blais et. al., 2005]. As can be seen in our Framework in Figure 6, BML is a key component of the Framework, as is geoBML. Since there is currently no standardization activity for geoBML within SISO or any other standardization organizatioin, the C-BML activity should consider whether to include the geospatial aspect of BML in its future phases.

Our current investigations with geoBML indicate that, as with C-BML, the C2IEDM can serve as the basis for a standard, but it is not sufficient in itself. With both BML and geoBML standardized and used in accordance with the framework shown in Figure 6, a new generation of systems, as shown by our case studies, will not only enable better interoperability, but will also provide much improved functionality for decision support, mission rehearsal and operations planning.

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Author Biographies

MICHAEL HIEB is a Research Associate Professor with the Center of Excellence in C4I at George Mason University. Dr. Hieb was the Co-Chair of the SISO C-BML Study Group and also was on the team that developed the initial BML concept for the US Army while with Alion Science and Technology. Dr. Hieb was the Technical Director of the MRCI interface project while at SAIC. He received his PhD in Information Technology at George Mason University in 1996, developing an instructable Modular Semi-Automated Forces agent. He has published over 70 papers in the areas of BML, Simulation Interoperability with Command and Control Systems, and Multistrategy Learning.

GARY SCOFFIELD is the Defense C4ISR Business Development Manager for ESRI. He also serves as ESRI's CJMTK Program Manager. He joined ESRI in 2002 and has served in business development and account management roles in support of the Army, Marine Corps, and Joint C4ISR Community. Prior to joining ESRI, Gary worked as a Systems Engineer for Leica Geosystems and served for six years in the US Navy, including a tour as an instructor at the Defense Mapping School (now NGA's National Geospatial-Intelligence School). Gary earned a B.S. in Biology from the Massachusetts Institute of Technology in 1995.

DAVID SWANN is the International Defense Business Development lead for ESRI. David Swann served for 12 years with the British Army, primarily with the United Kingdom Military Survey, rising to the rank of Major. He was educated at the University of Wales, the Royal Military Academy Sandhurst and received a MSc in Geographic and Geodetic Information Systems from University College London. In the 10 years since he joined ESRI, he has visited 60 countries and witnessed incredible progress in defense uses of GIS. He has contributed chapters to definitive textbooks on GIS as well as numerous articles for defense publications.

KAY PEDERSEN is a Project Manager at Systematic Software Engineering A/S and heads Systematic's Solution Center for product based solution deployment and support. Through this position, he sees the need to make the computerized processes seamlessly accessible, interoperable and unambiguous to war-fighters. He holds a B.Sc.E.E. and has worked as software developer and architect of real-time systems before moving into project management,. He has certifications from the Project Management Professional and the Information Technology Infrastructure Library programs.

JAMES A. MUGUIRA is an architect and engineer with Systematic Software Engineering (SSE) of Fairfax, Va. He is supporting the MIP community by providing enhancements to SSE's MIP framework, SitaWare to support interoperability at the coalition level. He has many years of software development experience and has conducted various development projects for NASA and other U.S. corporate customers.

MICHAEL POWERS is the Technical Director for Geospatial Research and Engineering for the US Army Engineer Research and Development Center's Topographic Engineering Center. His research interests are in terrain reasoning and geoBML. He has served as a Program Manager at the Defense Advanced Research Projects Agency working in the field of intelligence correlation. He has a background in physical geography, image processing, knowledge based systems, and reasoning with context. Mr. Powers received his B.S from Salisbury State University in Geography and his graduate studies were at the University of Maryland and the University of Virginia in Geography and Systems Engineering respectively.

J. MARK PULLEN is Professor of Computer Science at George Mason University, where he serves as Director of the C4I Center and also heads the Center's Networking and Simulation Laboratory. He holds BSEE and MSEE degrees from West Virginia University, and the Doctor of Science in Computer Science from the George Washington University. He is a licensed Professional Engineer, Fellow of the IEEE, and Fellow of the ACM. Dr. Pullen teaches courses in computer networking and has active research in networking for distributed virtual simulation and networked multimedia tools for distance education. He has served as Principal Investigator of the XBML and JBML projects.