Technical Evaluation Report

Dr. Andreas Tolk
Engineering Management and Systems Engineering
Old Dominion University
Norfolk, Virginia 23529
UNITED STATES

atolk@odu.edu

OVERVIEW

The NATO Modelling and Simulation Group (NMSG) Symposium (MSG-045) "Transforming Training and Experimentation through Modelling and Simulation" was conducted in Rome, Italy on 05 - 06 October 2006. All sessions of the Symposium were unclassified. The Symposium audience of approximately 100 persons included experts from NATO countries, Partners-for-Peace (PfP) nations, as well as invited nations.

Out of 39 abstracts submitted, 20 Papers were selected for presentation. In addition, two invited papers and two keynote presentations were given. 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 the discussions conducted during the symposium following each presentation and gives recommendations.

1   INTRODUCTION

The importance of Modelling and Simulation (M&S) and the effect it has had on transforming training and experimentation in NATO and national activities has been recognised for a number of years and is reflected in several symposium proceedings. Advances in low cost, high power computers, graphics and telecommunications/networking are some of the key technologies that have provided opportunities for extensive modelling and use of simulations in the live, virtual and constructive domains in new and exciting ways. Increasing collaboration with related NATO panels – such as Information System Technologies (IST) and Systems, Analysis and Studies (SAS) – and other related organisations – such as the Simulation Interoperability Standards Organization (SISO) and the Command and Control Research Programme (CCRP) – contributes to these advancements. As a result, M&S are today powerful tools that can assist in many ways towards the Allied Command for Transformation (ACT) mission and its commitment to the transformation of NATO's military capabilities. This symposium focused on papers that demonstrate how M&S has changed component command, joint training and doctrine development. Additional interest is the influence of M&S in research and technology, experimentation into Net Enabled Capabilities (NEC), effect based operations and interoperability for the effectiveness of NATO and the nations. In addition, the symposium addressed the themes of research, development and the application/adaptation of M&S in the defence and commercial environments. The Call for Papers explicitly requested papers addressing the following topics: the NATO Response Force, Military Exercising, Training and Decision Support, Network Centric Warfare, and Defence against Terrorism. In addition to these topics, the symposium also addressed the more general themes of research, development and M&S-related standards. Invited Papers dealt with the NATO Transformation process and implication for M&S, the NATO Joint Warfare Centre – and in particular their current and future applications of M&S, and paper from Australia regarding their use of M & S and the development of Commercial gaming technology and its impact in military applications.

2   KEYNOTE PRESENTATIONS

Two keynote presentations by high ranking officers were given during the presentation.

On the first day, RADM Lucio Accardo from the Italian Ministry of Defence welcomed the guests with an overview of the growing importance of M&S within the Italian Armed Forces. He focused in particular on the direct connection of M&S solutions to user requirements. Strong connections between military users and M&S engineers are therefore essentials in all application areas. At the same time, solid education is necessary to ensure that solutions can be reused and emerging technical solutions can be used efficiently. Italy is now using M&S support in all operational domains and technical areas.

On the second day, RADM Jean-Louis Kerignard, from NATO HQ Allied Command Transformation opened the session with a keynote emphasizing the role of M&S as a key enabler for reaching the goals of ACT's Training & Experimentation Transformation. He emphasized the growing importance of M&S for operational use, in particular the role of supporting operations. The role of MSG recommendations is essential in this regard, as only an orchestrated effort of the nations can help to reach this goal. Non aligned individual solutions are of insufficient use in NATO. Technically sound solutions enabling Networked Simulation & Learning Capabilities Supporting Education and Training are as necessary as the tight alignment with national efforts, among which the US Joint Forces Command is seen as the primus inter pares. Common challenges are to find enablers for a Live, Virtual and Constructive Joint synthetic capability, common scenarios, and better reuse of national contributions. In this context, he emphasized the importance of national capabilities in supporting NATO's efforts particularly on the Joint Multi-Resolution Model (JMRM)[1], the Networked Simulation & Learning Capabilities Supporting Education & Training (NETN), and the Simulated Mission and Rehearsal Training (SMART). RADM Kerignard explicitly mentioned the contribution of MSG Task Groups in form of experimentation and demonstration and emphasized that such contributions have an impact on ACT Budget and Programme of Work.

3   INVITED PRESENTATIONS

Two invited papers were presented in this session.

MP-MSG-045-01: Dr E Cayirci from the Joint Warfare Centre (JWC) in Stavanger, Norway, gave an overview on the components and objectives and tasks of organisations in NATO with relevance to Computer Assisted Exercises. Training remains the main component for which M&S is used, but other areas are of growing interest (as stated by RADM Kerignard). This objective is supported by the J3 Organisations: the Joint Warfare Centre (JWC) in Stavanger, Norway, the Joint Force Training Centre (JFTC) in Bydgoszcz, Poland, and the Joint Analyses and Lessons Learned Centre (JALLC) in Monsanto, Portugal. These centres enable NATO to supports in efforts in transformation, training and experimentation using modern M&S technologies and methods. The major constraint for effective training is that the training audience is distributed and uses the command and control systems they use in real operations as well. The M&S system of choice is currently the Joint Theatre Level Simulation (JTLS), as it has been for several years now. The use of a mature solution is that a working infrastructure in support of JTLS has been established in form of scenario generation solutions for JTLS, the JTLS ICC Mediation-ware (JIM) and other supporting tools. This solution is currently migrating towards the Joint Multi-Resolution Model (JMRM), which combines the high-resolution model JCATS with the high-aggregated model JTLS. Currently, scenario modules become more complex, as they have to support new events to be injected in an orchestrated way with the exercise flow and the training objectives. To this end, events and incidents must be captured and managed, which is done in an event and incident list. The current tool set still focuses on JTLS, but support of JCATS is in the scope. Figure 1 shows the target infrastructure.

---

[1] The first invited paper (paper MP-MSG-045-01) presents the ideas on JMRM and its use in NATO in more detail.
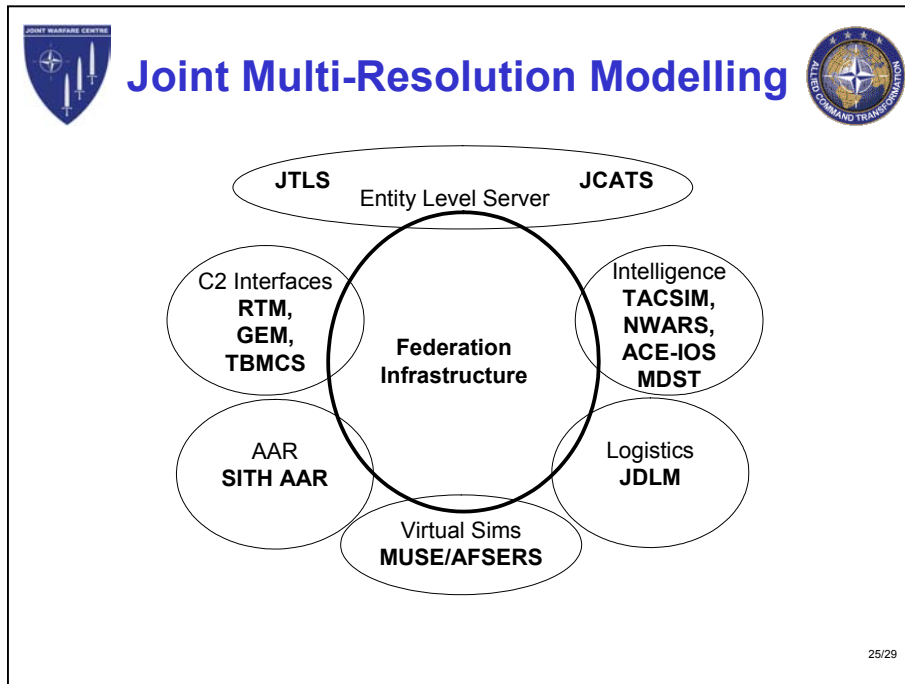
Figure 1: JWC JMRM Target Architecture

It should be pointed out that JMRM follows the ideas (presented by MITRE in several papers) using the entity level services for the coupling, which means that the information exchange happens on entity level. Aggregation or disaggregation is task of the federate, currently limited to JTLS and JCATS. It is planned to support non-military partners as well, as long as the requirement is captured for the exercise to be supported. In the scope of this technical evaluation, JMRM for JWC can become a milestone on the way to truly international federations. Figure 1 can easily be extended into multinational federations when allowing other federates to joint the architecture. However, the use of open standards beyond the HLA is necessary to fulfil such a vision, e.g., the use of standard FOMs (such as the Realtime-Platform-Reference FOM) and tools that support multiple federates. The current standard development efforts of SISO, in particular the Coalition Battle Management Language (C-BML, see paper MP-MSG-045-13) and the Military Scenario Definition Language (MSDL), are candidates to enable the vision.

MP-MSG-045-02: In the second invited paper, Mr. Darren McFarlane gave an overview of recent events and developments in the M&S community of Australia. Currently Australia cooperates with NATO as a 'Contact Country' and enjoys a special relationship enabling their participation and collaboration in a number of technical activities and is deployed as an international partner for security operations in many places. The Australian Defence and Simulation Office (ADSO) has been established to coordinate and orchestrate the use of M&S in support of training and experimentation supporting these activities. Their work is captured in roadmaps. The Body of Knowledge is captured in a Defence Simulation Manual (Volume I has 16 parts and deals with Defence Simulation Management; Volume II comprises five parts on focuses on Defence Simulation Application). Studies on Return of Investments were conducted in support of showing the necessity of using M&S to transform training and experimentation. All services support M&S activities up to the joint level, where JTLS and JSAF are used to train the forces. The Canberra Based Simulation Centre, the Defence Synthetic Environment initiative and the Joint Combined Training Centre working tightly connected with the US JNTC. Australia aims to broaden their contributions and is already engaged in a number of NATO MSG activities and tasks in particular the exploitation of commercial games for military use. Main M&S challenges are seen in simulating cultural aspects, resource management, the coordination of forces, obtaining data and geography. In the scope of

the technical evaluation, Australia can be seen as an example of non-traditional partners of NATO, which become increasingly important. Australia is strongly connected with the US JFCOM – as also envisioned by RADM Kerignard in his keynote – Australia also has a chapter of SISO to deal with their national needs in orchestration with SISO recommendations and standardisation efforts.

4   TRANSFORMING EXPERIMENTATION - NATO & INTERNATIONAL INITIATIVES

Three papers were grouped into this track, which is logically accompanied with the following session focussing on the national counterparts of initiatives presented here.

MP-MSG-045-03: The first presentation in this session gave an overview on Rapid Prototyping during NATO Experimentation in Support of the CIMIC Integrated Capability Team. The Crisis Management Exercise supported by this team is currently NATO's only political military exercise, although additional exercises with similar objectives are dealt with as near-future option in paper MP-MSG-045-21. Within this team, which comprises 26 experimenters from NATO and the nations, M&S is mainly used to evaluate innovations, in particular to be used to do some sort of risk assessment, very similar to the use as proposed in NATO's Code of Best Practice for C2 Assessment. Instead of a using the traditional specification driven prototypes, this group uses prototype driven specifications. The power of this approach became obvious when the options for the Crisis Management Fusion Centre Model and Simulation were set up. While the initial idea was to use a fully orchestrated and harmonized process view, in which the processes within the Fusion Cell, Political Cell, Civil Cell and Military Cell are fully aligned for analyses, the simulation driven specification led to the definition of a loosely coupled set of cells which all remained independent in conducting their tasks. Based on these ideas, the cells used their own simulation based on executable architectures derived from DoDAF compliant structures. This allowed the analysis of information exchange needs as well as actually exchanged information. This structure was used in support of CIMIC Experiment Campaign Plan, which is one of ACT's first, coordinated, coherent, planned experiment series utilising M&S and which focused on information collaboration and information sharing. M&S was not only used in support of the exercise, but mainly in analysis of the necessary information exchange between CIMIC partners, i.e., between NATO and non nationally organized groups. It should be pointed out that the selected M&S support is using off-the-shelf solutions, in particular Extend^{TM}. This new approach to modelling was evaluated not only to be effective, but also to have the possibility of giving a greater quality and variety of information than one could get from the large, inflexible models that one sees in use in some other places. In the scope of the technical evaluation the usability of alternative simulation tools is the most important aspect of this paper. It should be read together with paper MP-MSG-045-21, in which the NATO-developed tool Gamma is used in a similar context. Both solutions have their value and should be seen complimentary, not excluding.

MP-MSG-045-04: The second presentation of this session focused on lessons learned from the Multinational Experiment (MNE 4) as seen from the US Joint Forces Command (USJFCOM) Joint Innovation & Experimentation Directorate (J9). The paper presents the technical approach used to create a sufficient M&S environment for MNE 4, how this development effort may be leveraged for the upcoming experiment MNE 5 and how this work can support the development and integration of joint, interagency and multinational capabilities to meet present and future operational needs. The group decided to use a hierarchical approach with well defined tasks for the participating systems in support of effect based operations targeting all elements of the Political Military Economic Societal Information Infrastructure (PMESII) domain. Simulations are used to show strength and weaknesses of partners, allies and opponents. The simulation systems Alliance (FRA), Joana (DEU) and Joint Semi-automated Forces (JSAF, USA) were coupled using HLA to produce a consistent simulated operation. Every simulation contributed in the area it was best to use for, and all nations could use their simulation system to evaluate their ideas in the international context. This is very close to the NMSG Pathfinder vision. Additionally to

setting up the federation, C2 interfaces to produce the common operational pictures (COPs) needed by the training audience needed to be set up. Figure 2 shows the hierarchy of COPs.
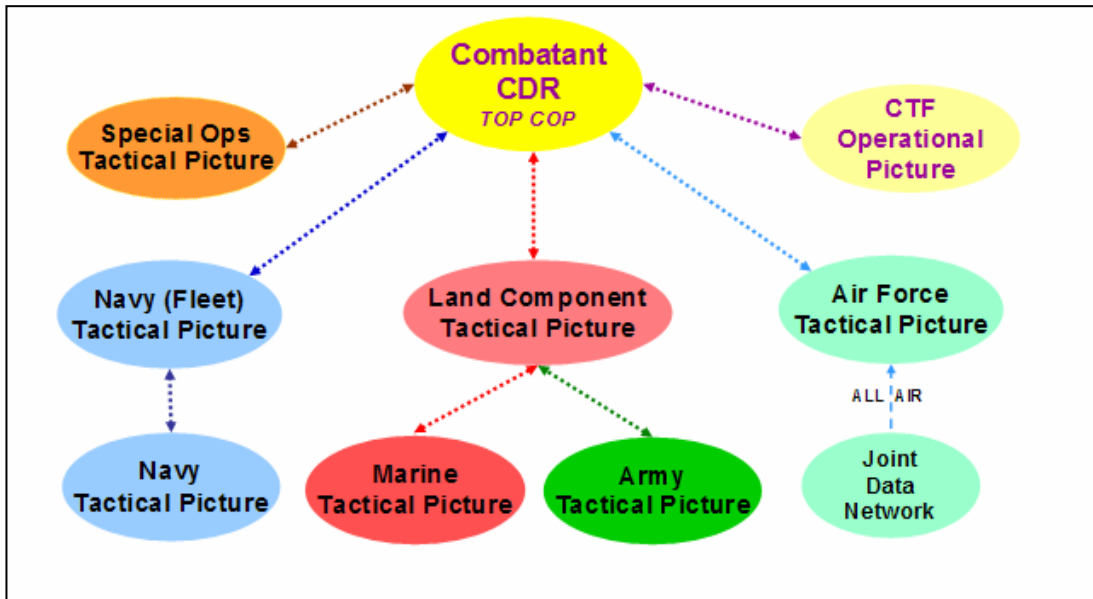

Figure 2: Hierarchy of COPs in MNE 4

Of particular interest is the use of Information Exchange elements based on the Joint Consultation Command and Control Information Exchange Data Model (JC3IEDM), which follows a recommendation given in the proceedings of the NATO MSG Symposium 2003 on C3I and M&S systems interoperability. MNE4 will be used as a logical starting point for PMESII and will be extended. It should be noted that JIM was used for injects. It is planned to use the newly initiated PMESII Centre of Excellence to continue the work. Paper MP-MSG-045-21 will give a slightly different view on MNE 4 from the perspective of NC3A participation. It should also be mentioned that V&V was not done beyond the face-value testing.

MP-MSG-045-05: The third presentation on "*Modelling & Simulation for Experimentation, Test & Evaluation and Training: Alenia Aeronautica experiences and perspectives*," must be regarded as an example how M&S is used to transform procurement and training processes and how reusable components are identified and applied. The presenting company is a main contributor to the Eurofighter projects. In order to meet the rapidly changing requirements, individual components are no longer sufficient. Using the example of a common synthetic environment for all simulators, several domains are identified, such as Human-Machine Interfaces, Image Generation and Geographical Databases, Tactical Scenarios, and more. Applying common components facilitates to multi-purpose use of this netted components, such as the use for test flight rehearsal and optimization with simulators that were designed for training. Another interesting aspect of the paper are the lessons learned from the Joint MSG-001/SAS-034 "Exercise First Wave", which was a multinational exercise of real-time distributed simulation, involving seven participating NATO Nations with several flight simulators. The presentation gave examples for the identified domains using products of the presenting company. Of high importance for NATO is the identification of underlying open standards for such components to insure the information exchange and also the use of potential alternatives for such components (such as using an alternative image generator in exchange for the proposed solution, if this satisfies the NATO requirements better).

This presentation can be seen as a connection between the international and the national efforts described in the following section. The use of national framework recommendations for international collaboration is also topic of other paper in these proceedings, such as papers 9 and 20.

5   TRANSFORMING EXPERIMENTATION - NATIONAL EFFORTS

As the previous session, this session also comprised three papers, but it emphasizes national efforts on Transforming Experimentation. It completes the session on internationally efforts.

MP-MSG-045-06: The session on national efforts started with the UK contribution on "The Use of a Conceptual Battlespace Architecture (CBA) to Manage and Exploit Concepts and Doctrine Experimentation". One aspect of particular interest of their approach is to define an architecture (MODAF) driven approach for reuse of contributions. One of the central questions for such a concept is: how to measure success? As the objective is to use M&S support for experimentation as a means to enable effective definition, development and delivery of NEC & Effects Based Operations (EBO), this question can also be formulated as: How can the findings from a range of experiments be combined to add value? The recommended solution is very close to the recommendations summarized in the NATO Code of Best Practice for C2 Assessment, namely to use a layered conceptual battlespace architecture which is depicted in detail in Figure 3.
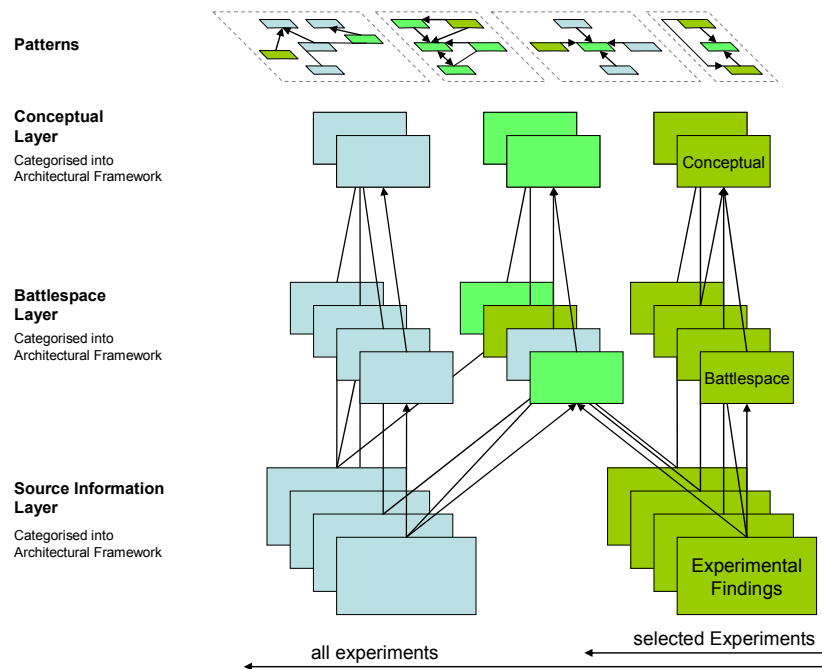

Figure 3: An overview of the elements of the conceptual battlespace architecture

The resulting framework allows the recognition of patterns and the reuse of such patterns for similar operational nodes (such as the general decision making process can be adapted for different instantiations of headquarters after level and type-tailored specifications). However, this derivation of knowledge is done by an analyst and with current technology automation is limited. Creating general knowledge from specific experiments is even more challenging. In summary, CBA is an approach to elicit additional value from a range of experimentation, doctrine, concepts and architectures. Direct impact on current work in the MSG is seen for the Task Groups MSG-027 and MSG-052. The work of C-BML – in particular the current definition of a set of controlled vocabularies – is of interest as well.

MP-MSG-045-07: The following Canadian contribution to this session focuses on capability engineering on the system of systems level. Core idea is to use the Department of Defense Architecture Framework (DoDAF) artefacts to define systems capabilities as the first step and then use executable architectures to

represent system in the second step. This allows using capability engineering methods to identify gaps in static (using the artefacts) and dynamic (executing the architecture) modes. The standard use of DoDAF is to use the operational view to say is needed and then using the system view to say what is delivered. The use of DoDAF is slightly different: While the operational view still defines the required capabilities, the system view shows which capabilities are delivered by each system of the system of systems. A traffic-light-code is used to add information to this matrix. If the applicable systems are using the same engineering approach, solutions become now exchangeable. Furthermore, the architecture products support the integration of underlying M&S systems. These ideas were successfully applied in a six week experiment. In the scope of the technical evaluation it is recommended to have a closer look at the applicability of complementing standards, such as UML and XML, to capture artefacts DoDAF artefacts, such as described in more detail in the 2006 special issue of the *Journal for Defense Modeling and Simulation* (JDMS; Applications, Methodology, Technology) on "Integrated System Evaluation: a Consumer/Warfighter Perspective." The cascading use of Architecture Documentation based on DoDAF (or UK Ministry of Defence Architectural Framework (MoDAF), as done in paper MP-MSG-045-06) followed by Process Modelling and the execution using executable architectures followed by Virtual and Constructive Simulation is an applicable scheme to analyse and evaluate heterogeneous systems and their operational support. In addition to the paper, however, it can be recommended to add system dynamics as a means before using architectures. Furthermore, the use of agents to evaluate "hot spots" or bottlenecks in the necessary detail is recommended. Some similar ideas are also mentioned in papers 4, 11 and 21.

MP-MSG-045-08: The Spanish contributions highlighted the use of applications of operational research methods and the use of simulation as one embedded tool in the suite of mathematical programming, heuristics and statistics. The paper shows furthermore the integratability of supporting related ideas, such as ontologies, the different implementation models of the model driven architecture (MDA) approaches as recommended by the Object Management Group (OMG) and other ideas, such as MSG-042 inputs, findings and recommendations. The ideas are used in support of the Spanish Navy Operations Research Laboratory (GIMO). The objective of their work is to improve the reusability of components. One of the identified requirements is to avoid semantic ambiguity of resources and is supported by an agreed formal semantic definition of resources Repository of tools can than rely on the unambiguous repository of terms. To support these unambiguous definitions on resource (component) and term (repository) level, ontology research is applied. In the opinion of the author of this technical evaluation, the main challenge will be the underlying assumption that a common ontology can be defined and will be used in NATO. Based on the standards literature on the ontological spectrum, a machine-understandable ontology as recommended in this paper can be defined as a data model enriched by axiomised business rules. Therefore, a rigorous data and metadata management is the necessary requirement to make such an effort successful. It is very unlikely that all NATO nations and partners will exclusively agree on one data definitions. Instead of a common ontology, the use of a meta-ontology enabling the capturing and mapping of national models is an option. Such an idea, based on the ideas of federated heterogeneous databases, is described in paper MP-MSG-045-16.

6   INTEROPERABILITY ISSUES

Many authors responded to the call for papers with interoperability focused contributions, so that two sessions were instantiated for this workshop.

MP-MSG-045-09: The first paper presented in this session gave an update on joint efforts to deal with the challenges of live, virtual and constructive simulation coupling. The US Joint Forces Command, the Joint National Training Capability (JNTC) copes with this related task. JNTC was already mentioned in the keynote of RADM Kerignard as a strong partner for ACT as well as during the second invited presentation, as Australia's joint combined training centre is connected with it. JNTC can serve as a model for NATO as the challenges dealt with are similar to those being observed by NATO, currently multiple protocols, gateways, and object models are often used to bring an LVC Environment together. The vision

is to gradually merge the different architectures often used, such as HLA, TENA and DIS – into one integrated LVC infrastructure. As a first step in this direction, the Joint Live Virtual Constructive Data Translator (JLVCDT) is currently developed to support a selected set of first architecture candidates as a sort of common gateway on the way to a common architecture. JLVCDT was designed to improve multi-service LVC component interoperability. It is envisaged that JLVCDT will deliver an open architecture via a public API to encourage broad adoption in existing LVC environments. JLVCDT and its plug-in modules will be JFCOM-certified in the Joint Advanced Training Technology Laboratory (JATTL). JLVCDT has been used in different international environments, including but not limited to MSG-027 experiments. It is planned to make the tool available in controlled contexts, i.e. the open architecture which is government owned. A timeline for release of the tool is not yet established.

MP-MSG-045-10: The second paper on "Verification, Validation and Accreditation (VV&A) Leveraging International Initiatives" not only gives an overview of the importance of VV&A, it also highlights the possibility of leveraging knowledge and results already available through other organisations. The paper describes high-level views of the following initiatives: NATO Modelling and Simulation Group Task Group NMSG-19; Simulation Interoperability Standards Organization (SISO): Verification, Validation & Accreditation Overlay to Federation Development Product Development Group (PDG) and SISO Generic Methodology for VV&A Study Group, and the European initiative Referential for VV&A (REVVA). Details on the individual initiatives are given in the paper. In the context of this technical evaluation it should be noted that this paper focuses much more on education and procedural support than the other more technology based papers in this session. It clearly supports the view that conceptual problems cannot be solved with tools on the technical level, but that a combined effort of efficient tool support paired with sufficient education in common engineering processes is necessary. It should be further noted that *Accreditation* is the formal process to be applied on the national level, the paper used *Acceptance* instead of *Accreditation*, which is the generic process that can lead to national accreditation established in the context of the user. It is also an interesting observation that VV&A has not been conducted to the full recommended extend in any of the presented application cases during this symposium, although it has been identified as a future activity in papers 4, 20 and 21.

MP-MSG-045-11: The third paper deals with "Effectiveness of JSAF as An Open Architecture, Open Source Synthetic Environment in Defence Experimentation", in which the authors critically reflect on practical reuse issues to evaluate new mission roles and to develop tactics for new missions and new types of equipment. The driving concept behind this evaluation is the idea to allow scalable fidelity, i.e., the ability to support current and future requirements ranging from high to low level of fidelity. The presentation did not exclusively focus on JSAF, but looked at other efforts as well. However, what is of significant interest in the context of this technical evaluation is the rigorous application of open architectures and open international standards. Lessons learned and recommended: pay a bit more and have more flexibility, but you need a sets of metrics to back your recommendations. Open source or Government Source Available solutions have been proven to be supportive of the ideas presented in the paper. It may be noted that during the recent Simulation Interoperability Workshop Fall 2006 by SISO the topic "Open Source and its Contribution to Simulation Interoperability" was the theme of the Academic Night. The insights of the participating experts from various universities may be a good additional source for the interested reader.

MP-MSG-045-12: The fourth paper presented ongoing work of research conducted for the Federal Armed Forces of Germany on scalable solutions for the new Information Technology in support of simulations for the Bundeswehr (ITSimBw). The proposed infrastructure is scalable concerning functionality (how detailed are functions/effects modelled/simulated?), time (in which time steps will the simulation proceed?) and space (which spatial scale will be chosen for modelling?). A second important aspect is the usability of intelligent software agents in such an environment. The third new idea presented in this paper is the use of an exact 3D representation of all physical entities, as this is considered to be critically important for a realistic representation of the environment within a military simulation. The

recommendation is to use voxels (pixel-like representations of volumetrics, regular volumes of space). The coupling with legacy systems is supported by wrappers. The project is still in the experimentation phase but shows some promising, but tentative first results. Furthermore it should be pointed out that the work presented is not a framework for mediated integration of existent solutions, such as proposed in earlier papers, but the implementation of a new model paradigm. It is the opinion of the author of this technical evaluation that more research and experimentation is necessary before this approach reaches the maturity of solutions as used in JWC or the JFCOM. The underlying vision, however, is aligned with several of the Pathfinder ideas and activities and it is recommended to observe technical developments and methodological contributions in these areas and continue to evaluate their maturity level for the practical use within NATO.

MP-MSG-045-13: The fifth paper highlighted the recent developments in Coalition Battle Management Language (C-BML). The SISO Study Group recommended to define C-BML as the *unambiguous language used to command and control forces and equipment conducting military operations and to provide for situational awareness and a shared, common operational picture.* Several BML tasks are currently under development by national as well as international expert groups presented in the paper. A common denominator is the use of a common data model to capture the information. C-BML uses the Command and Control Information Exchange Data Model (C2IEDM), the migration to next generation of this data model, the Joint Consultation Command and Control Information Exchange Data Model (JC3IEDM), is currently being prepared. This use of this data model follows the recommendation given in the summary of the 2003 NATO MSG Symposium, which focused on C3I and M&S Interoperability. Also, the BML idea was presented to the MSG community during the 2004 NATO MSG Symposium in paper MP-MSG-028-12. Of particular interest in the scope of this technical evaluation is the report on the MSG Exploratory Team on C-BML (ET-016), the current state of MSG's Task Group on C-BML (MSG-048), and the connections to the Simulation Interoperability Standards Organization (SISO) Product Development Group (PDG) on C-BML. The work is ongoing, relevant projects are referenced in detail in the paper. In the discussion following the presentation it was noted that – although the paper uses the complete recommended definition – the presentation exclusively deals with the reporting aspect of C-BML. The reason for this is that the first phase of the standardization efforts of SISO also focuses on this aspect and MSG decided to use the SISO recommendation to avoid the introduction of unnecessary and avoidable ambiguities.

MP-MSG-045-14: The sixth paper summarizes the lessons learned in the form of a success story on an effort conducted by MBDA Missile Systems. MBDA is present in France, Italy and the UK. They reported on current work targeting a European Distributed Experimentation Capability in support of their distributed and international company that grew together from historically independent technical centres. Their recommendations are insofar of interest to the MSG, as they aim for a common technical approach, based on a common architecture, a common infrastructure and common components to migrate existing and applicable solutions into a common framework. The Synthetic Environment Centre of Excellence of MBDA coordinated the efforts, using web based tools for workshops, user guides, video conference and a web based repository. This approach allowed the reuse of applications and components distributed and developed separately at the various sites of the company online in a collaborative environment. The paper presents the currently supported distributed architecture between MBDA in France, Italy and UK. It also reports on cost savings and the consolidating research activities based on sharing best practice and shared tools. To what degree these results can be used for NATO remains to be evaluated in detail, as the presented effort was international, but conducted with the borders of MBDA Missile Systems. However, in the light of the vision to establish a Networked Simulation & Learning Capabilities Supporting the NATO Education & Training Network (NETN), in particular the technical solutions for web-based distributed collaboration are candidates for more intensive evaluation.

MP-MSG-045-15: The final paper of the session on interoperability issues deals with Interfacing Simulations with Training Content. It is another collaboration of Aviation Industry CBT Committee, IEEE

Learning Technology Standards Committee (LTSC) and SISO of immediate interest to MSG. The paper is primarily based on SISO Study Group results and recommendation, which comprises many LTSC recommendations. This group was formed to study possible standardization for the integration of simulation-based learning experiences with Sharable Content Object Reference Model (SCORM) environments. The paper and presentation comprises many technical details of interest. However, in scope of the technical evaluation the recommendation to focus on standards for information exchange (i.e. notional data models) and architectural constraints is of particular interest. Beside the details of the study group the paper also comprises a description of the working procedures of SISO. SISO has now been accepted as a standardization body by NATO, this means that SISO standards can become NATO Standardization Agreements and as the study groups and product development groups are open to the public this means that NATO MSG Exploratory Teams and Task Groups can use SISO to recommend standardization work. It is valuable to know and understand these constraints. The paper is accompanied by paper MP-MSG-045-17 in these proceedings.

7   TRANSFORMING TRAINING, EDUCATION & DECISION SUPPORT

As the track on Interoperability Issues, the track on Transforming Training, Education and Decision Support was targeted by many authors and filled several sessions.

MP-MSG-045-16: The session was opened with an overview brief on Pathfinder activities and recommendations for the way forward given in paper MP-MSG-045-16 on a "Web Portal Approach for Knowledge Networks in Support of the Pathfinder Programme". Although rooted in MSG-027, this paper is not a presentation of the task group findings, but it is intended to place the MSG-027 into the bigger picture of other task groups, the advanced distance learning ideas, and the new ideas for the NATO Education & Training Network (NETN). The paper summarizes the important aspects of NATO's M&S Master Plan and the resulting flagship of the MSG: Pathfinder. This effort can be considered as being the yardstick for all technical activities and must therefore itself follow a set of guiding principles and rules. The presentation recommended that future MSG activities should be measured to what degree they support activities like Pathfinder and NETN and should not exclusively produce task force specific results. The presentation focused on two aspects given in the vision of Pathfinder. Firstly, instead of using one mandated or selected system, every nation brings their national systems. These systems can be federated in a timely way into the common solution. The idea behind this is that national ideas are nowhere better modelled than in the national simulation systems. JMRM described earlier in paper MP-MSG-045-01 is not such a solution, but is leading in this direction as it in principle, allows Users to federate with other systems than JTLS and JCATS. Secondly, M&S is only relevant when being applied to the benefit of the NATO user. To enable this, the convergence of operational systems and M&S is mandatory. The use of common standards and data models as recommended and demonstrated in several other papers of this symposia and all point to the same direction. The presentation focused on the web portal that was designed to support knowledge for the Pathfinder Integration Environment (MSG-027) and how to reuse the portal and the ideas to bring Pathfinder forward. The Pathfinder Integration Environment (PIE) Knowledge Web Portal is accessible from NATO ACT Web Portal `http://pathfinder.vmasc.` `odu.edu/pathfinder/` and describes M&S Resources in form of a repository as well as M&S Integration Knowledge in form of use case, processes and application steps using the resources described in the repository. The use of meta-schemas gives the user maximal flexibility and allows the import of other repository information based on their XML schema and support of W3C compliant web services. The presentation stressed the necessity to apply such open standards and architectures specified to the level of detail needed to align and orchestrate the contributing technical activities and task group results.

MP-MSG-045-17: The second paper, that accompanies paper MP-MSG-045-15 of these proceedings, deals with "Instructional Design Considerations and Planning to Transform Simulation Systems to a Platform for Delivery of Instruction". The paper focuses on the necessity to better deal with Simulation

Based Instruction (SBI). Current paradigms, such as following a strict Analysis, Design, Development, Implementation and Evaluation (ADDIE) process, are not appropriate and improvements are recommended. However, emerging standards exist in support of the community, such as Advanced Distributed Learning (ADL), Sharable Content Object Reference Model (SCORM), Content Object Repository Discovery, Registration Architecture (CORDRA), Sharable Content Object (SCO) and Learning Management System (LMS). These standards do not solve the problem, but they contribute to the solution. Paper and presentations show the need for formal instructional design method for SBI. This instructional design for simulation should be an independent discipline from the simulation design process and should be independent of development process, independent of underlying models and independent of specific implementation. While simulation models are based on engineering principles[2], instruction and student models must be based on learning principles. Also, instead of seeing the process as composed of a series of stages, a spiral development using the components Ontology, Process, Collaboration model and Product representation is proposed. In order to increase its effectiveness, SBI must be improved. The pure federation of simulation systems is not sufficient in support of these ideas. However, the need for metadata in support of not only composable engineering principles, but also pedagogically composable modules and the possibility to support multiple levels of abstraction is made in this paper. It is worth mentioning that these recommendations don't minimize the aspect of technical achievements, such as federation development on a big scale. It adds another dimension to the problem scale that so far was not sufficiently[3] regarded.

MP-MSG-045-18: The third paper summarizes Norwegian efforts on setting up an infrastructure in support of Distributed Simulation Based Joint Tactical Training. The experiment JADE was conducted with the goal to demonstrate and explore distributed simulation based training of procedures and air picture production between naval units and a Control and Reporting Centre (CRC). The hypothesis for this national experiment was that legacy stand alone training simulators can be federated as a first step towards a joint training capability. This is increasingly important as Network Based Defence (NBD) is likely to increase the need for collective and joint training. The synthetic environment for joint and combined air defence covered training simulators, a C2 system, tactical data link network, voice communications and simulation data exchange. The resulting infrastructure dealt with live entities and simulated entities and is depicted in Figure 4. While HLA 1.3 was the technical backbone, DIS-adaptors were used to integrate these simulators. Voice-over-IP and Tactical Data Links were supported. One of the resulting challenging aspects of integrating operational C2 systems was security. The results of the evaluations were positive. With regard to a technical evaluation it should be noted that the technical achievements are remarkable. However, the benefit of such experiments and other national efforts discussed earlier or later are no exception, could have been significantly improved by a more rigorous application of open standards (HLA IEEE 1516 instead of HLA 1.3) and integration results and lessons learned for such important questions as security solutions, integration of standardized C3I system interfaces (such as tactical data links), etc would have been captured in a form that it could be shared with NATO nations and partners. Paper MP-MSG-045-20 presents another very similar approach.

---

[2] The Federation Development and Execution Process (FEDEP) as standardized in IEEE 1516.3 is an example for applied engineering principles.

[3] Additional information on this topic can be found in paper 06F-SIW-056 by Haynes J, Maloor P, Lyell M, and Zbylut "A Narrative Approach to Simulation-based Training", Proceedings of the Fall 2006 Simulation Interoperability Workshop, which was awarded by the Conference Committee.
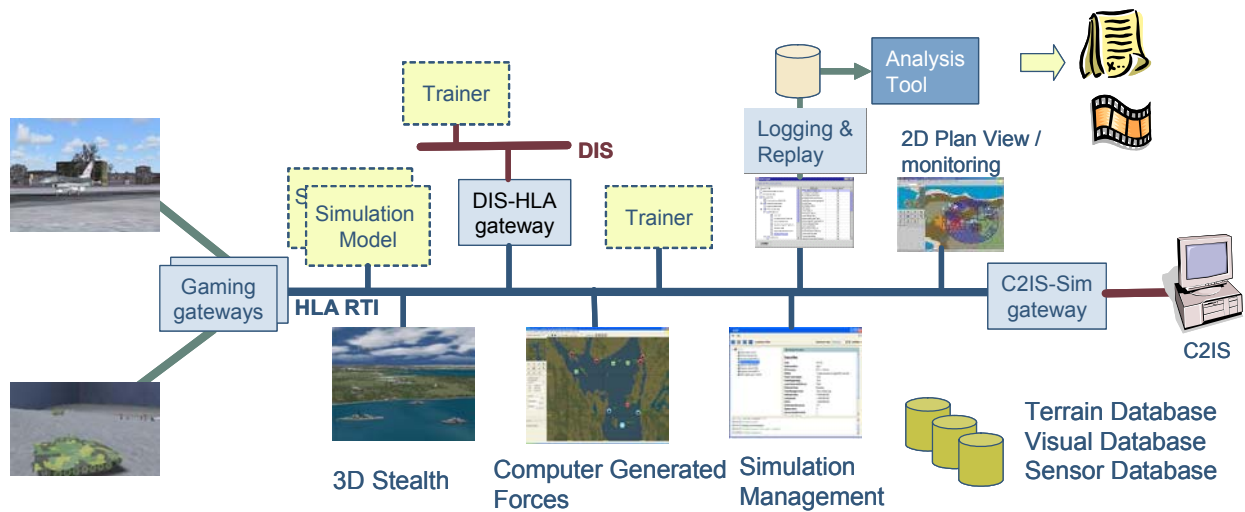
Figure 4: JADE Architecture and Integrated Systems

MP-MSG-045-19: The fourth paper continued in the spirit of the case study presentations of last years M&S Symposium that clearly should the efficiency of M&S for training and mission rehearsal (in particular RTO MP-MSG-035-008). It focuses on high-fidelity multi-player simulation for enhancing team, and inter-team skills to overcome constraints on range training and complement live-fly training in preparation for high-cost training events. The paper shows how in a SWE/US collaboration Distributed Mission Operations (DMO) ideas and Mission Training via Distributed Simulation (MTDS) concepts were used to integrate multiple training centres over long-distance. The objective was to evaluate to what degree DMO/MTDS can complement Warfighter training in the SWE Air Force and the US Air Force. The idea was not to reduce flight hours but to make the available flight hours more efficient for education. The Swedish Defence Research Agency Air Combat Simulation Centre (FLSC) in Kista, Stockholm, and the US Air Force Research Laboratory, Warfighter Readiness Research Division, AFRL/HEA in Mesa, Arizona, were utilized for the experimentation. The paper gives details on the experiments which were used to combine live flying with DMO experiments and the use DMO experiments to improve tactics. These combinations allowed training in complex and demanding tactics that normally cannot be taught in early stages of the pilot education. Competency-based training, defined as the ability to compare individual aircrew performance to a defined proficiency level, to maintain acceptable levels of performance and target areas requiring improvement, proofed to be feasible and effective. Pilots that trained using the principles explained in the paper and then participated in the live flying exercise Red Flag in Alaska, commented that "it felt like we already have been there."

MP-MSG-045-20: The fifth paper presents Joint Research on Air Defence Simulation (J-ROADS), which is an interactive simulation environment on extended air defence to support national and international armed forces with Analysis of System and Architecture Performance, Exercise Support & Training and Test Bedding. J-ROADS is based on experiences made with SEAROADS and was developed by TNO, The Netherlands. The objective of this paper is similar to the paper three of this session. However, while paper MP-MSG-045-18 focused on national efforts, this paper focuses on international support, such as a recent common CPX with NATO and the Russian Federation or the USA/NLD/DEU collaboration within the Joint Project Optic Windmill (JPOW). More examples are given in the paper. The target group is the Joint and Combined Task Force (JCTF) for Extended Air Defence, which is defined by a heterogeneous command and control structure and a multitude of engagement systems. Paper and presentation summarize several lessons learned from supporting JPOW. Of interest is the Application of Global Command and Control System (GCCS) proved valuable, the NATO ACCS functions demonstrated successfully, and the Link-16 network proved capable, but provide major challenges to operate. The

modular concepts of J-ROADS and the integration of tactical data link modelling and live systems is a very reasonable candidate for a NATO solution, although the project is still ongoing and some solutions are not yet standardized or strictly follow NATO recommended solutions. This paper is comparable to the earlier presented paper MP-MSG-045-18. Again, the main objective was the efficient technical design for the support of the exercise cycle, which resulted in highly efficient but not necessarily standard and generally reusable solutions.

MP-MSG-045-21: The sixth paper has already been referred to a couple of times. It presents Modelling & Simulation Support to the Effects Based Approach to Operations, in particular from the viewpoint of Gamma. This paper reflects the observations of the author and gives and alternative view to the PMESII observations presented in paper MP-MSG-045-04. The paper gives several references to earlier presentations describing architecture, functionality and application of the NATO-developed tool for the interested reader. The focus is the transformation of experimentation and training with regard to Effect Based Approach to Operations (EBAO), which is the NATO term for EBO. The process control model for EBOA is of special interest and is therefore shown here in Figure 5.
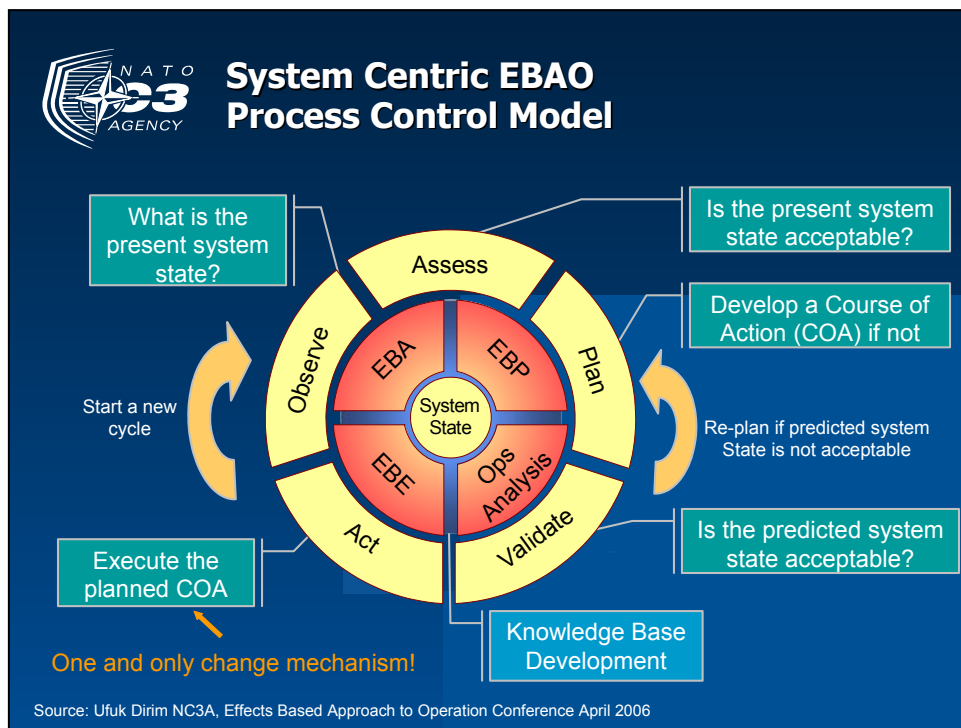

Figure 5: System Centric EBAO Process Control Model

Another valuable contribution of interest is the distinction between the different phases of EBAO: It starts with Effect-based Planning, goes into the Effect-based Execution and leads to the Effect-based Assessment. The role of M&S in all three phases is significant, including but not limited to what-if-analysis. Furthermore, the agent model as used in Gamma may serve as a mid-term alternative to a user-driven incident list. As Gamma is used in exercises in support of NATO staff, it may be a good candidate for decision support. Finally, the validation of Gamma is still very challenging and currently limited to face-value evaluation by subject matter experts. Although it is planned to validate Gamma more formerly, this remains a critical point. What makes Gamma nearly unique is that a conceptual model is captured not only in UML (of particular interest for the Verification part), but the underlying constraints and assumptions are also captured in form of the meta-model used for Zeta. Zeta is a multi-criteria decision support tool embedded within Gamma, linking effects, actions and resources to analyze predicted

outcomes of a selected civil-military course of action at the operational level. In addition it provides feedback on the status of the system under study at the aggregated and actor/element level and the degree of achievement of the operational level military end-state over time.

MP-MSG-045-22: The final paper presents an overview on the Bulgarian findings on Computer Assisted Exercise Environment for Terrorist Attack Consequence Management, conducted as part of a NATO project in which five other nations participate. The project was supported by different funding sources, which fits well into several other proposed ideas on doing research (see reports generated by several participating groups connected with MSG interests, such as SISO). The focus of the presentation was not technical, but organisational: What are the different aspects than can be supported by M&S in a CAX on these new topics. The resulting four topics are the presentation of a CAX based model for Concept Development and Experimentation, the use of training as a tool for change management, an evaluation on required M&S capabilities of the CAX environment (including the use of COTS), and the use of M&S in planning and lessons-learned. The paper included recommendations for organisational structures in support of inter-agency and inter-ministry CAX, focusing on structures, necessary cells, integration of real non-military command and control, and necessary set up process. In particular the J3-organisations of NATO may be interested in further evaluation of the presented results. The symposium was used to connect the scientists of these efforts with those who prepared paper MP-MSG-045-07, which deals with similar questions.

8   SUMMARY AND RECOMMENDATIONS

This section shows the major trends as observed 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. In summary, the symposium provided attendees a forum to advance the effectiveness and role of M&S in the Alliance. The combination of M&S users and developers concentrated in this one forum did not only educate attendees, but also provided fresh ideas for the furtherance of NATO M&S in continuing to provide a key building block in support of NATO's transformation process and national capabilities.

- National M&S infrastructures have been established in many nations can contribute to NATO capabilities. Several papers presented national, bi-national and multinational efforts on setting up such infrastructure. All presenting nations made sure that M&S applications in NATO and the nations have reached a reliable level of maturity.

- The best known application area of M&S remains training, but the need for support to operations was clearly established by military users. Several papers present first applications into that domain, such as decision support.

- Open Standards and Open Architectures have been identified by several contributions as essential for NATO. This was also stressed in the discussions. It was also identified that certification and V&V are essential. Several papers give recommendations in this direction.

- Web-based support was also identified in several papers: repositories, knowledge-management, collaboration tools, etc. are more and more web-based and used in a distributed style, including workshops and symposia. However, as these are emerging standards, the guiding role of coordinating institutions – such as MSCO – is essential to avoid non interoperable solutions in this domain.

- While the current work focuses on technical solutions, process alignment is as important and must be supported. Education and coordination are necessary.

- In several papers, the use of DoDAF and related frameworks (MoDAF, Zachman) for documentation is proposed. However, the artefacts produced by such frameworks leave room for

interpretation and have the danger of ambiguity. The use of UML has the potential to make such artefacts unambiguous for NATO efforts.

- Several papers focused on scalable solutions based on high-resolution information exchange paradigm: JMRM, MNE4 and scalable fidelity are examples for this trend. The work is driven by the objective to use configurable and scalable solutions to address various questions instead of setting up individual federations to address each question individually. Whether the current approach to use high-resolution models for information exchange is the best solution to insure interoperability or if alternative approaches are needed remains to be evaluated.

- JMRM is not the final solution for the flagship of MSG, but it is a good step in the right direction. If done correctly, it can be a first step to the Pathfinder vision of national systems providing the national capabilities to train users: the JMRM federation can be enriched by new federates. However, a well documented FOM – or even better a standardized FOM – and the rigorous application of open standards (such as Standards for Scenario Development, such as MSDL, standards for IE with C2, such as C-BML) is a necessary constraint. Also, the toolset around JMRM must support national solutions and not exclusively the first core federates of JMRM.

- Simulation Based Instruction becomes increasingly important. However, the composability constraints for instruction modules may differ significantly from the technical constraints of the underlying federation, so that more research is needed. Nonetheless it was observed that M&S and ADL are growing closer together.

- The often mentioned collaboration between MSG and SISO and other organisations is now a reality. Several papers presented reports on mutual groups and the reuse of results on both sides.

Figure 6 summarizes the resulting recommendations of the technical evaluator on domains that need to be aligned in order to make the Pathfinder vision a reality.[4] The elements of the Pathfinder house slide are defined as follows:

- The founding principle of Pathfinder are **Common Standards & Tools**, including but not limited to the High Level Architecture, command reference data model – such as the C2IEDM/JC3IEDM,- emerging web service. Based on this principle the two pillars of Pathfinder are procedural and technical requirements.

- The procedural pillar rests on **Education**. Just mandating and recommending technical standards or management procedures is not sufficient. Education is a key enabler.

- The next components are **Aligned Processes** and **Aligned Management**. Using the same elements only leads to interoperability and reusability if they are used in the same way.[5]

- The technical pillar rests on common **Documentation/Architecture** principles. Several papers emphasized this view and it looks like DoDAF becomes a strong candidate.

- The HLA Runtime Infrastructure – and increasingly emerging web-based solutions – become the **Common Infrastructure** which is used for M&S federations. This perspective may have to be broadened to be applicable to Command and Control Systems as well.

- The use of **Common Data**, in particular common data definitions and understanding including metadata capturing this and enabling the mapping of data representation onto each other, is part of this and a essential part of effective net enabled components.

---

[4] A similar "house slide" was successfully used by the US Army initiative Simulation-to-C4I-Systems Interoperability (SIMCI) to identify the role of participating projects and even for some funding decisions (see MP-MSG-022-01).

[5] Paper MP-MSG-045-16 shows an example how to support this with the Pathfinder Integration Environment Knowledge Web Portal, in which the *M&S Repository* section is used to capture *technical* requirements, and the *M&S Knowledge* section is used to capture the *procedural* requirements.

- This will lead to the establishment of **Reusable Components**. As highlighted before, NATO now sees a lot of very mature national contributions. However, it appears many of the common problems are solved by every nation individually. These resources can be used more effectively instead of "reinventing the wheel" with national resources.
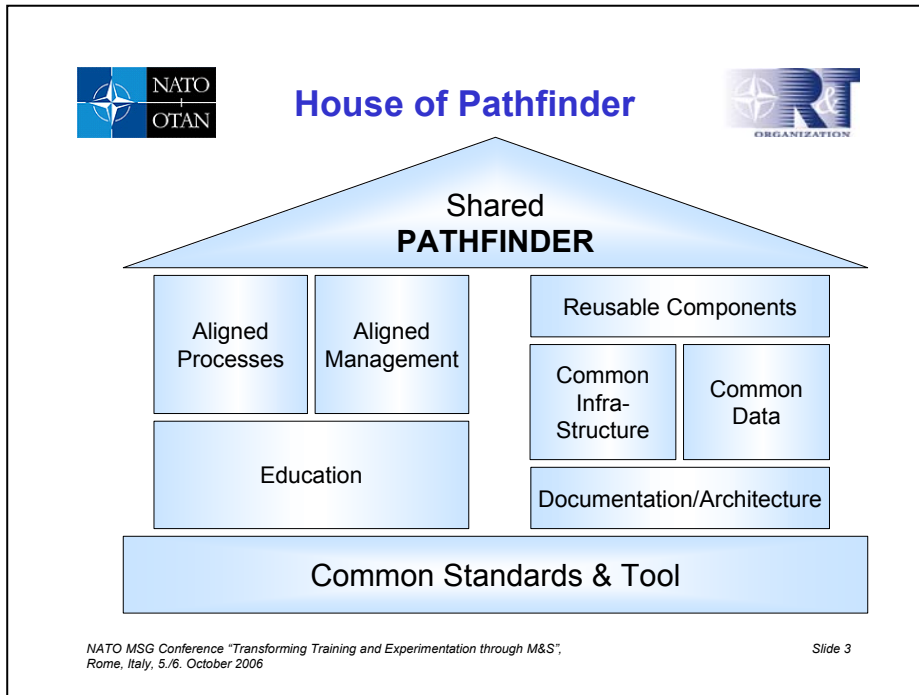

Figure 6: Pathfinder "House Slide"

These ideas are applicable to support the management and evaluation of various technical activities, national contributions and commercial contributions to Pathfinder, at least at the high level, such as within MSCO and MSG. An Integrated Overarching Project Team could be established to make sure that the Pathfinder vision can become a reality based on the common practice within NATO.

In summary, the symposium gave an excellent overview on how much the NATO M&S Community evolved in the recent years. All presenting nations and organisations are clearly in a stage of mature M&S application. The main challenge now may be to effectively and efficiently enable the sharing of solutions based on open standards and open architectures. While the presentations of this symposium can be characterized that all presenters showed mature M&S applications developed by the presenting nations, the hope of the author of this technical evaluation is that future workshops will present national contributions to a NATO wide framework representing a common NATO solution.