

NATO Modelling & Simulation Group (NMSG) Conference MSG-126

“Integrating Modelling & Simulation in the Defence Acquisition Lifecycle and Military Training Curriculum”

Technical Evaluation Report

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OVERVIEW

The NATO Modelling and Simulation Group (NMSG) Symposium (MSG-126) titled *Integrating Modelling & Simulation in the Defence Acquisition Lifecycle and Military Training Curriculum* was conducted in Washington, DC, USA, on 23- 24 October 2014. All sessions of the Symposium were unclassified. A host nation (USA) representative delivered a keynote presentation at the beginning of each day. Presenters delivered 21 papers at the conference which was organized into four topic Sessions. This Technical Evaluation Report summarizes the core ideas and results of each MSG-126 presentation, provides an overview of discussions occurring immediately after each presentation, and then adds recommendations and/or comments that represent solely the opinions of the Technical Evaluation Reporter (TER). The report concludes with an overall summary and recommendations section.

1.0 INTRODUCTION

The fundamental theme of the conference was to exploit M&S within NATO on a larger scale to enhance readiness and training. To support this theme, MSG-126 highlighted topics in the areas of defense acquisition, military training and the provision of M&S as a service (MSaaS). The impetus behind this is that the current state-of-the-art in M&S and emerging capabilities is increasingly able to integrate across the individual phases of the full acquisition lifecycle, and that MSaaS is promising capabilities in reducing costs, reducing setup times, and increasing interoperability.

The conference organizers solicited papers in the following ten areas:

- quantifying lessons learned from the application of modeling and simulation within the acquisition lifecycle,
- discussing strategies and technologies to implement a common model framework across all or most of the acquisition lifecycle,
- discussing the best practices of M&S development to support the acquisition lifecycle,
- discussing how M&S is or has been used to support Program Management decisions that lead (or have led) to successful milestone completion,
- discussing the role of M&S in assessing Key Performance Parameters during system acquisition,

- approaches to (or lessons learned from) replacing live instructor-based training with "self-serve" or "self-organized" training enabled through simulation,
- the permeation of simulation in novel domains within the military or in support of the military,
- roadmaps to future integration of simulation into curriculum supporting training in the military,
- approaches addressing multi-tier training (i.e., training at strategic, operational, and/or tactical levels) through simulation, and
- effective development and implementation of MSaaS within NATO and its context.

2.0 DAY 1 (THURSDAY, 23 OCTOBER 2014)

2.1 Keynote #1 - Modeling in Support of Defense Acquisition

- Ms. Kristen Baldwin from the United States (U.S.) delivered the first keynote address titled *Modeling in Support of Defense Acquisition*. She is the Principal Deputy in the Office of the Deputy Assistant Secretary of Defense for Systems Engineering (ODASD(SE)) in the Department of Defense (DoD). She began by noting that modeling is not a new concept for supporting defense acquisition, but there are now significant new modeling and simulation (M&S) tools to provide value across the entire acquisition lifecycle. There is certainly an increased emphasis on modeling for design in acquisition, which supports the current choice between procuring larger forces or smaller forces with more advanced technology capability. She stated that engineering relies on data from the test and evaluation (T&E) process and from M&S. To keep systems affordable, agile, and responsive throughout the acquisition lifecycle requires engineering M&S and capability prototyping. Engineering models help maintain consistency about the system, integrate technical and non-technical drivers, and provide understanding of various perspectives about the system under development. She mentioned a new effort involving data titled the "digital system model." She also discussed the "Engineered Resilient Systems" (ERS) project, which is applying science and technology (S&T) to increase engineering productivity and address changing threats and missions. ERS provides analytics to investigate over 10,000 design alternatives. She also stressed the need to move closer to the operational community for developing improved understanding of both the mission and the engineering contexts of systems. In summary, she stated that M&S remains an important enabler for the U.S., that the acquisition community should continue to benefit from M&S tools and practices, and that technical advances in modeling and data analysis offer tremendous opportunities.
- DISCUSSION: The first area of discussion concerned the U.S. Army's former "Simulation and Modeling for Acquisition, Requirements, and Training" (SMART) program and how current efforts extend this. Ms. Baldwin noted that the technology was not ready then, but that it is now. The second area of discussion involved the digital system model and how culture can be changed to take advantage of this. Ms. Baldwin stated that the answer was to partner with the U.S. Military Services (Air Force first) and then with industry for opportunities. To change policies and standards, the M&S practitioners need to reach out to leaders. The third area of discussion concerned eliminating surprise by using M&S. Ms. Baldwin presented the need to adapt to changing adversaries, changing financial conditions, and different partners as they evolve. This will require not just M&S, but M&S for successful systems from concept to disposal.

2.2 Session 1 - Decision Support

Session 1 Chair – Mr. Niels Krarup-Hansen

2.2.1 Paper #1 - Coalition C2-Simulation History and Status, Pullen, et al.

- Dr. Mark Pullen started with a quick overview of the past decade in Command and Control to Simulation (C2-SIM) developments and described the current state of the art in C2-SIM within NATO countries. Then he discussed the 2013 MSG-085 Technical Activity demonstration of December 2013 that featured military operational use of command and control (C2) systems interoperating with combat simulations. This demonstration supported a vision of interconnected networks, C2, and simulations that can be turned on and authenticated in a standards-based environment. The demonstration was based on the Military Scenario Definition Language (MSDL), the Coalition Battle Management Language (C-BML), and parts of the Joint Consultation, Command and Control Information Exchange Data Model (JC3IEDM). The operational focus of the demonstration was joint and combined mission planning. The approach involved three phases covering concept development, proof of principle, and proof of concept. The presenter discussed the operational aspects of the demonstration, which showed how C2-SIM can support commanders and staff assessments in improving the feasibility of selected courses of action, augmenting planning and rehearsing, and enhancing collaboration within a command structure. This effort has led to a new (and just approved) NATO M&S technical activity.
- **DISCUSSION:** The first part of the discussion concerned how this effort will support acquisition. Dr. Pullen stated that we need to take existing standards and start building them into the operational C2 system. This will require encouragement/support and Service activities. The second discussion area concerned CBML. Dr. Pullen stated that this is a “victory” standard as an exemplar of good, open standards. The third discussion area was about systems of systems (SOS). Dr. Pullen noted that we need to make sure that they work together and that we need to check that interfaces are properly connected.
- **RECOMMENDATIONS/COMMENTS:** The NMSG should continue to sponsor and publicize follow-on developments and demonstrations indicating the value of MSDL, C-BML, and JC3IEDM since realistic assessments of the utility of systems under acquisition rely on accurate predictions of these systems’ potential interactions with real-world C2 systems. The authors should continue to report to the NMSG on their continuing efforts as they are completed.

2.2.2 Paper #2 - A Proposed Process and Toolset for Developing Standardized C2-to-Simulation Interoperability Solutions, Heffner, et al.

- Mr. Ole Martin Mevassvik started by reviewing the Military Scenario Definition Language (MSDL) and the Coalition Battle Management Language (C-BML) open standards that have been developed for military scenario initialization and the run-time exchange of digitized military information among command and control (C2), simulation, and autonomous systems. He described an engineering process and prototype toolset for the development and maintenance of a unified C2-SIM Scenario Initialization and EXecution (SINEX) Model. The presenter then described a draft C2-SIM Distributed Simulation Engineering and Execution Process (DSEEP) Overlay for the development of federations comprised of simulation and C2 systems. He noted the need for a process and/or toolkit to evolve standards and protect investments. The goal is to attain the best of both MSDL and C-BML: an approach that is light and easy but also provides significant capabilities. The main issues include time management (a technical issue); dealing with “stakeholders” in both the C2 and simulation communities (a programmatic issue); preparation of the scenario to initialize a federation (a consistency issue); the end-users’ perception and the report management process (ground and perceived truth issues); and order/request message processing (consistency with doctrine issue).

- **DISCUSSION:** The discussion concerned the status of this effort and if this architecture has been applied in actual systems in Norway. Mr. Mevassvik stated that this is currently in the research stage.
- **RECOMMENDATIONS/COMMENTS:** The NMSG should continue to monitor this interesting effort as it transitions from research to application. The authors should continue to report to the NMSG on applications of the SINEX model, process, and toolset as they are completed.

2.2.3 Paper #3 - Capability-Based Models for Asset Mix Computation and Analysis, Wesolkowski

- Dr. Slawomir Wesolkowski began with a discussion of classic operations research tradeoffs for determining an asset mix, namely the mix of assets/personnel one would like to have to accomplish a set of tasks. The solution involves a set of models ranging from the micro to the macro. The macro models are used primarily for determining asset mix composition. The micro models are used primarily for determining asset mix performance. The basic technique for the micro effort is simulation while the basic technique for the macro effort is optimization. The presenter continued by discussing how to balance simulation with optimization. The simulation models need to be accurate at the micro scale and the optimization models and mathematical programming need to improve global efficiency of the asset mix. He then presented some requirements of optimization-based models and the requirements for scenarios used in both the simulation and optimization-based models. The objectives most appropriate for fleet mix studies are performance, cost, risk, etc. The presenter concluded by noting that simulations tend to overestimate the numbers of required assets, while optimization models tend to underestimate the number of required assets, and consequently analysts must use both.
- **DISCUSSION:** The first discussion area covered the concept of risk and its definition, and specifically if risk is defined as the likelihood that a platform is not available. Dr. Wesolkowski stated that risk can also be defined as a mission that cannot be performed, and that there are also “political risk” values. The second area questioned if this approach takes into account personnel skill sets since this would provide understanding/accounting for the loss of available skill sets due to budget cuts. Dr. Wesolkowski stated that the model could be adapted to treat this factor.
- **RECOMMENDATIONS/COMMENTS:** The NMSG should monitor this development since the successful interaction and interoperability of models and simulations at varying levels (e.g., campaign, mission, engagement, and engineering) is fundamental for assessing the potential utility of systems in the acquisition process. The author should continue development of this approach and report to the NMSG on actual applications as they are completed.

2.2.4 Paper #4 - Integration of Sonar Performance Modelling in Sonar Operator Training, Mission Planning and High Risk Decisions, Dombestein and Hermansen

- Ms. Elin Dombestein started by presenting information about anti-submarine warfare (ASW) and how advanced sonar systems are used to yield the long detection ranges crucial to counter submarine operations. She described how the new LYBIN model can improve sonar operations and tactics and hence improve decisions. Specifically, LYBIN is being integrated with external systems to improve sonar operator training, planning of underwater operations, and situational awareness supporting decision making in time-critical, high-risk situations.
- **DISCUSSION:** The first area of discussion concerned the integration of LYBIN into actual systems. Ms. Dombestein stated that it is being integrated into frigates. The second area was concerned about the incorporation of LYBIN into maritime patrol aircraft (MPA). Ms. Dombestein stated that it has been used, but not completely incorporated.

- **RECOMMENDATIONS/COMMENTS:** The NMSG should continue to monitor this effort and encourage the authors to report on the value of this approach and to delineate their specific measures of effectiveness. Also, the authors could extend LYBIN to operate in convergence zone ocean sonar environments rather than just the direct path environments reported on in this presentation.

2.2.5 Paper #5 - Using Virtual Environments to Evaluate the Operational Benefit of Augmented Reality, Evensen and Halsør

- Mr. Per Idar Evensen began by reviewing efforts at the Norwegian Defence Research Establishment (FFI) involving experiments with simulated Augmented Reality (AR). He described using virtual environments to evaluate the operational benefit of AR functionality in combination with a Battlefield Management System (BMS) in combat vehicles. They have conducted three experiments with combat vehicles, have collected quantitative measurements and feedback from the participants, and observed actual system use. This data is supporting the design of an operational AR system for combat vehicles. The virtual environment was initially based on the commercial game Unreal Tournament 2004 (UT2004) but now uses Virtual Battlespace 2 (VBS2) for a more extensive representation of military systems and scenarios. The results of the experiment indicate that the simulated AR system provides faster and more accurate perception of the BMS information. This improvement in overall situational awareness yields an average reduction of up to two thirds in target acquisition times.
- **DISCUSSION:** The first area of discussion concerned the next steps in the system development and whether it should go to a live environment. Mr. Evensen stated that the next steps will take the processes into operational areas. The second area involved the use of incomplete/incorrect AR presentations to users. Mr. Evensen noted that this has not been done on purpose. The final discussion area considered the use of other human factors such as external sound. Mr. Evensen noted that there have been some tests with voice recognition systems.
- **RECOMMENDATIONS/COMMENTS:** The NMSG should encourage and publicize additional efforts in this area as augmented reality offers huge potential payoffs in actual military operations. The authors should report on continued testing of emerging technologies and concepts in a virtual environment. They should also report on the value of this approach as it is integrated into actual systems and expand their measures of effectiveness and their methods of data collection.

2.2.6 Paper #6 - *Simulation-based Defense Planning*, Moradi and Schubert

This paper was withdrawn.

2.2.7 Paper #7 - Verification & Validation of the Targeting Task Performance Metric (TTPM) in OneSAF, Harkrider, et al.

- Mr. Brian Miller presented the verification and validation (V&V) of a new algorithm used by the U.S. Army's Night Vision and Electronic Sensors Directorate (NVESD) for the One Semi-Automated Forces (OneSAF) simulation. This effort supports determining the probabilities of when a target can be detected, recognized, or identified and forms the basis for essential representations of entities, behaviours and units across a full spectrum of military operations. The V&V involves a part of the current NVESD engineering level imager performance model, Night Vision Integrated Performance Model (NV-IPM) used to perform engineering trade studies and analyses on real and notional EO/IR systems. Specifically, NVESD has developed a module for NV-IPM that directly generates OneSAF input files. Mr. Miller described the V&V of both the NV-IPM module and its implementation in OneSAF.

- **DISCUSSION:** The discussion concerned whether this was a full V&V. Mr. Miller stated that this was not a full V&V, but that it was sufficient to provide needed understanding about the integration of the engineering-level model with the engagement model.
- **RECOMMENDATIONS/COMMENTS:** The NMSG should continue encouraging information and data from actual efforts to perform V&V on M&S supporting system acquisition since V&V is an important process that is not easily or economically executed. The authors should continue reporting on V&V for similar integrations and provide additional discussions about their V&V approaches and techniques. They should also provide the criteria for the accuracy of the numbers included in the tables in the paper.

2.3 SESSION 2 -Using M&S in Support of Acquisition

Session 2 Chair – Ms. Jie Hou

2.3.1 Paper #8 - How Does an Analyst Select M&S to Support the Entire DoD Acquisition Lifecycle Process? Examine ARL's Executable Architecture Systems Engineering (EASE) Research Effort, McGroarty, et al.

- Mr. Christopher McGroarty began by introducing the EASE tool and related processes developed by the U.S. Army Research Laboratory (ARL). EASE helps M&S users produce and understand simulation capabilities in complex M&S environments without an on-call technical staff. EASE, which could be considered as a follow-on to the Modeling Architecture for Technology, Research, and Experimentation (MATREX) program, also helps reduce the time for developing an experiment, analysis, or simulation. By encouraging reuse of architectures and models, EASE helps to reduce costs. EASE permits analysts to address increasingly multifaceted problems requiring extensive resources leveraging vast amounts of data. As a common model framework, EASE is being designed to work with multicore desktop computers, cloud architectures, and data mining tools.
- **DISCUSSION:** The first area of discussion concerned the relationship of EASE/MATREX with the rapid data generation (RDG) program; in particular, asking if EASE uses RDG and, if so, who maintains the data. Mr. McGroarty stated that EASE uses some aspects of these data sources. The second area of discussion involved the actual use of EASE; Mr. McGroarty noted that it is being used to some extent and that there is an available subject matter expert (SME). The third area concerned the scenarios in EASE and if they are doctrine based. Mr. McGroarty stated that the scenarios, as of now, are basic, at best. The final area of discussion concerned C2-SIM and how EASE works with MSDL for scenario definition. Mr. McGroarty noted that EASE can help with storing needed data.
- **RECOMMENDATIONS/COMMENTS:** The NMSG should monitor and assess the multiple approaches to frameworks having the potential to ease the development and application of M&S through increased reuse. This potential evaluation requires developing measures of effectiveness to determine the values of frameworks and methods to collect supporting data. The NMSG could also begin an effort to understand what is necessary to verify and validate (V&V) these frameworks. The authors could report back on the actual uses of EASE when they occur and supply their measures of effectiveness for the framework so that it can be evaluated against other frameworks. Also, the authors could detail how they performed V&V on their framework.

2.3.2 Paper #9 - A Chemical, Biological & Radiological Modelling Capability to Support Acquisition and Lessons Learned from Re-Use as a Common Cross-Domain Capability, Lloyd, et al.

- Mr. Jonathan Lloyd started by introducing a new Chemical, Biological, and Radiological (CBR) M&S capability, the CBR Virtual Battlespace (CBR VB), developed by the United Kingdom (UK) Defence Science and Technology Laboratory (Dstl). This modeling framework incorporates a synthetic environment supporting M&S and includes a dispersion engine for understanding the effects of contaminant dispersion across the defense battlespace. The framework can help generate CBRN measures of effectiveness such as casualties or sensor alarms. Mr. Lloyd presented how CBR VB provides sensitivity analysis on certain parameters within CBRN vignettes. This capability is used by the UK Ministry of Defence (MOD) for cost/benefit analyses supporting the procurement of individual protective clothing suits, body armor, medical countermeasures and sensor technologies. The system has been developed as a common CBRN M&S component that can be used as a modeling service by other systems. This effort supports the development of CBRN simulation interoperability standards for use by NATO.
- **DISCUSSION:** The first discussion area concerned the time management capabilities of the system and its data sources. Mr. Lloyd stated that the system runs in real time rather than using lookup tables. A second area involved the system's ability to handle the spread of Ebola. Mr. Lloyd suggested that one should use other models. The third area asked about the data for validation of results and if there were any sensitivity studies. Mr. Lloyd noted that the system manages and maintains a large amount of data that could be used for these purposes.
- **RECOMMENDATIONS/COMMENTS:** The NMSG should monitor and assess a full range of models and simulations for use in the CBRN area; there are many and their similarities and differences are not always obvious. The authors should report back on additional uses of this CBR VB when they occur, supply measures of effectiveness determining the value of this framework, and discuss how they collect the data supporting these measures. Also, the authors could detail how they performed V&V on this framework.

2.3.3 Paper #10 - Program Manager (PM) Model & Simulation (M&S) Playbook; A Tool for Program Managers to Employ M&S in the Defense Acquisition Management System, Harkrider, et al.

- Mr. Favio Lopez introduced the goals and design for a system that can educate and inform acquisition program managers on how M&S can assist them. The current sources of most of this information are the U.S. Department of Defense (DoD) Directive 5000.01, which describes management principles and overarching policy, and the Interim DoD Instruction 5000.02, which describes the operation of the Defense Acquisition Management System. The playbook will be a Web-based system organizing and providing easy access to this information for the program manager. Additional sources of information could include the Defense Acquisition Guidebook (DAG).
- **DISCUSSION:** The first area of discussion concerned how training and command, control, communications, computers, intelligence, surveillance, and reconnaissance (C4ISR) requirements are carried along in the system lifecycle. Mr. Lopez stated that policies and principles encourage reuse of testing tools for training across the lifecycle in delivering a system. The second area involved how DoD-wide were the answers provided in the Playbook; Mr. Lopez noted that they are DoD-wide. The third area was about who was going to be able to use the Playbook and if it was available now to help designers understand the acquisition process. Mr. Lopez answered that it can already help with storing data.

- RECOMMENDATIONS/COMMENTS: The NMSG should encourage efforts to improve M&S education for a full variety of users. The internet is one exciting alternative to the traditional student/teacher lecture approach, but the value of this alternative needs to be documented carefully. Consequently, the authors should report on this effort when it has been completed, tested, and used. They could then present data indicating how they determined the value of the Playbook, their measures of effectiveness, and how they collected the supporting data. They could also report on the lessons learned (feedback) from the actual users of the Playbook.

2.3.4 Paper #11 - Department of Navy (DON) M&S Enterprise Solutions, Reed, et al.

- Mr. Dennis Reed started by introducing a Department of Navy M&S enterprise effort to develop and integrate a common framework for enhancing interoperability and reuse of models, simulations, facilities, and infrastructure across the Acquisition Lifecycle. The end result will be a Common Integration Environment (CIE) supporting best practices in efficient use and development of M&S which can also be used to enable rapid tradeoffs throughout system acquisition. Mr. Reed continued with descriptions of (1) the Architecture Management Integration Environment (AMIE) which is a Government-owned, non-proprietary, open architecture integration environment; (2) the Virtual World Standard Interface (VWSI) which is a set of standard interfaces that allows integration of virtual worlds with existing M&S tools; (3) the Framework for Assessing Cost and Technology (FACT), which provides decision support tools; and (4) the Enabling Architecture for Interoperability Initiative (EAIL) which is a systematic means of documenting warfighting requirements and architectures. One goal of this effort is to develop a partnership with the DoD and the other Services. The effort will develop a catalog of capabilities, the Naval Infrastructure Capability (NICAP), and will also create a “neutral data exchange model” (NDEM). The effort is following a five-step process including requirements analysis, environment definition, environment allocation, environment integration, and environment visualization.
- DISCUSSION: The first area of discussion included inquiring if this process is actually in place across the Navy, if this process is joint, and what is now available to the Army; Mr. Reed answered that it is not yet fully institutionalized in the Navy. There was also a discussion of coordination, policy, and governance supporting the effort to make this framework DoD-wide and the need for a multi-prong approach to get people using it first and then policy supporting it.
- RECOMMENDATIONS/COMMENTS: As noted in the recommendations/comments for Paper #8, the NMSG should monitor and assess the multiple approaches to M&S frameworks, including measures of effectiveness, methods for collecting supporting data, and approaches to performing V&V on these frameworks. The authors should report back on the actual uses of their framework when they occur and supply measures of effectiveness determining its value. Also, the authors could detail how they verified and validated the NDEM and framework. Finally, the authors could present details about the NDEM conceptual model, methods to handle aggregation/disaggregation, and methods to handle mixed resolution.

3.0 DAY 2 (FRIDAY, 24 OCTOBER 2014)

3.1 Keynote #2 - US Joint Staff J7 Support to Joint Training and Exercises

- Mr. Tom Irwin from the United States delivered the second keynote address titled *US Joint Staff J7 Support to Joint Training and Exercises*. He is the Deputy Director for Joint Environment, U.S. Joint Staff, J7. He began by stressing that the operational environment provides the drivers for training. He then discussed the NATO Connected Forces Initiative and its goals of improving common understandings, connecting Allied forces and partners, supporting increased exercises, and enhancing the use of technology. He noted that the U.S. Joint Training drivers that constrain the U.S. approach include globally integrated operations, dynamic presence/rapid aggregation of forces,

maximum use of home station training, the Joint Information Environment (JIE), data-centric technology/big data, and the Federated Mission Networking/Mission Partner Environment (FMN/MPE) cornerstone for interoperability. He discussed the need for the Joint Training Exercise Architecture (JTEA) as the joint training platform and mentioned that the U.S. “couldn’t just polish the existing models anymore.” The new architecture framework should include the cloud, offer various services, incorporate cyber, be open source, encourage COTS/GOTS reuse, use industry standards, support legacy integration, and provide interface specifications. Mr. Irwin suggested that we can now move digits with 3D printing. Further, we will have robots on the battlefield of the future and we need to understand the cyber related issues. The JTEA is a move towards “process-based training” with machine understandable form and will also handle fidelity resolution to support joint, agile training. He reiterated that the JTEA Architecture Framework will be Web-enabled and use open source technology solutions and that its adoption will be easier if “we all move there.” He mentioned that the use of rapid data generation (RDG) data providers as a service called “RDG Online” will be part of the enterprise marketplace. He discussed the need for improved visualization for processing and management, virtual machine control, and states management. He noted that, in the future, we will see a shift toward auto-provisioning using workflow screens to leverage “machine understandable form.” He concluded with stressing that this is “more than just about M&S, this is about readiness” and we need to keep up with the pace of technology changes for our training.

- **DISCUSSION:** The discussions concerned the commonality of the JIE with emerging NATO approaches and when the JIE will be open to partners. Mr. Irwin stated the need to specify the technologies that users want to provision, when they are wanted, and whether there should be a common operating environment marketplace.

3.2 Session 3 - Training & Exercises

Session 3 Chair – Mr. Leigh Yu

3.2.1 Paper #12 - Towards an M&S Use Risk Identification and Management Methodology for Training, Roza, et al.

- Dr. Manfred Roza began by introducing a Netherlands R&D program (L1427 – Simulation) for investigating the use of M&S for risk management in simulation-based training. The goal of this program is to reduce risk. The presenter noted that the key M&S value drivers (of simulation for training) include business costs/contracting, M&S technical advances and accessibility, and training effectiveness. He stressed the risks arising from the use of M&S. These include the risks (1) that if it looks realistic then it implies good training; (2) if there is nothing else, it is the real thing; (3) the uncertainty from the randomness of man-made systems; (4) the uncertainty that we cannot measure or know it all; and (5) that the reality on its own may be of inadequate quality. He continued by discussing how to manage these risks and how to produce optimal value from simulation training. The program is using the ISO-31000 standard for the definition/vocabulary and framework of risk in which risk is defined as “the effect of uncertainties on objectives.” He stated that the risk chain includes events, their consequences, and the results on objectives (good or bad) and that uncertainty underlies all of this. ISO-31000 also includes a risk management process. He is using this to help tailor standards for M&S and is working with the Johns Hopkins University Applied Physics Laboratory (JHU/APL) on the DSAT M&S Use Risk Methodology (MURM) program for developing an M&S use risk roadmap.
- **DISCUSSION:** The first area of discussion concerned examples of M&S-based training that have provided negative training. Dr. Roza noted an example of helicopter whole crew training where the pilot received negative individual training. The next area of discussion concerned the V&V of training effectiveness, the relationship with test and evaluation (T&E), and the need to build an effective process.

- **RECOMMENDATIONS/COMMENTS:** The NMSG should monitor developments in this area and consider sponsoring similar efforts for NATO use as the concept of reducing risk in the applications of M&S is very important not only in training, but also in other applications of M&S (analysis, test and evaluation, etc.). The authors should report back on the follow-ons to this effort and specifically on results as they become available. They could also supply additional discussions on the actual relation of V&V to risk reduction.

3.2.2 Paper #13 - Agile Cyber Training: Moving Towards a Software Ecosystem for Modelling & Simulation, Amorim and Gustavsson

- Dr. Per Gustavsson presented the requirements for information security during the acquisition process and stated that cyber training for both professionals and the public is needed. This effort is moving toward producing a software ecosystem (simulation ecosystem) that can harmonize, standardize, and help build COTS. He noted that cyber capabilities are currently changing warfare and drew the analogy to the obsolescence of the Maginot Line as an indication for the need to change our approaches. He discussed the types of cyber issues and the need for governance to coordinate approaches. Analysis will be used for information analysis and risk analysis. The cyber development strategy is to (1) absorb attacks; (2) deny objectives; (3) deny objectives and improve cost; and, finally, (4) deny objectives, improve cost, and provide additional capabilities. This requires a stepwise development of capability: being reactive, being proactive, being predictive, and being prescriptive. He concluded with the needs for training and education for readiness.
- **DISCUSSION:** Members of the audience especially liked the Maginot Line analogy of higher and higher walls.
- **RECOMMENDATIONS/COMMENTS:** The NMSG should monitor and coordinate further developments in the cyber area since there are currently huge gaps in capabilities to ensure information security. Similar to the recommendations/comments for paper #8 and paper #11, the authors should report back on actual uses of this framework when they occur and then supply measures of effectiveness and the methods for collecting this data to determine the value of this framework. Also, the authors could detail how they performed V&V on this framework.

3.2.3 Paper #14 - LTD SPHINX: a Web-Based Tool for CAX Preparation and Capitalization, Tard

- Col. Laurent Tard began by introducing the efforts of the NATO working group MSG-106 that produced the SPHINX tool, an enhanced CAX architecture, design and methodology. This effort attempts to improve the applications and benefits of simulation for officers commanding exercises. Col. Tard noted that exercise sponsors are currently reluctant to rely on simulation to support exercises because of their lack of knowledge and their fear of the complexity of simulations. The SPHINX tool is designed to facilitate the preparation of simulation exercises and their capitalization. He stated that the CAX stakeholders include the suppliers (industry/administrations); the customers (people being trained); and the users (training centers) and that there is a need to coordinate these stakeholders. The SPHINX tool helps standardize the data models. Its conceptual model is structured and shared and provides a clever use of data links to exploit resources. The next steps for SPHINX include integration into the CAX process and a timeline to show the level of preparation of a CAX.
- **DISCUSSION:** The discussion centered on the ability of external users to develop content and the need to encourage participation.
- **RECOMMENDATIONS/COMMENTS:** Similar to the recommendations/comments for paper #10, the NMSG should continue to sponsor efforts improving M&S education for a full variety of users. The author should report back on continued uses of this tested framework. He could discuss

measures of effectiveness for determining the value of SPHINX and detail how he performed V&V on this framework. He could also suggest possible approaches and applications to extend SPHINX beyond CAX to other M&S applications.

3.2.4 Paper #15 - AMSP-03 M&S Standard Profile for NATO and Multinational Computer Assisted eXercises with Distributed Simulation, Huiskamp and Faye

- Mr. Jean-Pierre Faye reviewed the concept that simulation has become an essential tool to meet the training demands of the military forces through ongoing improvements in technical capabilities and of reduced costs. He continued by noting that multi-national Computer Assisted Exercises (CAX) are crucial to NATO's and to an individual nation's readiness. He stated that the current need is for technical and procedural standards to support rapid and effective development and organization of multi-national CAX events. The NMSG is addressing this through the AMSP-03 CAX standards profile. This profile provides the CAX manager guidance on the development and use of distributed simulation and it also provides recommendations for the governance of interoperability standards for Training Centres. It includes approaches for planning, executing, and evaluating multi-national CAX. The CAX preparations phases include (1) the exercise preparation process and (2) the development of the scenario modules and the main event list/main incident list (MEL/MIL). He concluded by calling for further improvements in standards and support procedures to enhance the use of multinational CAX and to address technical and procedural gaps.
- **DISCUSSION:** The first area of discussion included the status of integrating this effort with CBML as this would be useful for a wide band of contributors. Mr. Faye noted the need to focus before addressing MSDL, which will probably occur in follow-on phases of this work, and that there is a lot of work remaining. The second area included the relationship between this effort and SPHINX and if they could be combined. Mr. Faye stated that this is just a "view" for SPHINX. The final comments were that it is nice to see Live-Virtual-Constructive Architecture Roadmap (LVC-AR)-type work actually being applied.
- **RECOMMENDATIONS/COMMENTS:** The NMSG should continue their sponsorship of efforts, like this one, that both develops standards and then determines their value. The authors should continue reporting on this effort as it undergoes additional testing and application. They could then present data indicating the value of the standards including their measures of effectiveness and how they collected the data.

3.2.5 Paper #16 - LVC Simulation for Land Operations Training, Hannay, et al.

- Mr. Jo Erskine Hannay started by introducing a Concept Development and Experimentation (CD&E) activity investigating the feasibility of complementing the Live training range at the Norwegian Army Combat & Manoeuvre Training Centre (NACMTC) with Virtual and Constructive simulations of BLUEFOR and OPFOR vehicles, UAV and artillery. The focus of this effort was on leadership training. The LVC simulation system prototype was run as a trial during an actual military exercise over four days. The presenter discussed the ultimate measure: does this system yield a higher benefit/cost ratio for training by augmenting the live range with virtual and constructive entities? He noted that the LVC training effects drive the LVC training capability which in turn drives the LVC technical capability. This produces a hierarchy for requirements which can be investigated by "peeling down." He stressed that "training as you fight is not enough" and that there is a critical need to introduce artificial events for improving/training decision making and judgment. He also discussed the construct of external and internal threats to the validity of this prototype. He concluded by noting that the use of LVC simulation for training and education must be mandated at all levels and incorporated explicitly in training plans and curricula, with a sufficient business case, so that political decisions for acquiring LVC capabilities can be made.
- **DISCUSSION:** None

- **RECOMMENDATIONS/COMMENTS:** The NMSG should consider sponsoring and publicizing similar efforts to extend and improve the reach of M&S and LVC training. The authors should continue reporting on the results of this effort, its theory, and its actual applications in the field. They could also elaborate on the provocative statement that “training as you fight is not enough” and their perceived need to introduce artificial events to train decision making and judgment.

3.2.6 Paper #17 - An Agent-Based Serious Gaming Application Targeting the Training of Military Staffs in Urban Operations, Luotsinen and Wallden

This paper was withdrawn.

3.3 Session 4 - Architecture

Session 4 Chair – TRDir Horst Behner

3.3.1 Paper #18 - Outline of a Service-Based Reference Architecture for Effective and Efficient Use of Modelling and Simulation, Siegfried et al.

- Dr. Robert Siegfried started with a discussion of why M&S products are valuable to NATO and military organizations and why it is essential that M&S products, data and processes are conveniently accessible to a large number of users as often as possible. He stated that this leads to a need for a new “M&S eco-system” where M&S products can be accessed simultaneously and spontaneously by a large number of users. This environment needs to support both stand-alone uses and integrated simulation systems/real systems. He continued by showing why service-based architectures are promising and how combining M&S with service-based architectures yields “Modelling & Simulation as a Service” (MSaaS). Dr. Siegfried described information from an MSG-131 survey and experience from developing a service-oriented reference architecture for a distributed integrated test bed for the German Federal Office of Bundeswehr Equipment, Information Technology and In-Service Support (BAAINBw). He discussed the requirements for the next generation of simulation environments and a proposed reference architecture together with its relationship to the NATO M&S Master Plan. He concluded by noting that it is hard to document observed benefits, that there is a need for a risk-based approach for IT security, and that the way forward is part of MSG-136: “Federated M&S Ecosystem.”
- **DISCUSSION:** The first area of discussion concerned the MSG-136 effort. This will be more than an assessment and will provide the direction of standardized services and interfaces plus a roadmap. The second area was the need to incorporate legacy systems while looking forward. Dr. Siegfried stated that while it is good to reuse legacy systems, the recommendation is to go beyond the High Level Architecture (HLA). The third area involved the use of positional dead reckoning agreements; Dr. Siegfried responded that they are not specific to a service-based approach and hence they are not developing such a service. The final area concerned standard fidelity levels for the data, the meaning of fidelity, and the Generic Methodology for Verification and Validation (GM-VV). Mr. Siegfried stated that these may not be addressed for now.
- **RECOMMENDATIONS/COMMENTS:** Similar to the recommendations/comments for papers #8, #11, and #13, the NMSG should monitor and encourage the continued development of these integrating M&S architectures. The authors should continue to report on actual uses of this architecture as they occur, measures of effectiveness, and the methods for collecting supporting data to determine value. Also, the authors could detail how they performed V&V on this architecture. The authors should continue reporting on this effort and on related NATO efforts as they occur.

3.3.2 Paper #19 - Night Visions and Electronic Sensors Directorate (NVESD) Modeling & Simulation as a Service Activity, Harkrider, et al.

- Mr. Steve Webster presented information on an effort at the Night Vision and Electronic Sensors Directorate (NVESD) for the development of M&S as a Service. This work builds upon the cloud computing model for the delivery of M&S-specific services to provide a consumer only the services needed without requiring direct ownership of the Information Technology (IT) hardware, software, and expertise used to produce that service. This effort could potentially reduce costs by pooling resources, improving accessibility, and improving composability through combining individual services to form new services.
- **DISCUSSION:** The discussion concerned the actual use of algorithms and services in the NV-ID. Mr. Webster noted that the system is real time, represents an optical focal plane array, and generates an image.
- **RECOMMENDATIONS/COMMENTS:** NMSG should continue sponsoring and publicizing their efforts in the applications of cloud computing to M&S and assess how their efforts relate to independent efforts such as the one reported in this paper. The NMSG could also work to leverage/standardize the nomenclature provided by the U.S. National Institute of Standards and Technology (NIST) in this area so that there would be less confusion between the concepts of “virtualization” and “the cloud” and “services.” The authors should report on this effort when it has been completed, tested, and used. They should then present data indicating the value of this approach including their measures of effectiveness and how they collected the data to support the measures. They could also report on the lessons learned (feedback) from the actual users of M&S as a Service.

3.3.3 Paper #20 - Migrating OneSAF to Emerging Web Application, Virtualization & Cloud Standards-Based Framework, Kapadia, et al.

- Dr. Robert Wittman began by reviewing the status of current U.S. Army constructive simulations involving large system-of-systems federated architectures using heavy thick clients with complex configurations. While these simulations are effective, they are expensive, have large overheads, and large lead times. These difficulties in using constructive simulations prevent their reaching their full utility. Also, he noted that federates are stove-piped and this makes it very difficult to adopt and exploit emerging technologies that could mitigate some of these difficulties. Dr. Wittman explained that these difficulties become even deeper when integrating Live-Virtual-Constructive and Mission Command systems. He then highlighted some critical technology enablers such as Web services, thin clients, and cloud/virtualization that can be used in next generation constructive simulations. He concluded by noting that concepts such as using Apps and Web services widgets will streamline, simplify, and cost-effectively deliver simulation as a service.
- **DISCUSSION:** The first area of discussion concerned the treatment of classified data in the cloud-based solutions; Dr. Wittman noted that this has not yet been addressed and that it could be a potential “show stopper.” A second area involved the tie between this effort and those in the other U.S. Services (Navy, Air Force). Dr. Wittman answered that this is largely a U.S. Army and NATO effort for now. The final area concerned the open source status of OneSAF (considered a strength) and would this continue in the cloud. Dr. Wittman stated that the authors are starting to look at this.
- **RECOMMENDATIONS/COMMENTS:** Similar to the comments for paper #19, the NMSG should continue efforts in the applications of cloud computing to M&S and assess how they relate to independent efforts. The authors should report on this effort when it has been completed, tested, and used. They should then present data indicating the value of this approach with OneSAF including their measures of effectiveness and how they collected the data. They could also report on the lessons learned (feedback) from the actual users of M&S as a Service.

3.3.4 Paper #21 - Potential Role of an Enterprise Service Bus (ESB) in Simulation, Stapleton

- Mr. Douglas Stapleton began by presenting some ideas on how an Enterprise Service Bus (ESB) could contribute to advancing live and virtual simulation in the NATO context and its possible applications to the acquisition lifecycle. The basic areas are (1) data translation services (between multiple standards); (2) linking simulations with the live military environment; and (3) bringing corporate data into the simulation environment. The presenter noted that the ESB is the runtime infrastructure (RTI) that implements the service-oriented architecture (SOA) pattern. More detailed areas include populating the “Area of Operations” with environmental models, translation services between standards and versions of standards, parallel testing concepts for introducing a new service, exercise control, Battle Damage Assessment (BDA), tactical messaging, digital concepts of a fair fight, and acquisition M&S. The presenter noted that “our enemies will tell us nothing, and our friends even less.” He concluded by stating that the greatest need is getting simulation information back into live systems so they can see the full picture.
- DISCUSSION: The first part of the discussion included how to overcome restrictions on BDA information. The second area noted that this is a good approach for dealing with a variety of problems. The final area was about the availability of this system; Mr. Stapleton responded that his company is happy to discuss availability at any time.
- RECOMMENDATIONS/COMMENTS: The NMSG should monitor, encourage, and publicize the application of industry-developed information technologies to M&S as a means to leverage defense spending in a fiscally constrained environment. The author should report back on his industry approach to the use of services in simulations when it has been completed, tested, and used. He should then present data indicating the value of this approach including measures of effectiveness and data collection methods.

3.3.5 Paper #22 - An update on the developments and maturity of the NATO Education and Training Network (NETN) Federation Architecture and Federation Object Model (FOM), Mifsud, et al.

- Mr. Michael Mifsud began by summarizing technical developments made to the NATO Education and Training Network (NETN) Federation Object Model (FOM). He then described the final verification and validation (V&V) activities that exercised and validated the recommendations made within the Allied Modelling and Simulation Standards Profile (AMSP)-03 and that integrated and evaluated the NETN FOM developments within an operational use case. He discussed an example where the NETN FOM was used to support a large-scale exercise. Mr. Mifsud noted that NETN was designed to integrate and enhance existing national simulation capabilities by delivering (1) a persistent infrastructure; (2) distributed training and education tools; and (3) standard operating procedures to enable more effective M&S collaboration. He then described the history of NMSG 068 and the ensuing MSG-106. These produced the NETN Federation Architecture and Federation Object Model (FOM) Document (FAFD) which outlines a mechanism to define data models. The presentation provided an overview of the operational benefits of these efforts including the Real-time Platform Reference Federation Object Model (RPR-FOM) modularization, scenario initialization mechanisms, federation execution control, transfer of modeling responsibilities, multi-resolution modeling, simulation to C2 system interoperability, and support to the Chemical, Biological and Radiological (CBR) community with the CBR FOM. The presentation concluded with a summary of findings from the MSG-106 final integrating experiment.
- DISCUSSION: The first area of discussion concerned the power of NETN and its related developments. The second area noted that these efforts need to be publicized/advertised to senior-level people and that there is a need to exploit the results of this work.
- RECOMMENDATIONS/COMMENTS: The NMSG should continue publicizing the results of this and similar efforts since actual, quantifiable results from architecture and

framework developments are currently quite sparse. Also, the organizers of the symposium could feature this type of excellent summary paper earlier in the conference since it provides such a comprehensive introduction to a variety of real efforts underway and/or completed by NATO.

3.3.6 Paper #23 - (Invited Paper) Sensor Life Cycle Acquisition and Training with Modeling & Simulation, Harkrider, et al.

- Ms. Susan Harkrider began by reviewing the uses of M&S at the U.S. Army's Night Vision and Electronic Sensors Directorate (NVESD) Modeling and Simulation Division (MSD). In particular, the MSD supports sensor analysis, development, experimentation, testing, fielding, training, and operations by providing sensor performance modeling; refining models through field and laboratory measurements of developed sensors; and developing M&S using physics-based algorithms of actual sensor performance or platforms. Specific models and simulations represent electro-optic, infrared, acoustic, magnetic, seismic, synthetic aperture and ground penetrating radar sensors, as well as munition effects related to sensors' capabilities. Ms. Harkrider then provided details of the NVESD integrated performance model (NV-IPM) and the flow of information for its VV&A. She concluded by noting that NVESD uses M&S throughout the acquisition life cycle for many programs.
- **DISCUSSION:** The central discussion point concerned the use of classified training efforts since the NVESD investigations could easily involve classified data. Ms. Harkrider noted that NVESD has a classified laboratory that is kept separate from the unclassified one.
- **RECOMMENDATIONS/COMMENTS:** The NMSG should monitor developments reported here to help indicate to decision makers the value of M&S. Also, the organizers of the symposium could feature this type of summary paper earlier in the conference if they accept (as they did here) a variety of papers all from the same organization; this paper provides a natural introduction to the NVESD efforts reported separately.

4.0 SUMMARY AND RECOMMENDATIONS

The following is a summary of comments and recommendations developed by the TER during the conduct of the MSG-126. These comments and recommendations are solely the opinions of the TER and are not intended to reflect any form of official position.

4.1 Time Allocation

The organizers could have allocated some of the presentations significantly more time and reordered them to provide overviews of common efforts first. Also, the papers from NVESD could have been combined to provide a better indication of the breadth and depth of the efforts underway there. I found the discussions following each presentation to be the most informative part of the presentations and recommend that the time for these discussions should be increased.

4.2 Frameworks

The speakers presented and discussed a plethora of M&S frameworks. The approach for some of the frameworks appears to be "build it to my (special, proprietary, wonderful, exotic) specifications and it will work for everything and everyone – all domains, all fidelities, all times, and all users." While it is clearly necessary to prototype these approaches, many of the presentations seem to be claiming success without careful evaluation. I recommend examining more closely these "one size fits all" approaches in light of (at best) partial success in other large M&S programs such as the Joint Simulation System (JSIMS), Joint Warfare System (JWARS), and Joint Modeling and Simulation System (JMASS). I recommend that the NMSG:

- Develop measures of effectiveness to evaluate their value and investigate how one would collect the data for these measures;
- Examine whether the approaches presented are repeatable or reusable.
- Determine whether these frameworks have undergone the scrutiny of V&V and how this could be/has been done.
- For each of the suggested approaches for developing frameworks, examine what particular/specific problems they solve.
- Evaluate and publicize the successful approaches, conceptual models, and data sources/transformations that could actually ease the development of functional M&S.

4.3 VV&A and Risk Management

I recommend more extensive discussions of VV&A and risk management. For example, I do not believe that striving to reduce risk is always an advantage since this can reduce the ability to innovate – technology advances require risk. I also suggest that the NMSG investigate V&V frameworks and what the real problems are to be solved. There is a difference between developing technology and managing technology, and the risks need to be clear for both. I suggest the NMSG consider VV&A, and especially validation and testing, as topics for future workshops.

4.4 Cloud Technology, Virtualization, and Services

The applications of virtualization and cloud technologies to M&S are currently immature, but evolving. I perceive a “disconnect” in the presentations between what has really been accomplished and what is hoped to be accomplished. Too many of the cloud-related presentations were premature since they involved efforts that were mostly in the planning stages without concrete applications or results. I also recommend that the NMSG plan for determining the measures of success for these systems and to plan for how this information will be collected.

The NMSG could also work to leverage/standardize the nomenclature so that there would be less confusion between the concepts of “virtualization” and “the cloud” and “services.”

4.5 Other Acquisition Issues

I recommend that the NMSG solicit presentations on M&S used for acquisition decision support that define and involve direct attacks on the big problems in acquisition, as opposed to those that “nibble around the edges.” The NMSG could encourage efforts and presentations on some of the big issues in M&S such as human behavior modeling (HBR) – a vital part of the overall M&S suite of tools with important applications to the topics of this workshop. (Note that MSG-127 “Reference Architecture for Human Behaviour Modelling in Military Training Applications” is training focused). HBR could also be a theme in a future workshop.

4.6 Final Comments

The most provocative statement in the symposium was “training as you fight is not enough” in the presentation of Paper #16 *LVC Simulation for Land Operations Training*, by Hannay, et al. I suggest that the NMSG explore this issue in some depth to understand what additional factors are needed to train for improved decision making. Similarly, I also suggest that the NMSG carefully examine the conventional M&S lore that reuse of tools, reuse of data, and the use of common data are always good.

Thank you for the opportunity to interact with attendees at the workshop, to gain valuable knowledge, and to supply these comments.