**18th ICCRTS**

# Operationalizing C2 Agility Using the NCEL

**Topic Areas:**

Topic 5: Experimentation, Metrics, and Analysis
Topic 6: Modeling and Simulation
Topic 12: C2 Simulation Interoperability

**Authors:**
**Craig T. Doescher**
**Wesley Hamm**
**David Prochnow**



**McLean, VA**

**29 March 2013**

**Point Of Contact:**
**Craig Doescher**
**7515 Colshire Dr**
**M/S H613**
**McLean, VA 22102**
**cdoesche@mitre.org**
**703-983-6742**

# Abstract

The need to constantly do things faster, smarter, and cheaper coupled with the reality of constantly changing and improving technologies has levied a requirement for an environment where operators can quickly test and evaluate new technologies and procedures at a level of fidelity sufficient to support risk reduction in research, development, testing and engineering (RDT&E) decisions. This paper will explain an environment, the Net-Centric C4ISR Experimentation Laboratory (NCEL), which meets this requirement. This paper will also use its most recent Simulation Experiment (SIMEX) as an illustrative example.

The Advanced Sensor Technology (AST) Program Office, in conjunction with Naval Air Systems Command, PMA 231, sponsored a simulation experiment in December 2012 using NCEL to explore concept of operations and C4ISR architectures for Anti-surface Warfare (ASuW) in an Anti-Access Area Denial (A2AD) environment. This SIMEX explored C4ISR processes and CONOPs/TTPs associated with Littoral Surveillance Radar System (LSRS) and Advanced Airborne Sensor (AAS) capabilities in conjunction with E-2D and Net-enabled Weapons (NEW) in support of Maritime Operations Center (MOC) maritime surveillance operations in an A2AD environment. During the SIMEX, MOC and Office of Naval Intelligence (ONI) operators employed current and advanced C4ISR systems and procedures to support dissemination and exploitation of LSRS, AAS, and E-2D surveillance products as well as their integration into dynamic targets.

This SIMEX provided an environment to begin operationalizing C2 agility in an A2AD environment. It supported the collection of metrics on the ability of selected sensors, using specific C4ISR architectures, to shorten the kill chain and improve the survivability of friendly assets. We also collected data to measure the ability to execute the kill chain in SATCOM-degraded and SATCOM-denied environments. Due to classification reasons, we will not talk the specifics of this SIMEX; but use it as a model to demonstrate the power of simulations stimulating C2 systems as operators are executing in the environment.

# 1. Introduction

In March 2001, The MITRE Corporation, in partnership with industry and government sponsors, began a series of Simulation Experiments (SIMEXs) to explore improvements to Time Sensitive Targeting (TST) in the Net-centric C4ISR Experimentation Laboratory (NCEL). NCEL is a Service and Joint-sponsored lab federated (via SIPRNET , DREN, SDREN and DISN LES) with other Industry and Service labs conducting experiments using simulated sensors and weapons feeding real world C2 systems with uniformed operators in the loop. SIMEX 13-3 marked the 43rd experiment conducted over the 12 year time span with sponsors ranging from AST PO, NWDC, ONR, NSWG-3, MDA, and PMA 201. Although, due to classification constraints, we will not describe specifics, we will use this latest SIMEX as an example to help illustrate the power of this type of environment, the methodology used to get there, some general results from past experiments, lessons learned, and recommendations for the future.

SIMEX 13-3 was a distributed event conducted in NCEL at the MITRE Corporation in McLean, Virginia and at the Naval Air Station Patuxent (PAX) River, Maryland during the period 10-14 December 2012. The focus of this SIMEX was on examining the value added of the Advance Hawkeye Aircraft (E-2D), the Advanced Airborne Sensor (AAS) and the Littoral Surveillance Radar System (LSRS) in support of a Carrier Strike Group (CSG) using network-enabled weapons (NEW) in the conduct of anti-surface warfare (ASuW) operations. SIMEX 13-3 focused on the coordinated operations of a CSG conducting operations in an anti-access area denial (A2AD) environment. The CSG was supported by a Joint Force Maritime Component Commander (JFMCC) and an Office of Naval Intelligence Fleet Intelligence Support Team (ONI-FIST) from Suitland, MD located at the NCEL in McLean, VA. Several automated tools and command and control systems, supported by AAS, LSRS, E-2D, unmanned aerial vehicles (UAVs), Rivet Joint (RJ) and National Technical Means (NTM) assets were included in the SIMEX. These sensors were focused on the CSG's dedicated area of interest and were used to find, fix, track, target, engage and assess (F2T2EA) dynamic maritime targets of interest. The sensor simulations and automated tools within the NCEL allowed CSG and ONI-FIST personnel to execute the NEW concept with the support of PAX River personnel using the Manned Flight Simulator (MFS) and the Air Combat Environment Test and Evaluation Facility (ACETEF).

# 2. The NCEL Environment

The NCEL has provided a sought after environment to warfighters and service technology providers for over a decade due to its effectiveness and efficiencies. The late Deputy Assistant Secretary of the Navy for Command, Control, Communications, Intelligence, and Space, Dr. Federici said "Simulation Experiments (SIMEX) conducted by the NCEL team provide a cost-effective way to investigate new/innovative CONOPS and TT&Ps. SIMEX events are conducted with real C2 systems operated by uniformed users with simulated battlefield entities (red, blue, white) and live or virtual ISR and strike systems to provide an operationally realistic environment. The NCEL/SIMEX environment provides an excellent foundation that can be leveraged by the operational community to train and/or rehearse; by research, development, and acquisition professionals to address technology and systems development; and by resource sponsors to identify gaps for future development."

There are several primary reasons why a SIMEX is effective. For one, it provides a "penalty free" setting that allows for a broad range of simulated operational settings. It has the mechanisms in place to reach out to operators quickly capturing their current challenges and, from those, to develop realistic, detailed scenario-based experiments. The SIMEX environment leads to partnerships between warfighters and technologists to test solutions, minimize transition risk, and ensure eventual success with the users in the field. It brings together people from across Services, Government Agencies, and Industry to collaborate on best solutions. It also provides an environment for assessing system prototypes and can be used as a precursor to live tests or actual missions. It establishes a unique and flexible environment that can rapidly integrate extensive simulation capabilities with current or developmental system capabilities and technical innovations. This, in turn, saves developmental testing costs and allows programs to look at their systems from a different perspective and solve potential real-world problems before a major investment has been spent.

Another reason this environment is so cost effective is its quick turnaround time and relatively low cost, which sponsors can share amongst themselves, compared to other exercises and experiments with operators in the loop. SIMEXs are typically executed on a 3-month cycle from Initial Planning Conference to End of Experiment. Within this 3-month time frame, the right people are brought together, objectives are agreed upon and focused, scenarios are developed, operational and technical architectures are built, systems are integrated and tested, the experiment is executed, results are analyzed, and reports are generated and briefed.

# 3. Methodology

Having conducted over 40 SIMEXs, an effective methodology has evolved. This section describes the key aspects of NCEL SIMEX methodology. There are a couple of upfront items that must happen. First, you must have stakeholders that are involved and thereby will set clear objectives and agree upon a schedule. In addition, you must have the right people working on the team.

## 3.1 Team Composition

As with most successful projects, it is the people that are the key. To this end, the participants should be organized so all can work in parallel and provide checks and balances. The NCEL team is organized around 4 key groups. Each of these groups has a lead, and each SIMEX also has a Director and Technical Lead to pull it all together.

The Scenario/CONOPs group is responsible for developing the SIMEX CONOPs and scenario. Ideally you are just leveraging the CONOPs and TTPs from the operational unit that is playing; but often times when new technologies or new procedures are going to be assessed; the TTPs must be developed. Directly related to this is development of the scenario. Given the objectives and the CONOPs, a scenario must be built that supports those objectives and stimulates the necessary actions to determine the validity of the underlying hypothesis. This is the only team that interfaces with the operators—understanding that operators have day jobs—and only interfacing with them when necessary. Occasional in process reviews are conducted throughout the cycle to ensure synchronization.

The C4I systems lead ensures the proper C2 systems are present and properly stimulated, in addition to the sensors and other Intelligence assets that are involved.

The Simulation Systems team ensures the simulations are present that are needed to drive the scenario and stimulate the C4I systems involved. This is the first check and balance that occurs. Both the C4I team and the Simulation systems team have to work together to ensure the C2 systems are being stimulated with credible tactical messages.

Lastly, the Data Collection and Analysis team ensures experimental objectives are mapped to specific measures of effectiveness contained in the Data Collection and Analysis Plan (DCAP). This team does checks and balances with the scenario team ensuring that the scenario supports the examination of the variables in the Run Matrix.

The Technical Lead works with each of the above groups to ensure that everything works from an engineering perspective. That is, the simulations must be able to represent the scenario developed by the scenario team, and the simulations must be able to exchange data with the C4I systems using either existing interfaces or new middleware. In addition, the appropriate information must be collected from the technical infrastructure to support post-SIMEX analysis requirements identified in the DCAP.

The SIMEX director works with the Technical Lead, SIMEX groups, and stakeholders to ensure that event objectives are met and that the requisite technical support is brought to bear.

## 3.2 Operational Architecture

As the CONOPs and TTPs are being developed, an Operational Architecture (OA) begins to emerge. The OA is a single picture of the nodes and understandable data flows that are occurring between nodes. From this picture, operators and technologists can understand what systems are present in the specific nodes and what information is being transferred to where. See Figure 1.1 for the OA in SIMEX 13-3. Notice the sensors and platforms that are being played along with the organizations that are receiving the data.

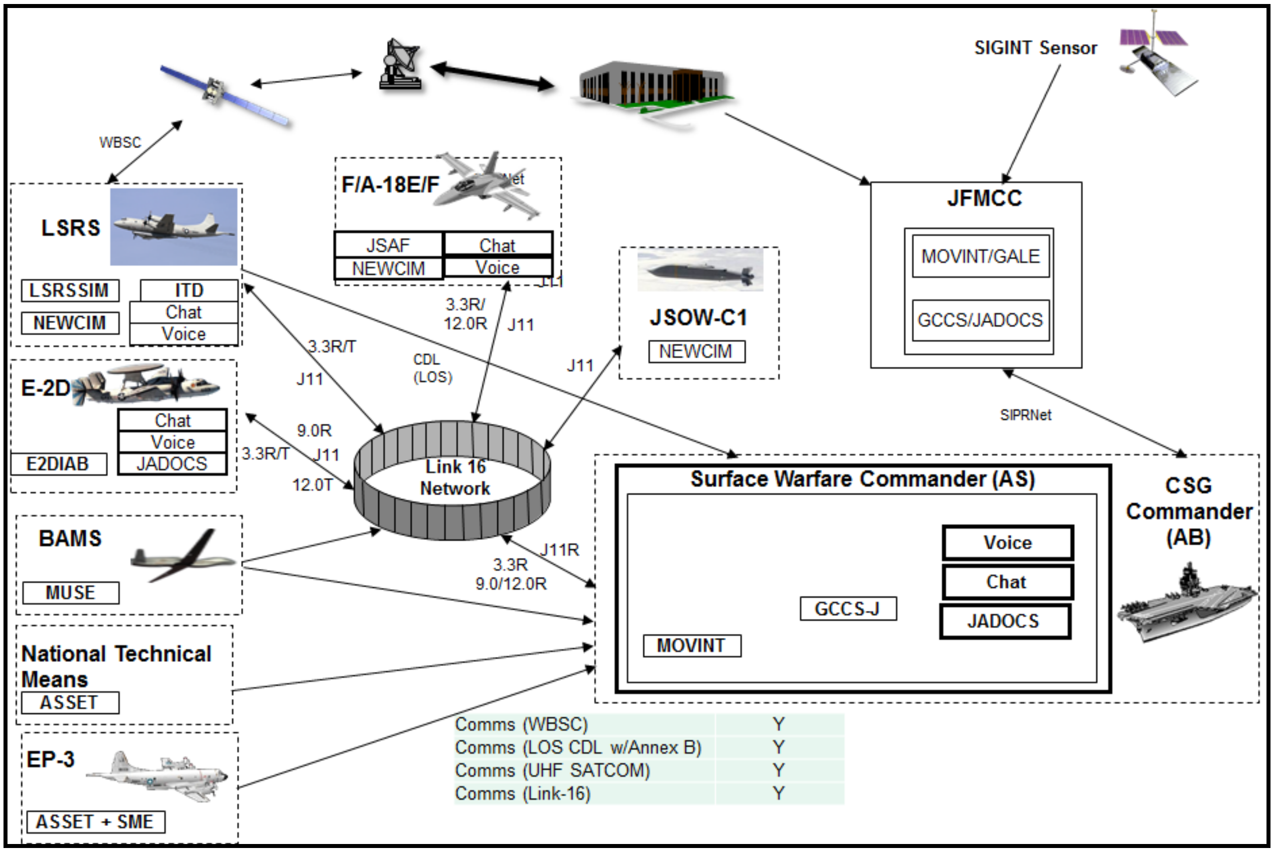


**Figure 1.1. SIMEX 13-3 Operational Architecture**

This depiction forces a conversation between operators and the technical team to ensure data is flowing as it would in real operations, and very often gaps begin to be identified even before the experiment is close to being executed.

## 3.3 Technical Architecture

The Technical Architecture drills down and depicts the specific systems and messages that are involved when executing the Operational Architecture. The Technical Architecture is captured in at least two pictures. One depiction represents the simulations and C4I systems that are used, along with a high-level view of what data is flowing between the systems, and an indication of which systems are currently fielded. Figure 1.2 shows an example of this. Depicting the fielded systems (or programs of record) is important because it lays out clearly what is in the operator's current architecture and what new systems are being introduced into the experiment.

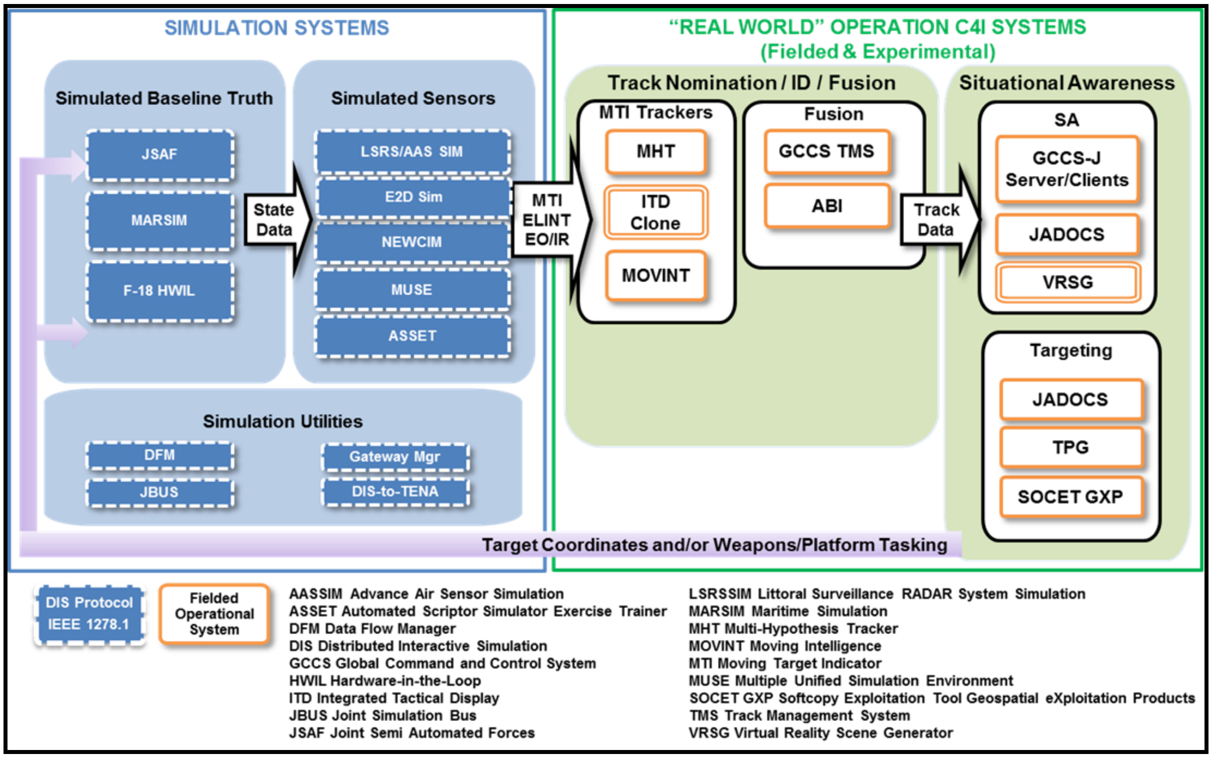


**Figure 1.2. Simulation-C4I Architecture**

The other key technical architecture picture contains the specific interface protocols between the simulations and the C4I boxes. An example of this is shown in Figure 1.3. As you can see from the example, the data formats for each interface are currently indicated. Furthermore, by differentiating the Simulations from the Operator systems from the middleware, it is clear which systems may require modification to support the interface. In the SIMEX environment, C2 systems receive data in the same formats that they normally expect in an operational environment. That is, no changes are made to the C2 systems to operate within the virtual environment. For this reason, the onus is on the simulations and associated middleware to generate data that the C2 systems can process. Some simulations are equipped to send data directly to C2 systems in tactical formats (e.g. OTH-Gold). Other simulations, especially legacy systems, are not able to produce data that can be fed directly into a C2 system. For these, we employ middleware to convert simulation data into formats readily accepted by the C2 systems. For instance, NCEL uses the Data Flow Manager (DFM) for this, as it is capable of receiving data in multiple formats and generating data in multiple formats. DFM is configurable, allowing a user to specify incoming connections (port, protocol, and specific data format) and outgoing connections.

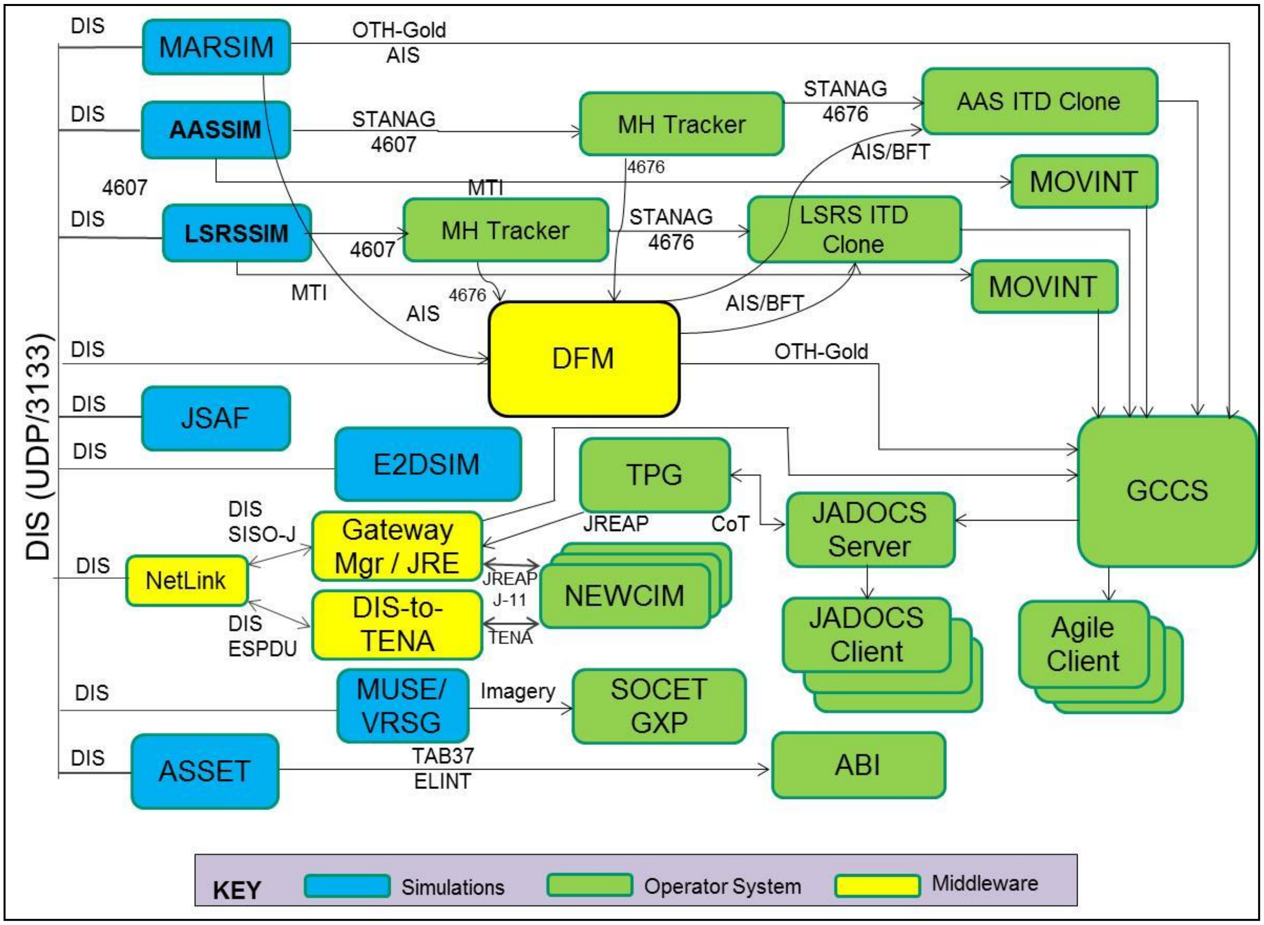


**Figure 1.3. Data Flows**

# 4. Results

Now that you have a sense for the NCEL environment and the methodology used to get at sponsor objectives, it is appropriate to share some general results captured during this and previous SIMEXs.

## 4.1 SIMEX Results

The primary objectives for this SIMEX were to examine and evolve the CONOPs and TTPs for NEW in an A2AD environment and to evolve the requisite C4ISR architecture.

The bottom line was the SIMEX served to evolve and refine the CONOPs and TTPs, as well as C4ISR architecture requirements, for this mission set. It was demonstrated that this concept was a game-changer from the standpoint of increased survivability of the launch platforms and increased flexibility of the 3rd party source. Also, machine-to-machine (M2M) technology in support of dynamic targeting was demonstrated and has the potential of increasing the responsiveness of fires.

One of the common takeaways in working with an operational scenario with the real-world C2 systems is that track management is hard. Positively identifying hostiles and ensuring neutral and friendly elements are accounted for during targeting are challenging tasks that get brought to light in this environment. It is through the fusion of different sources of information that ambiguities disappear and confidence in the Common Operational Picture (COP) begins to form.

In addition to evolving Maritime Dynamic targeting CONOPs and understanding C4ISR architecture needs, this environment has the added benefit of providing a risk reduction for a live fire event during Trident Warrior 2013. The sequence and flow of the J-11 messages used to enable the NEW concept was examined, gaps were identified, and the Operational Flight Profile software of the E-2D and F-18 was subsequently modified thereby assisting in a more effective and efficient live fire.

The specific A2AD aspect of this experiment was focused on the implications of a SATCOM denied environment. Referring back to Figure 1.1, the arrows between nodes represent specific communications channels and are dependent on the operational profiles of the different platforms. As certain capabilities are denied, these links are broken; and applicable nodes are no longer fed data. Implications of these nodes being cut off are measured and insights gathered. It was determined that the reach-back node at ONI would have more difficulty working the real-time problem, but based on this architecture and the C2 relationships set, there is enough redundancy built in to not have severe effects.

## 4.2 Past Successes

The above paragraphs are one specific example of SIMEX results. Other successes include:

- Developed and refined experimental CONOPS that assisted in evolving current ideas for units supporting OIF, and other coordinated operations. From a SIMEX an operational playbook was developed.
- Examined the roles of C4ISR systems, sensors, applications, and tools; identified gaps in their support of other systems. Worked with sponsors, such as MARCORSYSCOM, to evolve capabilities of C2PC.
- Identified needed changes to current doctrine, organization, training and/or equipment for deployed USMC, Navy, and Joint Forces.
- Rapidly integrated new S&T with the current set of capabilities. For example, integrated Swarm software into the platform and assessed its viability as a decision aid with more real world scenarios vice the tests it had conducted
- Evolved Joint and Service TT&P in Maritime Domain Awareness, SCJC2, and ASuW domains.
- Provided technical and operational feedback to PMs, developers, and Doctrine and Joint Commands.
- Provided early requirements gathering/refinement, early insights on effectiveness assessments, and early stage risk reduction experiments on feasibility.

- Propelled development of tactics, plans, policies, and processes that are required to integrate Navy's networks and computing and communications environments into an interoperable infrastructure.

# 5. Lessons Learned

Over the years, there have been numerous examples of C2 systems being fielded that either do not work or whose operators do not know how to properly operate them. The NCEL provides an environment to put these systems in front of operators in a low risk, high fidelity environment to help minimize these issues. We owe it to the warfighter to provide them with systems that can be used effectively.

## 5.1 Process Improvements

With respect to the SIMEX planning and execution process, a three-phased approach for the analytic methodology should be maintained; although there is room for improvement across all the phases. During planning (Phase I), the systems under analysis and the scenario requirements must be coordinated with the applicable working groups.

During Phase II, the Analysis team must verify that the data collection mechanisms and data repository structures are sufficient to meet DCAP requirements. The team must also verify that the event environment will provide the means to employ the system under analysis within the context for which it was intended to be used. This validation of the analytic approach requires the involvement of all user representatives, to include all stakeholders, agreeing to the scenario and ensuring it supports the analytic approach.

During Phase III adequate time and resources must be dedicated to the technical, functional and operational testing outlined in the Data Collection and Analysis Plan (DCAP). Also the data collected and archived in databases must be properly formatted, readily available, and usable by the analysts to support post-event analysis and reporting requirements.

## 5.2 Technical Challenges

The fundamental technical challenge is a recurring one for many complex federations. Sufficient time and resources must be allocated for integration and testing. As mentioned earlier, the time between initial SIMEX planning and the event itself is only a few months. During the months leading up to the event, systems are being developed or modified for integration into the NCEL environment, and scenarios are being built. Obviously, full tests of the SIMEX environment cannot occur until all systems are available and the scenario is complete. However, because there are many interfaces to test, piecewise integration starts with basic test scenarios early in the process. Testing and integration continues as incremental changes are made, including new software and new scenario data.

An additional technical challenge comes from SIMEXs being human-in-the-loop events. It is difficult to anticipate how the uniformed operators will use the systems, and it is often much different than what the NCEL engineers had anticipated. Therefore, our systems must be robust. This can also create scalability issues, as the operators may do things that cause unexpected, high demands on our computing resources. Human-in-the-loop events also cause challenges from an analytic standpoint. As operators become more familiar with the systems and TTPs and learning occurs; repeatability from run to run is not practical and must be taken into account.

In addition, whatever we represent in the virtual environment must be something that we can subsequently analyze. Thus, information that is important for meeting experiment objectives must be captured. This requires identifying the mechanisms for the data capture, and that can be anything from instrumenting the environment to automatically recording certain data or generating visual cues for a human data collector.

# 6. Recommendations

Continue to develop and utilize quick turnaround, high fidelity environments that put Programs of Record and systems going to the field in front of operators, so that feedback can be gathered to address issues prior to fielding the systems. Continue to mature TTPs in a lab environment before more precious resources are expended in live fire or real world operations. Continue to improve upon an end-to-end data collection capability to support sensor to shooter metrics across the kill chain.

# 7. Conclusions

With the pace of operations, and the constantly changing information technology landscape it is counter-productive to do lengthy experiments and tests that extend over months. What is needed is a flexible environment that brings together operators and technologists and allows experimentation to be conducted over days and weeks, rather than weeks and months. It was the aim of this paper to show the NCEL as one solution for such a flexible environment, and to provide some insight into the methodology used and the challenges that occur.

# Author Biographies

**CRAIG DOESCHER** is an Operations Research Analyst at the MITRE Corporation in McLean, VA. He has worked on numerous M&S federation projects to include tasks with the JTC, JSIMS, MC02, and the OF/FCS C4ISR Experiment; and currently works directing SIMEXes in the NCEL

**DAVID PROCHNOW** is a Principal Software Engineer in the Modeling and Simulation Engineering Department at the MITRE Corporation in McLean, VA. He has served as technical lead on many simulation efforts for a variety of sponsors.

**WES HAMM** is an Operations Research Analyst at the MITRE Corporation in McLean, VA. He has worked on numerous M&S federation projects for the TRADOC Analysis Center (TRAC) and the National Simulation Center (NSC).