DEPARTMENT OF THE ARMY
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ATTENTION OF:

AMSEL-RD-C2-SS-T 9 May 2003

FOR Bonnie Mottram, Evidence Based Research, Inc

SUBJECT: Paper for 8th International Command and Control Research and Technology Symposium

1. Attached please find the paper my colleague and I wish to publish and present at the subject Symposium. The paper and presentation describe on-going R&D and would fit best under the C2 Experimentation topic but any one of the following topics will also be appropriate in order of priority:

Coalition Interoperability
Modeling & Simulation
Network-Centric Applications
Information Age Transformation.
C2 Assessment Tools & Metrics

2. The paper is being processed for Public release. We do not see any problem getting it released. But please do not publish it until you hear from me that it was approved for public release..
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3. CECOM Bottom Line: THE WARFIGHTER

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Multinational C2 Experiments
Supported by C2 Systems and Modeling and Simulations
Addressing Army Transformation of Collaborative Planning and
Interoperable Execution in a Coalition Environment

Submitted to Track 2: Command and Control Experimentation
or
Coalition Interoperability
Modeling & Simulation
Network-Centric Applications
Information Age Transformation.
C2 Assessment Tools & Metrics

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Abstract

Future deployments of Objective Force units are required to be not only network-centric with respect to their own assets but also with respect to other Joint, National and Coalition assets. The main issue for any network-centric architecture is how to establish connectivity, federation, collaboration and interoperability in a self organizing way among all elements of the force to include combat, combat support, combat service support and C2 assets. When a combat force element such as a unit of action (UA) combat team or task force is organized it may include assets and resources that are not organic and include cross-attached coalition elements. Its combat support forces, combat service support as well as its C2 resources will most likely also require subordinated coalition elements. This necessitates a well thought out alignment of the different C2 processes employed by each of the coalition partners to enable and assure unity of command, synchronization of the tasks and critical battle space de-confliction. The recommended technical solutions and possible changes to tactic, techniques and procedures essential to achieve that alignment must be subject to a rigorous experimentation program supported by evolving C2 systems stimulated by combat simulations that would ensure outmost flexibility to support the full spectrum of operational needs. In addition, the capabilities of Joint, National and Coalition assets to partner with us must also be taken into account.

1.0 Introduction

This paper describes the integrated C2 and Modeling and Simulation (M&S) systems environment and approach the US is designing and implementing to support the conduct of such experiments. Progress is being made to represent various Information Exchange Requirements (IERs) including OPORDs and associated messages such as the Position Reports and SPOT Reports using common XML elements and attributes as well as similar XML schemas. Filtering of information that needs to take place to appropriately support effective collaboration and interoperability as well as for stimulating the exchange via combat simulations is highly flexible. It addresses source, content, time and location as basic criteria. Adopting and adapting evolving mechanisms to assure interoperability between C2 systems as a direct result of events generated in real-time by the M&S systems being used in this experimentation environment is key to driving the combat situation that provides context to these experiments. In addition, we will share our results in our efforts to align domain items with the Battle Management Language (BML) [7], the Joint Common Data Base (JCDB)[10], and the Army Tactical C2 Information System (ATCCIS)[11] Land C2 Information Exchange Data Model (LC2IEDM)[11]. To facilitate collaboration between current and future allies with disparate means for collaboration, we've have found it both necessary and convenient to provide Web services that include a Web C2 Browser (WebC2B) which enables the sharing of coalition domain items such as the coalition Common Operational Picture (COP) and the coalition plans and orders. We have also initiated the representation of the architecture of this experimentation environment in UML[9] and identified key use cases and issues for each of the four phases essential for network-centric C2 system of systems (SoS) integration: inter-connection, inter-federation, inter-collaboration and inter-operation.

2.0 Background

Since the end of the cold war, the US military has found itself challenged to support full spectrum of operations as part of a coalition force. Over the course of CY2003, a concerted and collaborative effort has been initiated and is underway to couple representative US Army and German (GE) Army C2 systems and appropriate M&S systems in a realistic coalition C2 experimentation environment. A Project Agreement has been signed by both the US and GE to pave the way and ensure support from both materiel and user communities standpoints for the execution of the proposed experiments. The intent is to set the stage for subsequent experiments in which other allied nations will be invited to participate. The name of this experimentation program is Simulation and C2 Information System Connectivity Experiment (SINCE)[1]. Over the past year, the SINCE Program has established a Technical Working Group (TWG) and an Operational Working Group (OWG) that design the experiments and are resourced to integrate the selected C2 and M&S systems, instrument the data collection, run the experiment, analyze the data, and develop conclusions and make recommendations. The OWG and TWG report to the Program Management Group (PMG) that maintains oversight to ensure progress and agreement as to the overall operational, system and technical architectures that will govern the scope of the experimentation.

3.0 Objectives

The goal of the SINCE Program is to support Army transformation into a more collaborative and interoperable component of a Joint, National and Coalition Force. This goal will be realized in part, by a set of objectives to be achieved by performing a series of experiments to define, examine and test various hypotheses that support different conceptual approaches with respect to operational and technical levels of collaboration and interoperability possible in various configurations of implementing C2 in various coalition environments. It is important to be able to explore the limitations, utility, and interaction between interoperability and real-time collaboration capabilities. A fundamental motivating hypothesis is that C2 is facilitated by a high degree of collaboration during military decision-making process (MDMP)[13] that will exploit the highest level of interoperability possible during execution. This requires that the MDMP must be able to run concurrently with battle management, execution monitoring and situation assessment processes stimulated by the external environment. The optimum points for collaboration within the MDMP process and for interoperability within the battle management, execution monitoring and situation assessment processes are also subject to experimentation. In this paper, we introduce the key concepts, architectural considerations and design necessary to support such experiments that are under development. The first experiment is planned to take place in November 2003. We review standard practices in accordance with established doctrine, explore opportunities to investigate more specific hypotheses and describe the operational and technical environment in which we plan to experiment during the course of the program.

4.0 Experimentation

4.1 Experimental Approach

Subject Matter Experts (SMEs) and users from Battle Command Battle Lab (BCBL) and Mounted Maneuver Battle Lab (MMBL) participate in the OWG with their GE counterparts to define the scenario events, vignettes, use cases and actors and the associated Information Exchange Requirements (IER). These IERs are further refined into operational domain products such as operations orders (OPORDs) and various reports and embedded domain objects that must be supported by the C2 System and whose states must be evolved and updated by the federated coalition simulation systems. Therein lies the essence of the SINCE Program, i.e., C2 systems are coupled to simulation systems which maintain ground truth and stimulate the C2 systems to maintain situation awareness. The C2 systems in turn, create and modify the plans of the simulated subordinate units. Engineers and scientists from Army Labs participate in the TWG with their GE counterparts to develop and /or adapt the XML representations of the IERs and align, map and filter the domain items that must flow between and among interconnected systems, subsystems and components. The OWG and TWG develop their own implementation plans that identify affordable resources and configurations of personnel, hardware, software and communications. The technical implementation plan must support the operational implementation plan. These implementation plans are flexible enough to support multiple experiments governed by an operational and technical experimentation plan. The experimentation plans address a number of hypotheses for testing and evaluating of the technical and operational concepts implemented for the conduct of the experiments. These plans establish the basis for experimentation collection for data verification and measures of performance analyses.

4.2 Experimenting with Coalition Liaison

A key operational hypothesis that will be evaluated during the conduct of SINCE is the need, time and place for conducting face-to-face liaison during the execution of coalition planning and operations. During the conduct of these experiments, while stimulated by interoperability and M&S technologies, the use of appropriate, network-centric, electronic collaboration technology will be substituted for face-to-face liaison in support of planning and situation assessments. The baseline need for Coalition Liaison is established in accordance with STANAG 2101 [2]. That standard agreement dates back to the cold war era and assumes that there is room to accommodate one ore more liaison officers, and their own equipments. This assumption may no longer be valid or even possible to implement given the highly mobile forces of today such as the Stryker Brigade and the Future Combat System of tomorrow. The term “liaison” refers to the “contact or intercommunication maintained between elements of military forces to ensure mutual understanding and unity of purpose and action.”[3]

Typically liaison functionality that is accomplished via face-to-face contact attempts to ensure “cooperation and understanding between commanders and staffs of headquarters or units that are working together, and to establish tactical unity and mutual support of adjacent front-line units.” With the advent of decision support, collaborative planning, and situation awareness technologies, the need for face-to-face discussions may become unnecessary and even obsolete. But no one has ever conducted an experiment to investigate or demonstrate this. Upon reviewing the documents that describe liaison functionality, it becomes apparent that the liaison role must be more than a mere formality. It may even hold the key to a successful operation. The primary concern of liaison is to coordinate the coalition combat and operational battle space and to track and provide early warning on significant/critical events and pending mission assignments. Liaison personnel must be familiar with the staff and operational organizations, doctrine and procedures of the force with which they will work as well as being subject matter experts on particular combat, combat support, and combat service support functions of the units which they represent. Liaison officers must be able to perform duties that are typically carried out by any commander’s staff. These include but are not limited to the following:

a. track the battle,
b. coordinate combat information,
c. advise on the use of coalition units capabilities to conduct combat, combat support, and combat service support.

d. integrate into the supported unit's operations by understanding the higher echelon OPORD, commander's intent, and understanding the supported unit's scheme of combat.
e. Prepare the assigned portion of plans and orders.
f. Establish and maintain communications between the combat support units and the supported unit.
g. Coordinate combat operations:
   (1). Within the combat force.
   (2). With area and regional commands.
   (3). With elements of other services.
   (4). With other allies in the area of operations.
h. Plan and co-ordinate the battle space use with coalition units.
i. Assist staff in analyzing enemy capabilities and determining measures to counter enemy courses of action (CoAs).
j. Monitor readiness status of coalition units.
k. Advise on impact of coalition support upon combat operations.
l. Plan and supervise assigned missions and tasks within area of operation.
m. Develop or review coalition and joint rules and procedures.

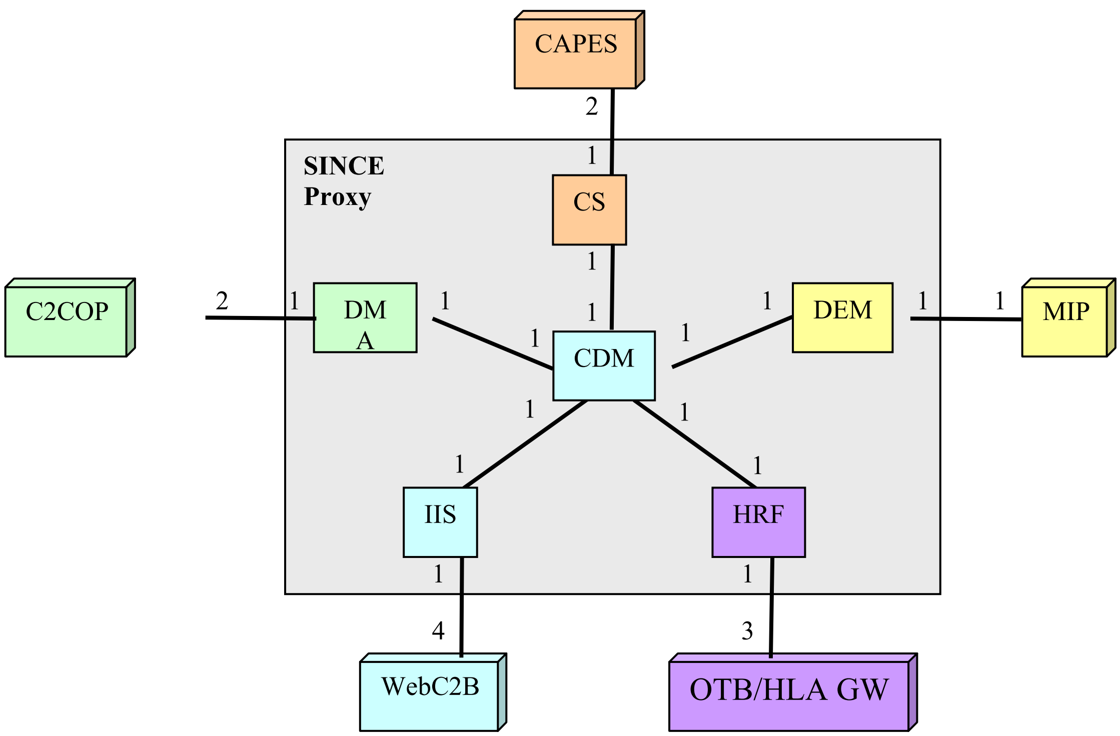

Figure 1: SINCE Overall Architecture for Experiment 1 (US Side only)

4.3 Overall Architecture

For the first in a series of at least three experiments, the overall architecture for the US side is shown in the Figure 1 below. Implementation of this architecture involves synchronization of five concurrent development and integration efforts, that will enable the user experimentation within 10 months of their initiation by both the US and Germany. The US experimental set up includes two complementary C2 systems, a web system, a Multilateral Interoperability Programme (MIP)[4] interface and a combat simulation system. The two US Army C2 systems shown are the Combined Arms Planning and Execution System (CAPES) that evolved out the Agile Commander ATD and the C2 Common Operational Picture (C2COP) system that reuses Army Battlefield C2 System (ABCS) software. For the US combat simulator we are using the OneSAF Test Bed (OTB)[6] system. For interoperability we are collaborating with MIP to integrate their Data Exchange Mechanism (DEM) component into the SINCE Proxy Server. The Web services are also being integrated within the SINCE Proxy Server using Microsoft Internet Information Server (IIS) and the Internet Explorer as the framework for the WebC2B.

A key aspect of our architecture in the SINCE Program is the isolation of the coalition interfaces and web services, and the coupling of the modeling and simulation through a proxy server. This allows the national C2 systems to evolve independently of the coalition collaboration and interoperability solutions, as well as independently of the Joint interfaces and the simulation based stimulation environment for mission rehearsal, and training systems. Coalition simulators are federated using the IEEE Standard for the High Level Architecture (HLA)[5] that includes federation rules, Real-time Infrastructure (RTI), and an agreed upon Federation Object Model (FOM). For Experiment 1, we agreed to use a subset of the Real-time Platform Report (RPR FOM 2.0) and the DMSO RTI, Version 4.0.

Another key aspect of our architecture is the use of web services via a web browser to insulate the national planning systems and situation awareness systems from the ally planning and situation awareness systems. This allows national security considerations to be preserved and impose a low cost fielding solution with minimal training requirements for the liaison officers.

4.3.1 The Proxy Server (PS) and the PS_CDM

The SINCE Proxy Server serves as a bridge, a filter, an adapter and a repository for all IERs and associated data collection. It bridges and filters collaboration between the CAPES Collaboration Server (CS) subsystem which supports a strictly US collaborative environment and the WebC2B which supports a strictly coalition collaborative environment to be integrated with the SINCE Proxy Coalition Domain Manager (CDM) subsystem. Our approach to conduct a US-only dry runs prior to any international experiment require that we provide additional PSs as surrogates for any ally PS system.

4.3.2 The CAPES and the PS_CS

The CAPES is an operational prototype based upon the Agile Commander Toolkit software being transitioned to ABCS. It is also anticipated that CAPES will be integrated into Transformation Force C2 Systems such as FCS. The CAPES will be responsible for displaying, updating, maintaining and providing access to the US COP/Plans and the Coalition COP/Plans IAW with the JCDB Data Model (JDM)/Agile Commander Data Model (ACDM). The SINCE PS CS (Collaboration Server) subsystem is a component of the SINCE PS that serves as a bridge for collaborative coalition planning (at Brigade and Battalion levels) that must be mapped between the US collaborative planning tools and the ally collaborative planning tools.

4.3.3 The C2COP SYSTEM and the PS_DMA

The C2COP system is an operational prototype based upon ABCS COP software typically found in MCS TOC Server, ASAS-Light, and FBCB2. The C2COP will be responsible for displaying, updating, maintaining and providing access to the US COP and Plans and the Coalition COP and Plans in accordance with the JCDB Data Model (JDM). We expect that this C2COP functionality will also be integrated into Transformation Force C2 Systems such as FCS. The SINCE PS DMA (Data Model Adapter) subsystem is a component of the SINCE PS that serves as a bridge for ally reports/updates (Friendly Status and Observations) that must be mapped between the LC2IEDM and the Joint Data Model (JDM) of the JCDB.

4.3.4 The WEBC2B SYSTEM and the PS_IIS

The WebC2B plays multiple roles. It plays an operational role by supporting a) our ally when its liaison officer is located in a US unit or b) our own liaison element when located at an allied unit. It provides the means to participate in the conduct of collaborative planning and in providing access to the coalition COP. It also provides the Blue M&S controllers with access to the OPORD that contains the tasks to the units being simulated. Using the BML language automated means is being developed to control simulated units directly from the WebC2B. Another role for the WebC2B is to provide navigational tools to browse the OPORD both textually and graphically. In additions the WebC2 Browser is made available to an ally, joint or even civilian users to enable them to collaborate even in the absence of their own planning systems. The IIS includes a database capability for coalition access through the WebC2B.

4.3.5 The Ally MIP SYSTEM and the PS_DEM

The SINCE PS MIP DEM subsystem is a component of the SINCE PS that serves as a bridge for ally reports/updates (Friendly Status and Enemy Observations) that must be mapped between the LC2IEDM and the Joint Data Model (JDM) of the JCDB. As part of the national testbed program, we are developing an external MIP System Driver as a surrogate to represent a MIP-DEM-compliant ally system that will be used for testing and experimentation in national-only configurations. The MIP DEM is stimulated directly by the national simulation systems to induce situation awareness at the coalition level.

4.3.6 The OneSAF Testbed (OTB) SYSTEM and the PS_HRF

The OTB system includes three workstations that are necessary to maintain a realistic stimulus to the coalition force: One OTB is needed to control the US Blue subordinates.

Another OTB is needed to control the enemy entities. A third OTB is needed to provide situation awareness, data fusion and information distribution to the federation. In the SINCE experiments only the national C2 systems subscribe to the OTB SA. For the US C2 systems this occurs through the PS_HRF subsystem. Since OTB is presently only DIS compliant, we use an available HLA gateway to federate OTB with external systems. We use BC 2010, an HLA-compliant simulator to represent an ally simulator to test the HLA federation during dry runs or limited US experimentation. One set of hypotheses to be tested with respect to the MS systems is with respect to terrain data. How will the COP change and what operationally significant discrepancies will be introduced if

a) terrain data of different terrain elevation resolution is used?
b) each simulator uses different terrain features?
c) we exchange terrain data between allies?

If these hypotheses prove true, can preprocessing the raw data mitigate discrepancies? Other potential discrepancies exist in the repertoire of commands that each simulation is able to support and in differing implementations of identical commands. Also of interest for the case where there is cross attachments, it is important to understand which orders may be used interchangeably with allied subordinates?

5.0 Concept of Experimentation

The SINCE experiments is conducted to address three abstract dimensions in an integrated way: People (Commander and Staff), Technology (C2 systems coupled to modeling and simulation systems) and Operations (Conflicts and Missions). Each of these abstract dimensions consists of a number of sequential yet interruptible and reentrant phases as shown in Figure 2. The red, blue, or lavendar phases corespond to the people, technology, or operations dimension, respectively. Orthogonal to each of these dimensions are three concurrent tracks of activites: a) stimulation, b)planning, and c) execution. These dimensions, phases and tracks will occur in each of the SINCE experiments proceeding from a) simple to more complex scenarios, vingnetes and IERs, b) simple to more complex networking and functionality, and c) small to large number of coalition and Joint partners.

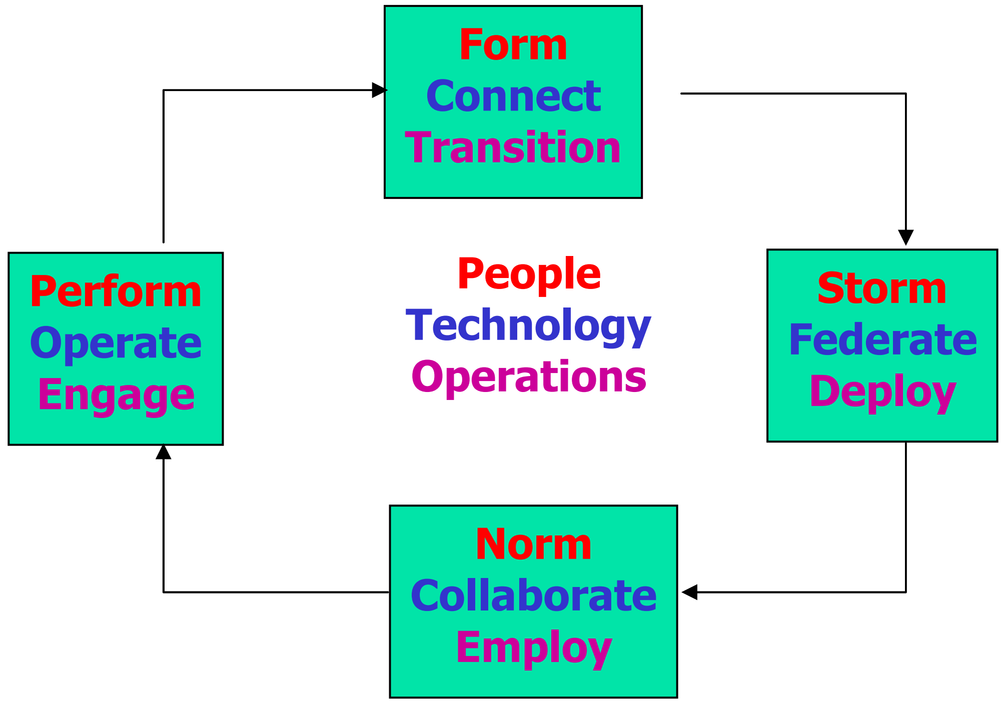

Figure 2: Analog Phases of **Team Building**, **SoS Integration**, and **Mission Execution**

The four sequential phases for each dimension under experimentation were motivated and derived from Druckman's teambuilding paradigm[12] as depicted in Figure 2. In building a team as a coherent organizational unit, whether for sports, a process, a product or combat, it essential for the individual team members to learn how best to perform as a team or as a team of teams (ToT). This learning process typically requires a number of phases or stages. Druckman's paradigm is one of the best known for providing insight into team building. The four distinct phases for teambuilding as shown in red in Figure 2 include: a) the **forming phase** which brings the members together, b) the **storming phase** which allows members to assert their role in the team, c) The **norming phase** which allows members to agree how best to employ their role toward a common goal, and finally d) the **performing phase** which allows members to apply and exercise their skills and execute IAW their agreed upon roles.

Tuckman's Forming-Storming-Norming-Performing theory may be extended and applied to systems technology as well as to operations. Since systems augment individuals or groups of individuals, the system of systems (SoS) augments the team. Therefore, as team members undergo the four phases of team building, individual systems also must undergo analog phases. These phases are shown in blue in Figure 2: a) the **connecting phase** links and networks the systems together to enable them to exchange information with respect to a given syntax/format type, b) the **federating phase** allows systems to assert their functionality and responsibility with respect to a given content type, c) The **collaborating phase** allows systems to support their users in the norming phase to agree how best to employ their assets with respect to a given situation toward a common mission, and finally d) the **operating phase** allows systems to support their users in the performing phase to interoperate and maintain situation awareness, to exercise battle management and execute IAW their overall intent, concept of operation, and mission.

Along the operational dimension, one may also apply the teambuilding concept to missions. Every mission, starts from a previous mission. The time needed to disengage or unwind from a previous mission and be prepared to understand and handle a new mission is the transition phase. Once the new mission is understood and preparations have been made, the deployment phase of a mission is initiated to dispatch assets to the vicinity of the next engagement area. In the third phase of mission development, assets evolve into the employ phase of the mission, in which planning takes place to determine the right time and place to initiate the engagement part of the mission. In the forth phase of the mission, resources are engaged until the mission succeed or fails.

6.0 Summarizing Conclusion

Experimental results will only be available after we conduct the first experiment in November 2003. Nevertheless, we have developed a comprehensive international program and initiated the development and integration of a long-term testbed with a robust architecture and an experimental framework to address key issues of C2 for the Transformation Force. The use of UML to design the experimental architecture has proven invaluable. The use of XML to provide a common coalition domain model is facilitating integration and bridging between disparate data models. We are leveraging existing C2 prototypes for planning and execution monitoring and coupling them to existing M&S systems to provide a dynamic operational environment. Our first experiment with Germany is under development and is scheduled for implementation in November 2003. Both countries are collaborating on a common scenario, hypotheses, and establishing mechanisms to couple complementary C2 systems to national M&S systems. The M&S systems are also being federated using HLA employing a common RTI and FOM to provide a common ground truth.

7.0 Acknowledgment

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