Technical Evaluation Report – RTO-MP-MSG-069 Symposium on the Use of M&S in Support to Operations, Irregular Warfare, Defence Against Terrorism and Coalition Tactical Force Integration

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OVERVIEW

The NATO Modelling and Simulation Group (NMSG) Symposium (MSG-069) "Use of M&S in Support to Operations, Irregular Warfare, Defence against Terrorism, and Coalition Tactical Force Integration" was conducted in Brussels, Belgium on 15 & 16 October 2009. All sessions of the Symposium were unclassified. The Symposium audience included experts from NATO countries, Partners-for-Peace (PfP) nations, as well as invited nations.

Out of the submitted proposals, 20 papers were selected and submitted for presentation. In addition, one paper was an invited paper and three keynote presentations were given. The conference contributions were presented in the keynote session followed by seven topic sessions. This technical evaluation report summarizes the core ideas and results presented in this wide variety of valuable contributions from NATO countries, PfP nations, and invited nations by capturing the main ideas in the flow of the symposium and connecting related papers with each other. Furthermore, the report provides an overview of discussions conducted during the symposium following each presentation and gives recommendations.

1 INTRODUCTION

The importance of Modelling and Simulation (M&S) continues to grow and its impact on training, experimentation, and analysis in NATO and other nations is well recognised. Recent conferences focused on special development areas. For this year's conference, the committee decided against a single focus area but looked for papers across a number of emerging topically key themes that many nations were currently engaging in and would merit further discussion, such as:

- Support to Operations
- Human Behaviour Representation
- Irregular Warfare
- Defence Against Terrorism
- Coalition Tactical Force Integration

All of the above have and continue to benefit from advances in low cost, high power computers, graphics from the commercial and telecommunications markets, combined with advances in the military environment to enable better interoperability and reuse between simulations and the integration of command & control systems.

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14. ABSTRACT
The NATO Modelling and Simulation Group (NMSG) Symposium (MSG-069) Use of M&S in Support to Operations, Irregular Warfare, Defence against Terrorism, and Coalition Tactical Force Integration was conducted in Brussels, Belgium on 15 & 16 October 2009. All sessions of the Symposium were unclassified. The Symposium audience included experts from NATO countries, Partners-for-Peace (PfP) nations, as well as invited nations. Out of the submitted proposals, 20 papers were selected and submitted for presentation. In addition, one paper was an invited paper and three keynote presentations were given. The conference contributions were presented in the keynote session followed by seven topic sessions. This technical evaluation report summarizes the core ideas and results presented in this wide variety of valuable contributions from NATO countries, PfP nations, and invited nations by capturing the main ideas in the flow of the symposium and connecting related papers with each other. Furthermore, the report provides an overview of discussions conducted during the symposium following each presentation and gives recommendations.

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There have been many technical activities and successes within NATO and nations to improve interoperability and ensure effective reuse. From an Alliance perspective in particular the vision of Project Snow Leopard, in particular, to create a persistent distributed network for training and experimentation is a significant step towards this goal. Furthermore, the following MSG activities should be highlighted. The HLA STANAG 1516, the SEDRIS STANAG series, MSG-027 Pathfinder Integration Environment, MSG-048 Coalition-Battle Management Language (C-BML) MSG-053 Rapid Scenario Generation, and several more activities often summarized under the Pathfinder programme provided valuable contributions.

With NATO engaged in long term operations ACT mission is focussed on both the short term and long term benefits to the warfighter. This increases the need to look for improved representation and rapid insertion of technology into training systems and interoperability. This conference focused on papers that highlight or demonstrate where technology is pushing the boundaries and making a difference in those key areas. In addition, the themes of research, development, and the application/adaptation of models and simulation in the defence and commercial environments were addressed.

The Research and Technology Organization (RTO) of NATO is coping with related topics in other panels as well. The recent events and developments have resulted in a radical change of tasks that the armed forces have to fulfil. These new tasks focus not so much on attrition, movement, and warfighting operations, but on reconstruction, crisis prevention, police tasks, and many other efforts that are conducted in collaboration with or in support of civil agencies and organizations. Challenges of these changing tasks require a new view on M&S support as well, as a “whole of society” approach is needed, focusing on human, social, cultural, and behavioural modelling. For a “whole world” approach that is no longer dominated by technical defence questions but includes all aspects of *Human, Social, Cultural, and Behavioural (HSCB)* models and methods, a close collaboration of all panels is needed, in particular between MSG, the Systems, Analyses and Studies (SAS) and Human Factors and Medicine (HFM) panels. Also, the results and findings need to be integrated with command and control systems, so alignment with the Information Systems and Technology (IST) panel is needed.

The papers and presentations highlighted various aspects of the resulting challenges. The evaluations summarized in this report focus on the presented and discussed aspects. The interested reader is referred to the papers for details. The topics “human behaviour representation” and “defence against terrorism” were presented in two topic sessions each during the symposium; however, they are comprised in one section for this report each.

2 KEYNOTE PRESENTATIONS

The conference started with two host nation keynote presentations, both focusing on the use of M&S in the Belgian Armed Forces.

- Regis Benoit presented the TTF Navy Simulator and its use to train Belgian and Dutch members of the Armed Forces at the Mine Warfare School. With the introduction of new technologies and systems, like, e.g., the mine hunter system “Seafox”, new simulation for training and education became necessary as well. The development of the new Mine Warfare Training Centre offered the opportunity to apply several of the recommended solutions from earlier NMSG activities. For example, the same software used in the operational systems is used in the centre as well, so that interoperability of training system and operational systems is designed into the solution from the beginning. Also, instead of expensive central server solutions the centre uses distributed clustered solutions running on commercially available computers providing a powerful and adaptive infrastructure. Furthermore, requirements for a build-in scenario tool reducing the time to prepare a new training scenario from weeks down to hours were fulfilled, even allowing users to change scenario elements during execution without having to reset all participating systems. Another feature

recommended during presentations in earlier MSG conferences is the identification of common components that build the structure for reusable simulation support, such as a common environment simulator, damage simulation, communications simulation, providing of 3D pictures for virtual cameras, etc.

- Major Thierry Vanden Dries presented the Belgian Land Component Simulation Program. Within the Belgian Armed Forces, the focus shifted from services towards capabilities, which is reflected by the use of the term Land Component instead of Army. The focus of current developments is on the development of a driving simulator (clear go), a tactical simulator (making progress), and a dual purpose simulator (in its infancy). A major constraint for the Armed Forces is that new systems were needed for the new military tasks, but no additional money was available for extra systems to be used for training and education. New systems, like the Dingo, were immediately used for operations, so that simulation alone could be used to train soldiers at home. New requirements to keep the education of soldiers on a higher level, like having a certain amount of annual driving hours to be eligible to operate certain systems in operations, also require the use of simulation. Although currently legacy systems and their simulations are still used, better adaption is needed. The new simulation nucleus will focus on common equipment and capabilities that can be extended and enhanced by additional modules.

Both host nation keynote presentations emphasized the intensive use of M&S within the Armed Forces of Belgium and the use of new technologies as identified in the introduction.

The third keynote presentation was given by Admiral (RADM) Christian Canova, Deputy Assistant Chief of Staff Future Capabilities, Research and Technology, Allied Command for Transformation (ACT). The focus of this keynote was the use of M&S within NATO in general and within ACT in particular. ACT is the leading agent for change, identifying gaps or areas of improvement, but it is not the force agent of change. As such, ACT's role is to define new requirements and provide first solution idea. M&S is integrated into these tasks. The ACT vision on M&S summarizing these ideas was officially approved in 2008. A close collaboration of ACT and the United States Joint Forces Command (JFCOM) has been identified as a major key to success. M&S is integrated into the procedures of ACT. It is one of the main decision aids used today. ACT is looking at MSG in support of providing solutions for the identified requirements.

Remark: Papers 4, 12, and 14 were withdrawn and are not part of the report.

3 INVITED PRESENTATION

MP-MSG-069-01 *Collaboration and Synergy among Government, Industry and Academia in the M&S Domain: Turkey´s Experience* by Isler V. and Aydemir H. (TUR)

The invited paper presented a systemic approach to M&S by the Turkish Armed Forces and the Under-Secretariat for Defence Industries and the roles the academia and local industries play within this approach. Turkey summarized its vision in a master plan. The master plan envisions common components shared between users on the tactical level, interoperable solutions on the operational level, and aligned solutions on the strategic level. The respective projects are showing the feasibility of such ideas, ranking form technical evaluations to work on conceptual models to identify and bridge the gaps between different viewpoints, such as operational command and control and required featured in training and analysis. The projects utilize the findings and recommendations of several MSG task groups, including ideas derived from rapid scenario generation, support to operations, and more.

The role of academia is research, education and dissemination of information. As part of the education, the Informatics Institute offers a Master of Science in Modelling and Simulation. Academia is also often asked for independent consulting and providing of unbiased evaluation of technical maturity and

appropriateness of proposed or recommended solutions as well as for first feasibility studies and proofs of conceptual new ideas.

The role of industry is to provide the professional workforce and deliver the products. Using national conferences, the local industry could well identify their needs and start building competitive capability in M&S. Industry is in collaboration with academia while working on R&D projects.

The systemic approach using national conference to orchestrate academic and industrial R&D addressing the warfighters needs was proven to be successful in Turkey.

4 HUMAN BEHAVIOR REPRESENTATION

MP-MSG-069-02 *Comparative Analysis of Computer Generated Forces' Artificial Intelligence* by Abdellaoui N. (CAN)

The objective of the presented study was the development of better computer generated forces (CGF), particularly for training applications. CGF's are mainly used to drive the behaviour of simulated forces in a realistic and situation-adequate manner. In lieu of good CGFs, human experts have to provide the input. To reduce the amount of subject matter experts (SME) needed to conduct an exercise, better CGFs are needed. Artificial Intelligence (AI) provides tools to support this objective.

The presentation demonstrated how to set up scenarios to compare AI enhanced CGFs based on established requirements. To allow subjective assessment allowing variation of coverage, four degrees of compliance were defined. The paper shows that this does not only allow the comparison of an available solution alternative, it can also be applied to identify capability deficiencies common to currently-available products. The approach was applied to compare Government Off-The-Shelf (GOTS) and Commercial Off-The-Shelf (COTS) simulation products as well as some serious games.

There are still significant gaps to be closed, particularly in the domains of learning and self-organization. Also, reusability of AI methods across several alternatives is still an issue, as many solutions are still hard-coded into proprietary solutions.

MP-MSG-069-03 *Light and Human Vision Based Simulation Technology* by Delacour J., Fournier L. and Prados T. (FRA)

To make the case for more realistic simulation of visual effects influencing perception, as this is a driving factor for decision making of the trainees, this paper introduces the requirement to simulate the human vision as well as enabling light models. The objective was to drive the expected behaviour of trainees. Enablers were physics-based models of light, reflection, projection, etc. The results were not yet to be applied to agents or CGF, but used to produce a more realistic synthetic environment for trainees, e.g., by introducing glare effects, diffusion of light, etc, to the simulation display system. The underlying physics allows to model natural lighting as well as artificial lighting (interior and exterior). Adding a model of the human vision allows taking additional factors realistically into account, such as colour perception and luminance detection variations depending on the age of the observer (visual acuity).

The presented examples show that the desired effects could be achieved. In addition to providing more realistic training, it allows both ergonomists and designers to improve the conditions of global visibility by day and by night taking into account the user's age, artificial support by additional lights, etc.

MP-MSG-069-05 *Human Character Representation for Military Operations in Urban Terrain – The Middleware Approach* by Kamp D., Starmer B. (GBR) and Pujol O. (FRA)

Military operations in urban terrain are not new, but the focus of training on urban warfare in the scope of new military operations has changed. The request for more detailed representation of environments, buildings, interior, etc., as well as the representation of military and non-military characters exposing realistic and situation adequate behaviour needed to be satisfied. The high resolution posed two big challenges: better correlation of environment and object representation in simulators and alternatives to the scripted paradigm to control CGFs.

Commercial solutions provide a good basis for correlation. The presentation emphasized the need to publish to the best available format. Publishing in this context means to support all data and metadata required by the most demanding model using this format.

The recommended approach using middleware given in the presentation combined two aspects: sharing perception based on a common representation and sharing higher-level orders that are broken down by AI methods into actionable items within the CGF. This middleware approach has been applied in government, military, and gaming domains. It should be a subject of further research to evaluate to what degree this solution may provide some answers to the challenges identified in paper MP-MSG-069-02. Another positive aspect of the recommended middleware approach is that the raw source data used for perception sharing is identical to the data shared between operational systems as well. This facilitates later integration.

MP-MSG-069-06 *Engaging with Complexity – Human Behaviour Representation* by Dack L., Sanderson J., Allen J., Schranz N. and Beautement P. (GBR)

The presentation was rooted in two projects conducted within the UK: Decision Support in Complex Environments (DSCE) and the Hybrid Conflict Context Model (HCCM). Both were conducted by Niteworks, which is staffed by employees from MOD and its' Industry Partners and Associates, a group of some 50 companies including most of the major UK defence providers as well as small and medium enterprises, research establishments, and major consulting companies. As such, Niteworks is an approach similar to the aligned collaboration presented in paper MP-MSG-069-01.

DSCE copes with the question regarding which techniques, tools, and resources does a modular brigade HQ require in order to enhance its understanding of an increasingly complex operating environment (COE) in order to support the decision maker's planning function? The approach taken by Niteworks is to apply a 'landscape' of complex environments to identify the issue, a capability review that identifies potential solutions, and the HCCM that provides a high-level visualisation of possible outcomes, all described in more detail in the paper.

The HCCM combines the fields of human sciences, military doctrine, and plain common sense to provide the basis for actors – representable as agents – and places them in an environment of physical, political, and human geography allowing them to act based on the cognitive dimension (human behaviour), organisational dimension (interaction between actors), and geographical dimension (operational environment). The model has been implemented using system dynamics.

This model was not design to produce good answers but helps decision makers ask good questions and evaluate underlying assumptions. This may be a new way to apply models. Current research focuses on academic underpinnings as well as better user interfaces.

MP-MSG-069-07 *Data Farming in Support of Military Decision Makers* by Horne G., Sanchez S. (USA), Seichter S., Nitsch D. and Haymann K. (DEU)

While data mining is looking for valuable data required by decision makers, data farming produces such valuable data sets based on M&S and evaluations. Data farming is an iterative process that uses many simulation runs to first debug the model and its implementation sufficiently and then produce data sets to be used to answer customers' challenges. The data farming activities around Project Albert, originally designed for the US Marine Corps, and now internationally applied and discussed in workshops, is a good example.

Currently, there are insufficient models as well as data in the domain of Political, Military, Economic, Social, Information, and Infrastructure (PMESII) and Diplomatic, Information Operations, Military, or Economic (DIME). However, data farming can help to identify bifurcation points in decision parts, tipping points of effects, and other tendencies relevant to the warfighter.

The Simulation Experiments and Efficient Designs (SEED) Center for Data Farming at the Naval Postgraduate School (NPS) in Monterey, California, has been established to cope in detail with underlying questions.

The German Federal Armed Forces Transformation Center currently supports two models that are also designed in support of data farming efforts: the model PAX for peace support operations is an agent-based model used for analysis; the model ABSEM is an agent-based sensor-effecter-modelling to evaluate complex technical systems with a detail physical approach. Both models use methods aligned with the SEED recommendations and methods.

MP-MSG-069-08 *Transitioning Human, Social, Cultural Behaviour (HSCB) Models & Simulations to the Operational User* by Starr S. and Baranick M. (USA)

The R&D community has developed many good tools that have never made it into the hands of operational users. The presentation emphasises how to transition tools dealing with human, social, cultural, and behavioural (HSCB) challenges to the operational user. It summarizes the results and findings of two workshops conducted at the National Defense University (NDU) in Washington, DC. In this workshops, HSCB modelling needs were classified into three expert groups and twelve interrelated categories. The driver for the needs arises from the representative questions from operational users and senior decision makers (first expert group). For this group, four key categories were identified: data, VV&A, education and training, and outreach. Four categories are of particular concern to the social sciences experts (second group): definitions, basic research, Measures of Merit, and theories. Operations analysts (third group) identified the following four topical domains: tools, representation in tools, explorations of "possibility space", and design of experiments. In order to align these different approaches and schools, communities of interest and communities of practice are needed, as supported by SAS activities. Several related activities are enumerated in Section 11 - Summary and Recommendations. As key steps, the experts that meet in SAS and NDU – and also in parallel workshops conducted by the Military Operations Research Society (MORS) – workshops identified the following:

- Develop a lexicon to enhance multidisciplinary communication;
- Sustain a Community of Interest/Community of Practice;
- Evolve a methodology that can be employed by operational users;
- Evolve an HSCB data repository;
- Enhance the education and training of all stakeholders;

- Refine HSCB requirements;
- Employ an evolutionary acquisition process to develop an operational testbed.

A close collaboration of experts of all relevant domains is needed to address these challenges efficiently and avoid stove-piped community specific solutions. MSG must play an active role in these efforts.

5 SUPPORT TO OPERATIONS

MP-MSG-069-09 *Serious Gaming Contribution to Concept Development and Experimentation within the French Battlelab* by Cantot P. and Martinet J. (FRA)

The French Battlelab supports analysis studies on the capability and system-of-systems (SoS) level. It supports the iterative process of starting by first doing an analysis of concepts, then applying M&S to evaluate the system in the context of SoS, then by doing experimentation with prototypes, and finally testing the prototypes before they are introduced.

The PHOENIX 2008 experiments are used as an example for the use of the Battlelab. The objective of the experiment was to evaluate new tool sets and their net enabling capability. The question to be answered was how to support the Army-Unit Commander in the future using networks, sensors, and better fire support. A mixed team of procurement, industry, and French army experts conducted the iterative steps described before.

One question dealt within the paper was how to use “serious games” in this chain of processes. In the experiment, the tool VBS2 was used to support scenario generation, mission rehearsal, producing virtual videos during execution, and to conduct after action reviews. Overall, the results were promising, but several of the shortcomings identified in recent NATO M&S conferences are still valid, particularly the validation and verification of doctrine and behaviour as it is represented in the underlying game.

MP-MSG-069-10 *Socio-Technical Systems Models of the Information Chain in Unmanned Vehicle Operations* by Baber C. and Houghton R. (GBR)

The work presented here was motivated by an HFM technical activity dealing with human integration into the net-centric environment. It uses calculus as proposed by Miller and Shanahan (see [2] in MP-MSG-069-10). The approach allows formulating event chains as motivated in traditional command and control views and deriving logically equivalent events that are alternatives to the original plan. Using these taxonomical structures allows users to pull or push information in blackboard style from and to the network, making the approach net-enabled. Furthermore, the notion of dynamic use cases then can be used to evaluate resiliency and redundancy of solutions.

Another application is to identify the best points from supporting decision makers with decision support tools, although this was only covered in the oral part of the presentation. Nonetheless, these methods may be very valuable for analysing plans provided by applications described in MP-MSG-069-11 or even the ongoing efforts on Coalition Battle Management Language (MSG-048).

MP-MSG-069-11 *Modelling a Simulation-Based Decision Support System for Effects-Based Planning* by Moradi F. and Schubert J. (SWE)

Sweden is currently supporting an effort to develop an integrated M&S-based Decision Support Systems supporting effect-based planning. The presented approach proposes three categories to cope with the resulting challenges: the decision support challenges, the modelling challenges, and the simulation challenges. The study uses the definition of JFCOM for effect-based operations.

The decision support challenge can be summarized by the task to support building an operational plan, defining a user-friendly and understandable input and output interface, and identifying indicators for the decision maker. In the modelling challenge category it is necessary to identify applicable and sufficient models for the plan, activities/actions/events, actors, environment, and the scenario. The simulation challenge is to implement these models and provide effective means to provide a decision maker with a good decision when required. In particular, the study recommends the use of an A*-search algorithm for recommended solutions.

It may be worth evaluating the recommended modelling approach for operational plans, activities, actions, events, actors and their capabilities is of interest for integration with operational C2 systems as well their contribution to efforts regarding the Coalition Battle Management Language (MSG-048), as the approach emphasises the simulation view instead of being derived from operational constraints.

The system is still in its infancy. During the discussion, the point was made that similar approaches – although based on expert systems – were conducted earlier without success. New technologies like agent-directed simulation and improved understanding of data (such as data engineering, data farming, and data mining) may support this new approach sufficiently to make it a success.

6 DEFENSE AGAINST TERRORISM

MP-MSG-069-13 *Similarity Search in a Large Collection of Biometric Data* by Zezula P., Batko M., Dohnal V., Novak D. and Sedmidubsky J. (CZE)

The topic of this presentation was presented and awarded in several conferences and is even featured in a recent book. The underlying thesis is that M&S maps well to the challenges of complexity and systems. The research is mainly applicable but not limited to data engineering and management aspects, the Multi-Feature Indexing Networks (MUFIN) that are extensible, scalable, and infrastructure independent. The driving idea is to understand data as points in a metric space and similarity that can be defined by distance measures. As various models use various metrics, the second pillar is the definition of similarities of metrics, captured in the Metric Similarity Search Implementation Framework (MESSIF).

The method has been implemented and applied for image search, browsing the database of the online-image-sharing system “Flickr” with more than 100 million images and presented live during the presentation. It should be mentioned that the search is driven by data and similarity metrics in a metric space, therefore the method is directly applicable to evaluate farmed data as described in MP-MSG-069-07 and related applications.

MP-MSG-069-15 *Predicting the Structure of Covert Networks using Genetic Programming, Cognitive Work Analysis and Social Network Analysis* by Baber C., Stanton N. and Houghton R. (GBR)

The objective of the presented project is to build prospective social networks on the basis of plausible task models using a process involving compiling intelligence, building task models, exploring alternative network structures, and comparing and analysing social networks. The underlying method uses assumptions-based planning. Using the taxonomical structures of assumptions-based planning, genetic programming can be applied to “breed” new possible social networks and derive new communication structures that should be observed in such networks.

The application for defence against terrorism is to combine assumed networks and observed behaviour in a common model. The assumed networks can use initial seeds to breed new networks. The intelligence reports are used to report observed behaviour that can be clustered with predicted behaviour of new networks.

MP-MSG-069-16 *Serious Games for Training and Education on Defence Against Terrorism* by Bruzzone A., Tremori A. and Massei M. (ITA)

The presentation introduces serious gaming as logical evolutionary step in the process of using simulations for training and experimentation. In order to fulfil its promises, emphasis on graphics and representation is not sufficient. The human component needs to be fed by realistic serious human behaviour models as well. The detail and emphasis of these models must be appropriate for the serious game to be an improvement.

The paper documents a reusable model approach for serious games called Polyfunctional Intelligent Operational Virtual Reality Agents (PIOVRA). It was applied in support of role playing supporting games and demonstrated in the multinational effort Simulation of an Intelligence Board for Interactive Learning and Lofty Achievements (SIBILLA). The game SIBILLA was applied to educate users regarding critical infrastructures and the need to collaboratively share data in teams. The players get information on planned terrorists' activities. If they share the data they can avoid the attacks. The budget of each agency is increased with success. The architecture supported by SIBILLA is open and scalable, allowing multi-user level in locally distributed environments. The game SIBILLA was successfully applied in international experiments. The technical details were also presented during the recent Summer Multi-Simulation Conference 2009, Istanbul, Turkey.

MP-MSG-069-17 *Modelling of Conflict Controlled Networks* by Ignatenko O. (UKR)

This presentation was the first presentation given in Ukraine during an MSG conference. The topic of the presentation is cyber attacks on the Internet, emphasising denial of services attacks. In general, a denial of service attack is any attack which makes an online service unavailable. To cope with this issue from an M&S perspective, the Internet can be modelled as a controlled system using network models. The real physical networks are normally very complex. However, for the purposes of control design it is normally possible to construct models of reduced complexity. Such simplified networks can be used to derive effective control solutions for the physical system of interest. They also serve to enhance intuition regarding network behaviour.

The demonstrated model OMNeT++ is an object-oriented modular discrete event network simulation framework. It has a generic architecture allowing modelling of wired and wireless communication networks, protocol modelling, modelling of queuing networks, modelling of multiprocessors and other distributed hardware systems, and validating of hardware architectures. The simulator was so far mainly applied to validate the approach, but can be scaled for real network developments.

MP-MSG-069-18 *Streamlining Simulation Development Using a Commercial Game Engine* by Myers S. (USA)

The paper and presentation provided an overview on how developments in computer technology, sensor technology, and gaming grow together from the viewpoint of the featured product: Checkpoint Recon. This game is a rules of engagement trainer and is a single person system for classroom education. The underlying game engine provided the necessary plug-ins for realistic movement and behaviour for the identified scenarios.

The paper makes contributions regarding "lessons learned" on how to set up a serious game derived from warfighters' requirements and training needs. The ideas and application experiences were also presented during recent I/ITSEC events referenced in the paper.

7 COALITION TACTICAL FORCE INTEGRATION

MP-MSG-069-19 *Architecture for a Distributed Integrated Testbed* by Neugebauer E., Nitsch D. and Henne O. (DEU)

This contribution presented the current German efforts to set up a common distributed integrated testbed. Several efforts of industry partners are orchestrated by the Federal Office of Defence Technology and Procurement, giving another example of successful orchestrated alignment of activities as recommended in the invited presentation.

The distributed integrated test bed system demonstrator "VIntEL" will comprise live, virtual and constructive simulations and real systems. As in many other NATO nations, the major use of simulation systems is still training. The objective of the described effort in Germany is to broaden the application and, in particular, to support the fast and effective evaluation of technical solutions. It shall provide a realistic and operational test environment for the development and acquisition of material and equipment including providing a net-centric environment. To this end, three fields are aligned to support a cohesive approach: common architecture concepts using a common reference architecture, application of data farming tools allowing the effective evaluation of solution parameters, and common control and orchestration of the leading agency ensuring verification and validation, common workflows, etc.

The common reference architecture specifies a bus-oriented net-centric communication structure supporting HLA connectivity for simulation systems, effective data distribution for data intensive applications – such as exchange of maps or bulks of data –, and access to common general services, such as common terrain, weather, communications, etc. The three categories of systems that connect to this triple bus structure are simulation systems, real operational systems, and service providing systems. The triple bus structure supports a practical view of information exchange between the systems: each system can be connected to several buses fulfilling various needs, e.g., using the data bus for initialization data, using the service bus to get access to the common services, and using the HLA bus to access the RTI for information exchange within the federation. First implementations were successfully demonstrated.

Of particular interest is the "fair fight" challenge in the testbed. The use of common services has been proven to be necessary, but not sufficient to solve the problem. From a user's perspective, reliability of results is as important as reproducibility of experiments and reusability of components.

This approach combines several of the ideas presented during this and earlier workshops and benefitted from recommendations from MSG task groups, such as scenario generation (MSG-018 and MSG-053), integration environments (MSG-027), verification and validation (MSG-019), reusability (MSG-042), and more.

MP-MSG-069-20 *Virtual Ships: NATO Standards Development and Implementation* by Duncan J. and Henry G. (GBR), De Kraker J. (NLD), McTaggart K. (CAN) and Reading R. (USA)

The NATO Naval Armaments Group Sub-group 61 (SG 61) on Virtual Ships applies M&S on a large scale. The NATO Submarine Rescue System (NSRS) is a jointly funded project by France, Norway, and the United Kingdom. One of the main challenges is the rigorous definition of hardware interfaces to be provided by all partners to allow that NSRS can actually by applied to all submarines to be rescued as well as all vessels that support the operations. The design of these interfaces needs to be assessed as early as possible to discover design and safety flaws. This can be supported by the use of M&S.

Applying a general purpose standard like IEEE1516 does not provide the necessary guidance to allow for seamless integration as desired in the SG 61 context. Within SG 61, a repository was envisioned that not only comprises reusable components, but these components should provide standard interfaces directly

supporting the SG 61 vision. The underlying idea is using the IEEE1516 High Level Architecture and extending the Simulation Interoperability Standards Organization (SISO) standardised Real-time Platform Reference Federation Object Model (RPR-FOM) into the Virtual Ship Reference Federation Object Model (VSR-FOM). The paper comprises descriptions of three simulation projects that used these extensions successfully in support of SG 61.

The presentation concluded with the observation that the goal of rapidly creating simulations of complex ship systems from reusable components can be achieved by mandating a standard data exchange mechanism and creating and maintaining a repository of components that respect that standard. The Virtual Ship STANAG and associated repository will be able to realise this goal. For physics-based simulations that share common physical standardized interfaces as well, this standards-driven approach is possible and was proven to be successful.

MP-MSG-069-21 *Multi-Platform Operations in the Underwater Warfare Testbed (UWT)* by Keus D., Benders F., Grootendorst H. and Fitski H. (NLD)

This presentation demonstrated – similar to the approach presented in MP-MSG-069-19, but on a different scale and for another application domain – the advantages of using a common modifiable and composable infrastructure. The underwater warfare testbed uses the same architecture for all active entities of the simulation, such as submarines, torpedoes, diver devices, etc. The components are used for the same capability, which allows using the same solution multiple times and ensuring consistency in case of changes.

Modelled activities are torpedo defence (supporting procurement and deployment), anti submarine warfare (underwater detection), multi-static operations – which combines active and passive sonar components (procurement and deployment), and mine warfare (hunting and sweeping effectiveness and operations).

Several applications were demonstrated showing the broad applicability of the proposed approach. The tool was adapted to warfighter needs by developing a user friendly scenario editor (with less degree of freedom than the research prototype exposed).

MP-MSG-069-22 *Supporting Coalition Battle Management Language Experiments with Scripted Web Services* by Pullen M. (USA) and Heffner K. (CAN)

The activities of MSG-048, which is nearing completion at the end of 2009, were presented during several MSG symposia as well as on other conferences, such as the Simulation Interoperability Workshop of SISO, the Symposia on Distributed Simulation and Real-Time Applications (DS-RT), and more, showing the broad interest of various communities in this topic.

The update presented in this paper emphasizes the scripted web service application, which connects two of the three conceptual layers of Coalition-Battle Management Language concepts. The lowest level is the systems representation, which is JC3IEDM based and uses transactionals of the NATO data model as its atomic components. The middle layer is the language defined by the BML grammar. The highest level is doctrine represented by the language. The approach described here is “mediating” between the representation and the language using scripts.

The web services is driven by scripts based on the Command and Control Language Grammar (C2LG) as presented to MSG before (2007 Conference MP-MSG-060-07). The script defines implementation of consistently exchangeable business objects, also defined as transactionals in related publications (constituents of the higher-level BML grammar), over the JC3IEDM data model. The presentation gave several examples on how the scripts work and showed how it supported the recent MSG-048 demonstrations.

8 IRREGULAR WARFARE

MP-MSG-069-23 *Using Agent Based Distillation to Explore Issues Related to Asymmetric Warfare* by Adelantado M. and Mathé J-M. (FRA)

This paper is an example on how to use agent-based modelling on the technical level to help understand issues related to asymmetric warfare. To this end, the commonly available definitions of asymmetric warfare are used to build a model using the NetLogo software to exemplify the applicability.

The agent-based simulation paradigm has been recognized as a powerful tool helping to introduce findings from the social sciences. The Synthetic Environments for Analysis and Simulation (SEAS) system was used as an example what degree of analysis is already supportable by agent-directed simulation.

In contrast to traditional simulation systems, agent-based systems should be used to gain insight into the systems behaviour using agent-based distillations. These are defined as agent-based simulations that attempt to model scenarios by implementing a small set of rules that allow agents to adapt within each scenario. The main insight is not a single recommendation for one course of action, but a broader understanding how agents do adapt in certain scenarios. This maps well with observations captured in MP-MSG-069-06.

MP-MSG-069-24 *Asymmetric Warfare in the Simulated Training Environment: Comprehensive Approach Wanted!* by Necas P., Liska M., Harakal M. and Andrassy V. (SVK)

This presentation summarizes the viewpoint of the presenter and his co-authors on where NATO can and should go regarding training for asymmetric warfare. Urban terrain prevails in this context and should be evaluate at least regarding its physical, functional, and social structures. This human terrain is also defined by urban networks, including transport, communication, and utilities. The most challenging part, however, remains the social subsystem. As addressed also in MP-MSG-069-06 and MP-MSG-069-08, current M&S support of these topics is still in its infancy.

On the other hand side, the urban warfare is a complex environment characterized by unfriendly non-combatants, a high operational tempo and a short decision process, potentially high casualty rates, and other challenges requiring improved training of NATO personnel before being exposed to such an environment. The authors proposed a Comprehensive Integrated Simulation and Training System to effectively support NATO with Live, Virtual, and Constructive simulation components that are federated to support mission planning, training, and rehearsal. The integration of sensors, communications, and operational command and control systems is mandatory for success.

9 SUMMARY AND RECOMMENDATIONS

This section presents the major trends as observed by the technical evaluator in the papers as well as in the discussions following the presentations and the sessions. Each paragraph summarizes a main trend and gives a recommendation on how NATO, in general, and the NMSG, in particular, should act regarding the results of the technical evaluation.

- A topic that was mentioned in various papers is the alignment of efforts by government agencies or technical leaders of consortia. While until recently such efforts were often characterized by mandating common technical standards, such as using the IEEE1516 HLA or focusing on a common Federation Object Model, the new approaches apply increasingly common reference solutions with well defined management procedures. This effort allows reuse as well as diversity of solutions. The management efforts described in paper MP-MSG-069-01 and the common reference architecture described in MP-MSG-069-19 should be mentioned in particular.

- Collaboration and alignment of efforts was also recognized for NATO efforts across panel borders. Paper MP-MSG-069-08 presented the findings on NATO System, Analysis and Studies (SAS) activities on defining challenges to be solved regarding IW. However, as recognized in the context of an international expert panel conducted under the umbrella of the Society for Modelling and Simulation (SCS) earlier this year,[1] the mutual information about project is not sufficient. Common symposia and tutorials that inform the other audiences about the capabilities available in the panel are necessary. The current effort on "Human Modelling for Military Applications" (HFM RSY-202) is one such common symposium organized by the panel on Human Factors and Medicine (HFM) in collaboration with MSG and SAS. In order to systematically address the challenges of human, social, cultural, and behavioural (HSCB) modelling as well as IW, such events must be organized on a regular basis and cannot be one-time events.
  Another example for the need of more collaboration exceeding mutual information is the activities of the NATO Armaments Groups. While this MSG conference presented and demonstrated diverse national and NATO solutions in direct support of procurement and acquisition, the knowledge transfer of solutions from MSG expert to these groups as well as the requirement transfer from such groups to MSG experts is improvable.
- The use of common services and common components to represent comparable or the same concepts and processes in federations was another theme of the conference. The host nation keynotes both addressed this idea, and several papers followed. Of special interest is the rigor that is applied for defining a common information exchange model for the NATO Naval Armaments Group Sub-group 61 (SG 61) on Virtual Ships for two reasons:
  - For physics-based models, this approach is very promising, as the rigor of engineered solutions is transferred into the M&S domain. If mechanical interfaces between systems are as well defined as in the real world (literally defining nuts and bolts), interoperation is significantly easier to achieve than with non-application specific agreements.
  - For cognitive and social models, or even for tactical and operational models, it is doubtful that such definitions will be possible, as this would mean to standardize psychological and social theories or doctrine.
  - The Coalition Battle Management Language (MSG-048) effort faced similar challenges. The solution chosen here by the group is the definition and standardization of minimal exchangeable concepts as captured in the representation (so called transactionals) accompanied by the standardization of the combination rules.

  NATO task groups have to carefully evaluate in which category of possible standardization challenges their projects belong.
- Interoperability is not a cookie-cutter function. It has been defined in layers by many scientists and approaches, introducing layers of interoperation. Although several approaches exist, at least the following three layers have been observed in most of them:
  - The infrastructure layer that allows the distributed execution of simulation systems. Standards for networks and distributed computing are applicable on this layer. Also, the mixed use of various bus systems and their orchestration is dealt with here. In their analysis of an early version of the Levels of Conceptual Interoperability Model (LCIM[2]), Page and colleagues[3] refer to these

1 Tolk, A. (2009) Emerging Challenges for Human, Social, Cultural, and Behavioral Modeling," Proceedings of the Summer Computer Simulation Conference, July 13-16, Istanbul, Turkey

2 Tolk, A., Turnitsa, C.D., and Diallo, S.Y. (2008) Implied Ontological Representation within the Levels of Conceptual Interoperability Model," *International Journal of Intelligent Decision Technologies (IDT)* 2(1): 3-19

challenges as the realm of *integratability*. Integratability contends with the physical/ technical realms of connections between systems, which include hardware and firmware, protocols, networks, etc.

- The implementation layer addresses issues and challenges to achieve *interoperability* of simulation systems. Interoperability contends with the software- and implementation details of interoperations; this includes exchange of data elements via interfaces, the access of middleware, mapping to common information exchange models, etc. Most recent M&S standardization efforts focus on the implementation of simulation systems.
- What is needed in addition is a layer that addresses the challenges derived from the fact that model-based solutions use different conceptualizations. Each model is a purposeful abstraction from reality, so each viewpoint is slightly different. Only because models deal with the same domain doesn't insure that they use the same data, processes, and constraints. What interoperability does for simulation systems is achieved by *composability* for models. Therefore, composability contends with the alignment of issues on the modelling or abstraction level. In particular for net-centric systems it is essential that M&S services are not only technically interoperable, but that they are also conceptually aligned. This topic was already addressed in last year's conference (MP-MSG-069-TER) and needs further attention.

The NATO approaches to interoperability should use at least these categories to document standards, results, and recommendations. As the multitude of contributing nations and supported different national doctrines are likely leading to different conceptualization, capturing this composability questions is of high importance for NATO. As no other panel of RTO focuses with the same detail on model-based solutions supporting the warfighter, it should be the responsibility of MSG to address these issues and drive towards solutions.

- The use of agent-based methods was discussed in several contributions. Whether agent-based models are used to generate input for data farming efforts, or if they are used to produce reliable and situation adequate input using agent-in-the-loop instead of human-in-the-loop structures, or if they are in a new generation of simulation systems, agents have become an accepted paradigm in NATO M&S community.
  However, the use of agents is manifold and it may be worth to use categorizations as successfully applied in the academic community. Yilmaz[4] introduced the categories for "agent-directed simulation" system. Based on his characterization, agent-directed simulation consists of three distinct, yet related areas that can be grouped under two categories as follows:
  - Simulation for Agents involves the use of simulation modelling methodology and technologies to analyze, design, model, simulate, and test agent systems.
  - Agents for Simulation involves the use of agents in support of simulations, with two main sub-categories:
    (1) Agent-supported simulation dealing with the use of agents as a backend and/or frontend support facility to enable computer assistance in simulation-based problem solving;
    (2) Agent-based simulation focusing on the use of agents for the generation of model behaviour in a simulation study.
- Unfortunately, the rigor of academic definitions is not always applied in all NATO supporting R&D efforts, often leading to confusion and misunderstandings or even to misjudgement of the applicability

[3] Page, E.H., Briggs, R., and Tufarolo, J.A. (2004) Toward a family of maturity models for the simulation interconnection problem. Proceedings of the Spring Simulation Interoperability Workshop, IEEE CS Press, Washington, D.C.

[4] Yilmaz L., and Oren, T. (Editors): Agent-directed Simulation and Systems Engineering, Wiley 2009

of methods, tools, or paradigms. Several challenges identified in papers on the use of agent-based methods already have been covered in detail in academic conferences like conferences of the Military Operations Research Society (MORS), the Command and Control Research and Technology Symposia (CCRTS), the Winter Simulation Conferences (WSC) and the Spring and Summer Multi-Simulation Conferences of the Society for Modeling and Simulation (SCS). Often, solutions are already implemented by industry partners and presented during the Simulation Interoperability Standards Organization (SISO) Simulation Interoperability Workshops.

The references used in the papers, however, show clearly that the cross-fertilization of MSG know-how with these organizations is still in its infancy and MSG experts being "at home" in more than one of these conference groups are the exception. This bears the danger of reinventing the wheel or come up with stove-piped or otherwise sub-optimal solutions. It may be of interest to the MSG to establish closer connections in form of observers or liaisons to these conferences.

- A significant number of papers addressed new application domains of M&S. While the focus of recent conferences was often training, the view has been broadened. In particular, this is also true for the application philosophy. Data farming views models no longer as a way to preserve and communicate knowledge or to evaluate several options to look for the best solutions; it understands M&S as a way to gain new knowledge in otherwise hardly understood areas. The statement, *"[t]his model is not design to produce good answers but helps the decision makers to ask good questions and evaluate underlying assumptions"* describes a new school of thought regarding the use of M&S. Oren did foresee this trend and introduced five forms of knowledge processing using M&S:[5]
    - Computational activity: generation of model behaviour to simulation-based problem solving environments (training, optimization, etc.)
    - Systemic activity: the application of system-theoretic approaches, including, but not limited to, data mapping and farming activities (input data, system states, and output data are correlated)
    - Model-based activity: construction of simulation-based computer-aided problem solving environments, including ontological mappings (axioms of data, processes, and constraints)
    - Knowledge generation activity: model-based experiential knowledge generation, integration into other knowledge generation activities (free combination of knowledge parts to generate new knowledge)
    - Knowledge processing activity: combination of modelling, model processing, and other knowledge processing engines to have advanced simulation environments (modelling of models, model bases, use of artificial intelligence to create models)

    The trend shown in this conference is therefore a necessary step towards a higher level of maturity – eventually even leading to a paradigm shift – regarding the use of M&S within NATO.

- Several papers also introduced mathematical background concepts for applications of M&S. The most explicit paper of this category was MP-MSG-069-13, but other papers identified the necessity for more rigorous and unambiguous theories as well. Similar ideas have been discussed in the context of net-centric M&S services as well.[6] The reason for this requirement is that in order to define a problem to be solved, identify applicable services, select the best services in the context of the current federation, compose these services to deliver the needed functionality, and finally to orchestrate their execution, all constraints and requirements must be provided in machine-understandable form.

[5] Oren, T. (2009) Modeling and Simulation: A Comprehensive and Integrative View. In Yilmaz & Oren: *Agent-directed Simulation and Systems Engineering*, Wiley 2009

[6] Yilmaz, L. 2004. On the Need for Contextualized Introspective Simulation Models to Improve Reuse and Composability of Defense Simulations. Journal of Defense Modeling and Simulation, 1(3). pp. 135-145

Machines – including intelligent software agents – understand logic, hence mathematical models are necessary. The approaches can be applied to capture interoperability and composability challenges as well.[7] The MSG may be interested to evaluate such mathematical models for interoperability and composability and their extension towards interoperability and composability maturity matrices further and work on Best Practices for practitioners, resulting in applicable tools and methods rooted in established academic foundations. For NATO, both of these aspects are necessary.

- The MSG may be interested to furthermore support a symposium on agent-directed simulation, as this paradigm is of interest for data farming and knowledge processing as well as for new approaches to combat modelling including Political, Military, Economic, Social, Information, and Infrastructure (PMESII) domains. Also, several models are free and can be used for NATO research, such as the agent-based model Pythagoras (V.1.10.5) that is accessible via the NPS website http://harvest.nps.edu. There are more facets to this topic than human behaviour modelling. It is worth evaluating if a lecture series will be effective in sponsoring for MSG, SAS, and HFM to create a common technical understanding and identify common areas of application interest.

In summary, the symposium gave an excellent overview on how much the NATO M&S Community has evolved in the recent years and what new trends are starting to emerge. All presenting nations and organisations are clearly in a stage of mature M&S application and are applying sound engineering principles including the sharing of solutions based on open standards and open architectures and starting to work towards mathematically sound models. New application paradigms, spearheaded by the data farming community, are expanding the use of M&S from simple computing to knowledge processing. In order to cope with the challenges of new application domains, in particular human, social, cultural, and behavioural modelling tasks for IW and Defence against Terrorism, a close collaboration with experts from human and social sciences is needed.[8] The necessity for education in enabling methods and the alignment with experts of other NATO RTO panels has been realized.

Using M&S in Support to Operations, Irregular Warfare, Defence against Terrorism and Coalition Tactical Force Integration is a complex endeavour, but the papers presented in this conference are clear evidence that MSG experts are starting to work on solid foundations. What is needed is a clearer "landscape" of challenges that helps place the different solutions into a context that makes it easier to learn from each other and identify a common way forward. This, however, is not a task for the presenters but for the MSG, who is ultimately in charge of all technical activities and their results. Knowledge management and transfer, as currently evaluated by MSG-052 for Federation Architecture and Design, needs to be extended respectively and is more important than ever before.

[7] Tolk, A., Diallo, S.Y. and Turnitsa, C.D. (2008) Mathematical Models towards Self-Organizing Formal Federation Languages based on Conceptual Models of Information Exchange Capabilities, Proceedings of the Winter Simulation Conference, Miami, FL

[8] Davis, P.K. and Cragin, K. (2009) "Social Science for Counterterrorism - Putting the Pieces Together," RAND Report, Los Angeles, CA