M&S Interoperability within the DII COE: Building a Technical Requirements Specification

Francis H. Carr
The MITRE Corporation
1820 Dolley Madison Blvd, MS W544
McLean, VA 22102-3481
(703) 983-6042
carr@mitre.org

Michael R. Hieb, Ph.D.
IITRI/AB Technologies Group
1901 N. Beauregard St.
Alexandria, VA 22311-1705
(703) 933-3376
mhieb@iitri.org

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ABSTRACT: *Key to the future interoperability of Simulations with Command, Control, Communications, Computers and Intelligence (C4I) systems is the Defense Information Infrastructure Common Operating Environment (DII COE) Architecture. The DII COE is composed of configurable, layered, reusable software components that work together with specific C4I mission software to perform a task. All future DoD C4I systems will design to the DII COE. However, because Modeling and Simulation (M&S) has not been involved with the development of DII COE components to date, simulation capabilities fall short. Recently, a DII COE Technical Working Group (TWG) was set up to address M&S Functionality. This paper describes the development of an initial Technical Requirements Specification (TRS) that will formalize M&S Requirements to the DII COE Community.*

The DII COE M&S TRS seeks to identify requirements for functions, features, and capabilities of the DII COE that would facilitate the interface of models or simulations. Through implementation of these M&S requirements, developers of DII COE infrastructure software will be able to provide this missing M&S functionality. DII COE TWGs typically have a Software Requirements Specification (SRS) that guides the development of common infrastructure software. The DII COE M&S TRS identifies requirements in other SRS (such as the Common Operational Picture TWG, the Message Processing TWG and the Data Access TWG), as well as unique M&S requirements that do not belong in any other TWG SRS.

The initial TRS is organized according to an established C4I/M&S Interoperability Technical Reference Model (TRM) developed over the last three years and cited in the SISO C4I Study Group Report. The TRS allocates requirements into the three main categories of the TRM – 1) Management Control; 2) Persistent Data; and 3) Non-Persistent Data. The paper describes how the TRS is being developed within the DII COE TWG structure, the organization of the TRS, gives an overview of the requirements, and gives examples of the software functionality in the DII COE that is expected to be developed from these requirements.

1. Introduction

This paper describes how M&S requirements are being introduced into the DII COE. Although being defined as general requirements, it is expected that they will be refined as requirements for specific DII COE segments. *The intent is to develop a standardized set of M&S services within the DII COE.* These M&S services may result in new segments (software) within the DII COE, included as new functionality, or added as new interfaces to existing segments. An example of a new segment might be a scenario builder segment or data collection management segment. An example of new functionality is the work done to allow the DII COE Common Message Processor Segment to automatically parse and format messages for M&S.

The purpose of this paper is to both give a status of the DII COE M&S TWG requirements work and to make a case for and request involvement from the SISO community.

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1.1 Background

At the end of 1999, the DII COE Architectural Oversight Group (AOG) convened a study group to determine if an M&S TWG should be formed. At the beginning of 2000, the recommendation was made to the AOG to form an M&S TWG, with the Defense Modeling and Simulation Office as the Chair.

There are currently no standard Simulation Infrastructure Components in the DII COE. The M&S TWG is currently sponsoring two primary tasks: 1) segmenting the High Level Architecture's (HLA) Run Time Infrastructure (RTI), and developing a Requirements Specification. The larger challenge is to identify which functionality is needed to facilitate M&S integration and interoperability with the DII COE.

All DII COE TWGs are required to produce a requirements document. As will be described in Section 2.2.1, this is usually a Software Requirements Specification (SRS), but could also be a more general Technical Requirements Specification (TRS). This paper describes the initial requirements document (TRS) that is available as [4]. This TRS will be continually refined and presented to the AOG later this year.

1.2 Scope

The scope of this paper covers the software development within the DII COE. We do not address the data interoperability aspect identified in Tolk [18]. We assume a general knowledge of the HLA and it's Interface Specification and the DII COE Architecture. We go into detail throughout the paper where we feel more detail is needed. The emphasis is to present the initial TRS requirements and request involvement to refine these.

The initial TRS is organized according to an established C4I/M&S Interoperability Technical Reference Model (TRM) developed over the last three years and cited in the SISO C4I Study Group Report [14]. This has been extensively documented in the SISO literature [1, 8, 9, 13].

1.3 Roadmap to Paper

The remainder of this paper is organized as follows. Section 2 presents a description of the DII COE architecture from a software developer's view and the functional delineation of the various TWGs. Section 3 describes how the DII COE M&S TWG TRS was constructed. Section 4 presents the TRS organization and, most importantly, a description of the requirements. Section 5 offers a brief conclusion.

2. The DII COE

The DII COE is similar to the HLA in that it is an architecture consisting of many components including a software infrastructure and a collection of reusable software. However, where the HLA has one primary software component – the RTI, the DII COE has many software components. This is because the HLA is focused on interoperability and the DII COE on development. In the next two subsections, we describe the DII COE Architecture from a software developer's view and then describe the TWG structure. For more detailed information on the DII COE, refer to the DII COE WWW page [3] or recent SISO papers (such as [8]).

2.1 DII-COE Architecture

The DII COE serves as a foundation for building interoperable systems across the Department of Defense (DoD). The DII COE should be considered a "plug and play" open architecture designed around a client/server model. Functionality is easily added to or removed from the target system in small manageable units, called segments. Segments are defined in terms of functions that are meaningful to users, not in terms of internal software structure or size. Structuring the software into segments in this manner is a powerful concept that allows considerable flexibility in configuring the system to meet specific mission needs or to minimize hardware requirements for an operational site. Segmentation is the process of packaging application software into segments. This process includes conforming to a specified directory structure, creating segmentation descriptor files, and automating the installation of the software so that it can be installed with the tools provided by the DII COE runtime environment. Segmentation is necessary but not sufficient to achieve the required level of DII COE runtime compliance mandated in the Joint Technical Architecture (JTA) [10]. Site personnel perform field updates by replacing affected segments through the use of a simple, consistent, graphically oriented user interface.

2.2 DII-COE Technical Working Groups

The DII-COE Technical Working groups (TWG) were established to identify or review and consider the requirements, needs, and interests of a number of specific areas within the DII-COE. Per the DII COE Architecture Oversight Charter [3], portions of the DII COE are being updated using requirements generated by approximately 20 joint service Technical Working Groups (TWGs). Each group focuses on a well-defined functional area (such as Kernel; Mapping, Charting and Geodesy; Alerts) and identifies requirements for hardware and/or software components that will contribute to functional capabilities to answer these requirements. Once identified, these requirements are documented, published, and made available to those who seek to create functional components to provide the capabilities. More information about the specific TWGs and current requirement specifications are available from the TWG DII-COE website [5]. A listing of the TWGs is given in Table 1.

Table 1 – DII COE TWGs

- Administration Services TWG
- Alerts Services TWG
- Common Operational Picture TWG
- Communications Services TWG
- Configuration Management (CM) TWG
- Data Access Services TWG
- Distributed Computing & Object Management Services TWG
- Human Computer Interface Style Guide TWG
- Kernel TWG
- Mapping, Charting, Geodesy, and Imagery TWG
- Message Processing TWG
- Modeling and Simulation TWG
- Multimedia/Collaborative Services TWG
- Network Management Services TWG
- NT Advisory Group
- Office Automation TWG
- Real Time TWG
- Security Services TWG
- Toolkit TWG
- Visualization TWG

A recent addition to the TWGs was the Modeling and Simulation Technical Working Group (M&S TWG). It was established to identify potential M&S requirements for incorporation under the DII COE. Efforts that are focusing on the integration of C4I systems with modeling and simulation products are of particular importance to the group. The TWG meets every 3-6 months to review various projects in the C4I-Sim community and to help codify requirements. Recently, a DRAFT version of the requirements specification has been developed, and made available for review and comment [4]. This document will serve to guide other TWGs and developers of DII-COE segments in the particular requirements of those who wish to interface M&S applications with DII-COE segments. It also serves to guide those who wish to develop M&S applications as DII-COE segments.

2.2.1 M&S TRS Background

When this task was originally undertaken, it was determined that the appropriate form of output for the requirements from the DII-COE M&S TWG should be a Technical Requirements Specification (TRS), rather then a System or Software Requirement Specification (SRS). This distinction was made that a TRS, a more general classification, specifies requirements that can be implemented in HW, SW, or both. Also, it identifies requirements that can be implemented throughout a variety of lower level systems. The precedent for this, within the DII-COE, was taken from the DII-COE Common Operational Picture (COP) TRS [2]. This document describes the requirements imposed upon any and all providers of components that contribute to the COP, which represent a number of distinct segments. It also implies that the same (or similar) requirements may occur within a number of requirement specifications, rather then simply appearing in a single one.

Some Requirements within the M&S TRS are general in nature and subject to interpretation, refinement, and implementation within segments submitted for acceptance within the DII-COE. It is expected that other TWGs, and designers of DII-COE segments will consider the M&S TWG's requirements in light of operational requirements for their specific segments. It is expected that they will make modifications and/or additions to facilitate interfacing Modeling and Simulation components to their segments. In some cases, SRSs may include M&S components themselves, and would find adoption of these specifications beneficial not only as guides for their simulation components, but also to facilitate their use by external projects.

Figure 1 shows the relationship of the M&S TRS and the DII COE SRSs. Where possible, requirements relevant to individual SRS's are cited in the M&S TRS. Where necessary, new requirements will be developed and reside only in the M&S TRS. The following sections draw upon the Draft M&S TRS and describe these general requirements.

3. M&S TRS Genealogy

The M&S TRS starts by describing the modeling and simulation domain for the TRS reader. It describes various types of M&S applications, as well as some example uses for modeling and simulation. This is done not as an attempt at an exhaustive overview of the domain, but rather as an introduction or overview for those within the DII-COE domain who may be unfamiliar with M&S uses. Numerous examples are given and links are made to documents within M&S literature for those who wish to pursue further reading in the area.

The TRS then discusses various levels of relations established between the DII-COE and M&S applications. The C4ISR/M&S Interoperability TRM and the seven classes of simulation services in the HLA Specification were used to organize the requirements in Section 3. The Management and Control Services, in Section 3.1, correspond to the "Exercise Control" category of the TRM as well as some of the Service Classes in the HLA Specification. Section 3.1 is broken down into 5 subsections: M&S Services, Time Management, Communications, Distribution, and Management Authority. M&S Services corresponds to the Federation Management Services in the HLA Specification. Time Management corresponds to the same Services in the HLA Specification. Communications corresponds to the Data Distribution Services in the HLA Specification. Distribution corresponds to the Declaration Management Services in the HLA Specification. And Management Authority corresponds to the Ownership Management in the HLA Specification

Figure 2 illustrates the C4ISR/M&S Interoperability Technical Reference Model (TRM) that is used to describe and organize virtual connections between C4I system components and M&S components. The TRM was originally developed by Carr & Hieb [1] and refined by various other efforts [8, 9, 13]. It is currently being solidified and proposed as a standard SISO product [14]. Within the purposes of the DII-COE M&S TRS the TRM was used to organize and suggest groups of requirements by their relationship to the information flows between (or those wholly contained within) potential C4I system components (segments) and M&S components. The 3 groups of requirements are defined below.

4. M&S TRS Requirements

The intent of the DII-COE Modeling and Simulation Requirements is to identify what can be done to facilitate integration of M&S applications. Past efforts at integration have been difficult due to a variety of factors, many of which have resulted in specific requirements. In other cases, M&S integration efforts have been limited by

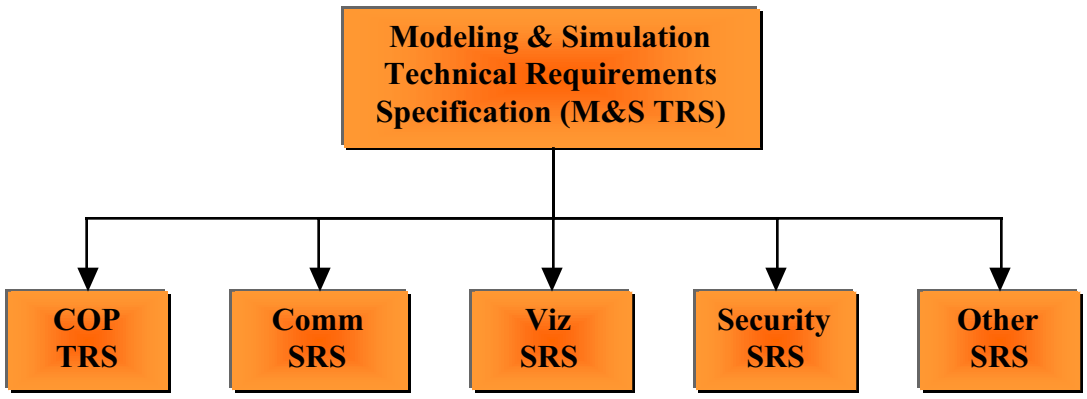

Figure 1 – Relationship between M&S TRS and other DII COE SRSs

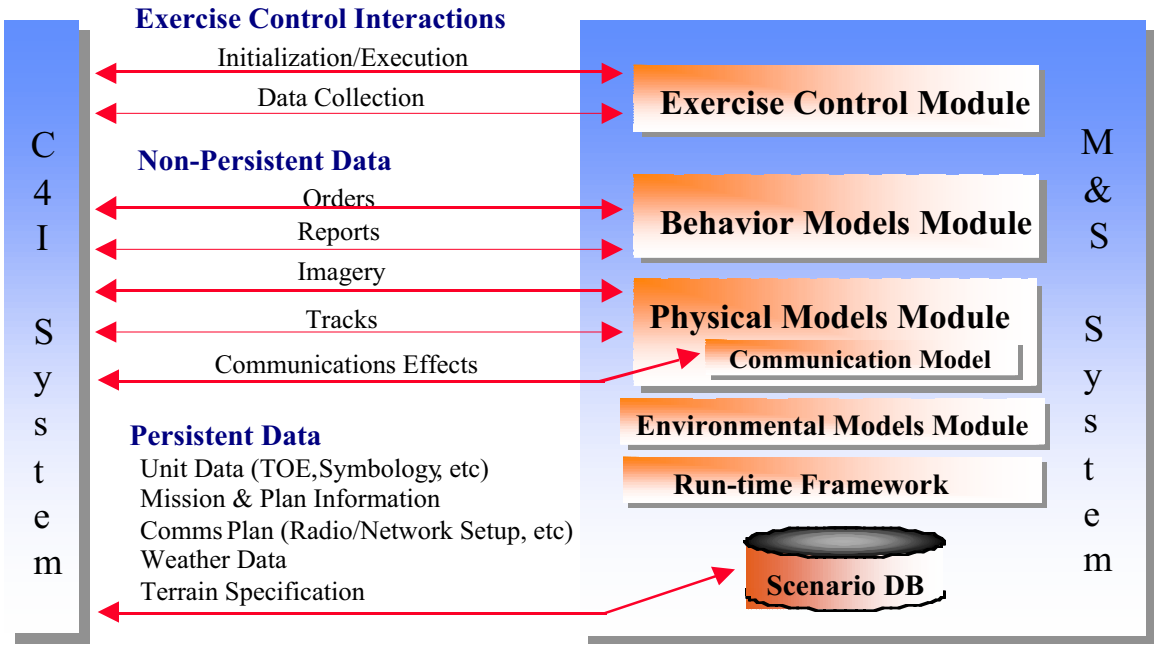

Figure 2: C4ISR/M&S Interoperability Technical Reference Model

limited access to existing segment APIs.

The following sections discuss the requirements placed in each referenced section, some of the background or rational for including the requirements, and the intended impact on DII-COE engineers and or segment developers. As the requirements are currently in DRAFT form, and being considered and discussed by the DII-COE TWG, they are not literally reproduced here. However, interested readers are strongly encouraged to access the actual document at http://www.dmso.mil/index.php?page=181 for review, and provide comments or input to TWG members.

Interested readers should note that there is a correlation between the following sub-sections of this paper and sections of the TRS. For each section of this paper discussion (e.g 4.1 Management & Control) there is a similar TRS section (e.g. 3.1 Management & Control). This correlation is true for all requirement sections, and was matched as of TRS Draft version 0.8

As mentioned previously, Figure 2 illustrates the C4ISR/M&S Interoperability TRM. It is used to describe and organize virtual connections between C4I system components and M&S components. This TRM was used to suggest the overarching classifications for requirements contained within the TRS. As a major classification heading, the more general "Management and Control" was used instead of "Exercise Control Interactions" for 2 reasons. First, because it was recognized that M&S applications are used other then in an "Exercise" or training environment. As should be known by the reader, they may also be used for analysis, acquisition, mission, and test & evaluation.

The other reason was recognition that "Control" aspects of the 1st category may be bi-directional. In addition to the original capability for C4I systems to control simulations, it would be desirable to allow for the capability for simulations to control or "influence" aspects of C4I system, beyond delivery of simulated products. These observations are being fed back into the TRM working group for consideration.

The other 2 classifications of requirements are more directly drawn from the TRM and reflect requirements for "Sharing Persistent Data" and "Sharing Non-Persistent Data" respectively.

4.1 Management & Control

These requirements represent those levied on DII-COE application users to control simulations through DII-COE services. Examples of these types of interactions might be the ability to start, pause, or reset a simulation. Further, this category includes requirements that may be imposed on other DII-COE services to allow control by simulations. Examples might be the ability to set/reset

system time or other system settings, deny or allow particular capabilities/resources, etc.

It should be noted that categories for some classes of requirements within the TRS draw upon the High Level Architecture (HLA) as a model. It was felt that the original HLA specifications, as well as the 6 categories for functions within the RunTime Infrastructure, provide a good overall structure. Also it was felt that following the categorizations for DII-COE requirements in these sections would help to frame their relationship to potential areas in the modeling and simulation domain.

4.1.1 M&S Services

This section defines requirements requested by the M&S domain of the DII-COE system. Included in this are general requirements levied upon Mission Applications, as well as requirements for Initialization, and Control.

An example of the types of problems that this requirements section addresses includes the ability to integrate M&S applications seamlessly within the native DII-COE Mission Applications. Past efforts at integration required treatment of M&S applications as separate entities within training environments, with no connection to the native system. Specific concessions for individual projects included modifications made to operational menu items to allow training applications to be loaded. However, these changes were made to non-operational C4I systems at considerable M&S development expense. Further, it had to be replicated for each version of the C4I system and M&S application. It is proposed that requirements defined in this section could embed hooks within the native system to facilitate this type of integration with minimal effort.

Requirements for Initialization seek to establish that there should be a recoverable, single start (or initial) state for a DII-COE system, and the facilities should be available for M&S applications to trigger a return to this state.

Control requirements cover general issues of archive, retrieval, and playback control. This section was essentially drawn from a similar section of the COP TRS.

4.1.2 Time Management

Requirements in this section discuss the proposed relationship between system time, segment operation, and simulation delivery of products to specific segments. It seeks to encourage segments to rely less upon the system clock as part of their processing, which in the past has caused problem when simulated products have been available a greater then (or less then) real time rates.

It also seeks to establish a standard suite of operational functions, (e.g. Start, Stop, Pause, Continue) for internal simulations that would match potential actions available for external applications. This would have the benefit of creating a synergy for internal and external simulations and increase the potential to use internal simulations and display functions for rehearsal, exercise, and after-action review systems.

4.1.3 Communications

This section covers the general area of accepting external simulated communications, as well as the specific area of configuration for communications resources. It proposes that external simulations may send and receive messages with the system. It also proposes that communications resources and database management plans may be subject to the influence of simulations. This intent of these requirements is to address problems encountered during past integration efforts. The problems occurred when attempts to modify system network files, communications tables, address books, and other communications or database update resources would not only be ineffective for integration purposes, but would be terminally destructive to the system.

This section also refers and defines general requirements based on COP TRS requirements establishing network and communications hierarchy based on roles.

Finally, it proposes expansion to current means of establishing data feeds to: limit extraneous network traffic in reduced network configurations, facilitate use of embedded simulations, and allow introduction of simulated GPS feeds.

4.1.4 Distribution

This section extends Communications requirements to include the ability to consider M&S components as part of distribution plans. It also proposes the ability to mask the presence of a simulation through the use of NO-OP surrogates. These requirements are intended to ensure that internal specifications of external systems (e.g. address lists, mailing lists, network tables) consider M&S surrogates as possibilities. It also proposes the availability of NO-OP constructs for active workstations as a distribution reduction method.

4.1.5 Management Authority

This section speaks directly to the ability to consider M&S components as potential replacements for ANY system within the C4I service hierarchy.

4.2 Persistent Data Services Requirements

As defined in the TRM, Persistent Data refers to those databases, resources, and mechanisms that are relatively stable and unchanging during an operational activity. Examples include Unit Data (e.g. TOE, Symbology), Terrain Specifications, etc. Specific requirements for individual classes of information are not identified. Rather these requirements are more generic, suggesting a specific instantiation within a lower level SRS for each underlying data type within the SRS domain.

For each data type, it is requested that the system support the use of simulated version of the data for the following functional capabilities; initialization, load & display, processing, and retrieval of source and processed results. Further requirements establish the need to differentiate between simulation and native data sources, and the protective capability to restrict, control, and purge simulation products.

Although it is recognized there are system level methods through which this data is maintained, M&S applications frequently desire automated initialization or modification to these data sources without human intervention. Similarly, DII COE Services may desire controlled initialization or modification to data "owned" by M&S applications. Requirements that fall in this category are those that impact DII COE segments that maintain or include persistent data sources.

4.3 Non-Persistent Data Services Requirements

This section establishes requirements for M&S Services provided to support the integration of models and simulations with Non-Persistent Data sources within the core DII-COE, and supported mission applications. Non-Persistent Data is considered data that *may* be set during initial configuration of the system but is subject to repeated modifications throughout the Mission Applications use. It also applies to transient data that does not exist prior to Mission Application use but develops over time. Examples of such data sources are Orders, Reports, Imagery, Track/Position reports, etc.

As with Persistent Data requirements, it is suggested that these are generic and should be instantiated for each lower level source with the individual SRS. They are predicated on the need for M&S applications to access information components in their initial form (e.g. messages). Also that any products, or databases, which result from processing of these information components be available for interested integration efforts. Examples of the use of these items include stimulation with simulated versions of valid sources and data collection for after action review.

For convenience, the requirements within this section have been divided into 2 distinct sub-categories**: Orders, Messages, and Database Updates** as well as **User Defined Parameters**.

4.3.1 Orders, Messages, and Database Updates

These requirements apply to data components which are normally received from external sources, or are part of processing which occurs as a result of such a data component. Examples include Strategic or Tactical messages in Service formats native to the system (e.g. USMTF, OTH-Gold, VMF) or database updates received as part of normal system operation (e.g. Track Updates). It also applies to such computer system service components such as Global Positioning System (GPS) feeds and TCP/IP networking service tests (e.g. "ping")

Potential benefits derived from these requirements include the ability to stimulate the system with simulation generated equivalents, data collection for after action review, and injection of simulation surrogates to native message processing systems. Specific requirements within this section discuss simulation product acceptance, processing, as well as retrieval of source and processed

results. Further requirements discuss issues involving the discrimination between live and simulated products and potential exclusion of simulated products.

4.3.2 User Defined Parameters

These requirements apply to parameters, settings, and configuration information available to and modified by the user during normal operation. This information includes both "set and forget" parameters, which may be established once during an operation, and settings which are modified repeatedly during system use. Actual parameters are numerous, but examples include: Mail/Distribution Lists, Screen Settings & Preferences, Alert and Filter Settings, or Overlay settings and groups.

Similar to externally produced simulation products referenced in 4.3.1, it is proposed that the requirements identified in this section would cause user modifications to be made available to, and potentially influenced by M&S applications.

5. Conclusions

In this paper, we describe current activities to establish a set of requirements for M&S within the DII COE. Our purpose is to clearly delineate to the DII COE development community those common services that are needed to "build in" interoperability and also M&S functionality. We firmly believe that once these requirements are approved and put into the DII COE architecture, they will have a synergistic effect.

The HLA provides an excellent model for services necessary for simulations. The RTI is software that implements a specified interface to HLA services. It still remains to segment the actual services themselves (via the RTI) into the DII COE. Thus, the HLA specification can be used to identify necessary APIs in the DII COE. Existing APIs can be mapped to the required specifications and new APIs can be identified for development.

The authors recognize the enormous investment and legacy of the DII-COE. We suggest that the M&S Community continue to seek opportunities to work within the DII COE paradigm. The DII COE architecture provides a unique opportunity to perform integration of simulation infrastructure and functionality into the C4ISR Domain.

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Author Biographies

FRANCIS H. CARR is a Senior Software Engineer with the MITRE Corporation, and has been with the Information Systems and Technology Division since February 1996. He has been working with Simulation to C4I interfaces for over 4 years. Mr. Carr is a graduate of Boston University and lately from George Mason University with an MS in Software Engineering. His background includes work in Artificial Intelligence, Reliability Engineering applications, Mathematical Systems Modeling, and Financial Systems.

MICHAEL HIEB is a senior scientist with the IITRI/AB Technologies Group. Dr. Hieb is the chief architect of the Army SIMCI OIPT and was the technical supervisor of MRCI project while at SAIC. He received his Ph.D. in Information Technology at George Mason University in 1996 and performed his doctoral research at the Center for Excellence in Command, Control, Communications and Intelligence at George Mason University. He has published over 35 papers in the areas of learning agents, knowledge acquisition, interface technology and multistrategy learning. Previously, he worked as a Nuclear Engineer for General Electric. Dr. Hieb received his Bachelor of Science degree in Nuclear Engineering from the University of California in Santa Barbara and received his Masters of Science degree in Engineering Management from George Washington University.