

1 WG1

Simulation support to wargame for multi-domain operations in urban environment concept validation

Jan Hodicky

Wargaming is experiencing renaissance in NATO and Nations. There is an increased demand on the execution of analytical wargames to support complex political and military problem domains. Modelling and Simulation (M&S) is independent discipline with variety of unique theories, techniques, best practices and standards applied to reduce the uncertainty in decision making, to support experimentation and to deliver individual and collective training. While wargaming brings mostly qualitative aspects into analysis, M&S enables quantitative view into the complex problem. Terminology wise, M&S is brought to wargaming (WG) through computer assistance. The paper deals with the symbiosis between WG and M&S and discusses a different form of computer assistance to WG design, execution and analysis. Second part describes a use case when simulation is used to a) support WG Planers during the WG rehearsal to understand the mechanism of the game and b) bring quantitative aspects to WG adjudication during its execution. The use case describes the validation effort on NATO operating concept of multi-domain operations in urban environment. Main take-away is a) visualization is the key enabler of any analytical WG activity, b) simulation can aggregate effects from the tactical level to the operational ones and c) Design of simulation based experiment needs to be employed to reduce computational power and undercity related to complex problem analysis.

2 CC1

A GAP ANALYSIS OF CBRN M&S: TOWARDS NEXT GEN M&S

Piergiorgio Ventura

CBRN and Environment M&S seems not to be fully exploited within its potential in the military domain, namely, Education and Training (Exercise), Support to Operations, Planning (Course of Action Analysis), Execution (Decision Support), Mission Rehearsal, Concept Development & Experimentation (CD&E) and Procurement. Many tools do exist, like the ones providing model to simulate the dispersion of CBRN Agents, or the wearing of IPE during training and many others.

However, there is not a full integration of these tools, and many are still missing. A comprehensive approach, which integrate all existing tools, providing also the missing ones, could be a powerful way to cover an important gap still existing in M&S.

The aim of this research is to provide NATO with a roadmap to perform a GAP analysis on CBRN M&S whilst deeply investigate the existing resources and opportunities, which could lead to improvement in the CBRN and Environment M&S applications.

3 ST1

The use of NATO M&S Standards and Services in the VIKING 22 Exercise

[Björn Löfstrand](#)

The Viking Exercise is a distributed computer-assisted (CAX) command post exercise (CPX) conducted regularly since 1999 in the spirit of NATO's Partnership for Peace (PfP). It is a multidimensional, multifunctional, and multinational exercise with an emphasis on realism and current operational concepts to prepare civilians, military, and police together for deployment to a peace or crisis response mission area.

The exercise is supported by Modelling and Simulation (M&S) applications and services to create a realistic representation of the scenario. In addition, services for the generation and distribution of intelligence reports are used to stimulate the C2 systems used by the training audience from 50+ nations and 90+ organizations at 10 sites around the world.

NATO standards for Distributed Synthetic Training have been applied in the design and implementation of the Viking M&S environment which includes more than 130 federated simulation services executed at 5 different sites over 10 days of execution.

In this presentation we will share the Viking 22 technical challenges, the overall design of the federated system and the lessons identified.

4 CD2

Building an Enduring Innovation Capability

Keith Harrison-Broninski

In an era of continual low-level competition from non-government actors as well as nations, military planning must include the infrastructure impacts of changes to trade rules, climate issues, political tensions, the pandemic, energy prices, economic challenges, new forms of automation, hacking and ransomware, and more.

In the face of emergent threats that are so diverse, government bodies and other organisations cannot plan for resilience, and must aim to thrive on disruption. This is antifragility – a way of working that welcomes change, as an opportunity to grow stronger through reconfiguration of resources. Nations must learn to model and simulate the holistic impacts of emergent threats then respond with continual innovation. However, innovation is hard. Between every great demonstration and the delivery of a usable capability is the “valley of death” into which so many great ideas fall.

In the UK, Royal Navy is using the Supercommunities model (Harrison-Broninski, 2021) to create an innovation capability that delivers antifragility. The FASTER programme (Future Architecture for Submarine Technology to Enable RIOT, where RIOT stands for Rapid Insertion of Technology) takes a 3-fold approach to deliver:

1. Ownership of the processes underpinning system change
2. A technology platform flexible enough to rapidly embed emergent solutions
3. A collaborative supplier community that aims not just for outputs but for positive outcomes

The remit of FASTER is submarine Combat Management System technology but the model is entirely generic and can be applied to the development of any new military capability. It is also applicable to non-military capabilities, such as those required by countries, regions, and cities seeking to rebuild stability, either following conflict or due to disruption that could in time lead to conflict.

This talk will explain:

1. The Supercommunities model, including the underpinning formal Human Interaction Management theory of collaboration across boundaries (Harrison-Broninski, 2005) commonly known as the 5 Cs - Commit, Communicate, Contribute, Calculate, and Change
2. The FASTER programme design, focusing on the modelling and simulation of future underwater threats
3. How FASTER is increasing the scale and pace of capability change within the UK submarine Combat System enterprise
4. Ways in which the programme approach can be replicated in other environments for different purposes.

5 SN1

M&S Standards in NATO Federated Mission Networking

[J Mark Pullen and Kevin Galvin](#)

We propose a one-hour session, updated from our Workshop "C2SIM and Related Standards for FMN" which was very well received at NATO TIDE Sprint Spring 2022. We can package this as two half-hour talks or compress it to a shorter talk if needed. However, given the importance of FMN as the future training environment, the topic is an important one for CAX in NATO and deserves a full hour for presentation and attendee discussion. Outline follows:

- a. Why M&S in FMN
- b. NMSG-201 in FMN Spiral 5 Syndicates: role and challenges
- c. Early Operational Requirement: Mission Rehearsal at Operational Level
- d. Operational Coordination: Mission Threads and Procedural Instructions for Mission Rehearsal
- e. Capability Planning: Service Instructions for Modelling and Simulation
- f. Validating Spiral 5 proposed M&S standards and practices in CWIX
- g. Spiral 6 Operational Requirements: Collective Training and Decision Support
- h. attendees discuss the above

6 CT1

Enhancing Wargames and Training Simulations with Accurate Logistics

Michael Hugos

Wargames need a way to accurately integrate logistics without requiring players to go through complicated, time-consuming calculations before they can make a move. Based on work over the last two years with the U.S. Air Force, we show how a commercial-off-the-shelf (COTS) supply chain modeling and simulation (M&S) application can add accurate logistics to wargames without adding complexity or slowing down the pace of game play. This enables wargames to rigorously explore the logistics required to support different battle strategies.

Additionally, we show how a COTS supply chain M&S application can connect to a federation of real-time virtual reality (VR) training simulations used in computer assisted exercises (CAX). This enables people to see, understand and manage the supply chains that would be required to support operations happening in the other VR training simulations. It adds a new layer of reality to other simulations, and enables realistic training of logistics personnel in a way not previously possible.

The COTS supply chain M&S application employs a geospatial and map-based user interface (UI). Players define logistics entities such as warehouses, vehicles, and transportation routes, and the entity icons appear on a digital map. Then, in the same manner as placing game pieces on a game board, people drag and drop the icons to place them on the map. The map shows the same geographical area as the game board for the wargame. Zoom in on the digital map and turn on satellite view to place icons in exact locations.

By defining and placing icons on a digital map, people define rigorous mathematical models of supply chains that are then run in simulations. But people are not burdened with additional complexity, and do not need advanced math or engineering skills because the computer handles the math. AI algorithms can also be used to find optimal facility locations, delivery routes and frequencies. This makes the application usable by a wide range of military, government, business, and academic people.

Our presentation will include a hands-on demonstration where people do what logistics officers are doing currently in two U.S. Air Force logistics training programs. They will model and simulate supply chains to support different strategies and missions. We'll use strategy scenarios based on the current Russian invasion of Ukraine, and mission scenarios based on humanitarian disaster response missions in Nepal and Ecuador.

7 CD3

Development, Programmatic Transition, and Sustainment of VR Medical Simulation Training for TCCC Responders: The Virtual Advancement of Learning for Operational Readiness (VALOR) Program

[Karthik Sarma, Michael Barrie, John Dorsch, Talia Weiss, Jennifer Polson and Ryan Ribeira](#)

In future multi-domain combat operations against near-peer competitors, efforts to achieve the "Golden Hour" (the doctrinal requirement to provide definitive care within 60 minutes of sustaining traumatic injuries) are likely to be overwhelmed by casualty counts incurred from the use of highly effective weaponry employed by powerful nations on a scale not seen in combat by NATO nations in recent decades. The rapidly evolving geopolitical climate requires nations to develop solutions to address this limitation in order to maintain optimal readiness for such a conflict.

This presentation will discuss ongoing efforts to develop and sustain such capabilities through the United States Air Force-funded Virtual Advancement of Learning for Operational Readiness (VALOR) program, a large-scale XR for medical simulation training research program which has developed capabilities and training curricula in the areas of Tactical Combat Casualty Care (TCCC), Advanced Resuscitative Care, En-Route Care, and more, including live test and evaluation, as well as current deployments and sustainment efforts.

Particular detail will be paid to the VALOR CORE curriculum, a 25-scenario TCCC VR medical simulation training curriculum spanning TCCC, Prolonged Casualty Care, Small Unit Care, Chemical, Biological, Radiological, Nuclear and high Explosives medical response, and medical certification readiness. Additionally, the core design principles of the VALOR project will be discussed, which were developed to address drawbacks and limitations of prior virtual simulation efforts.

8 ST2

Simulating the Whole Picture with Distributed Mixed LVC

[Emilie Reitz, Sander Cruiming and Kevin Seavey](#)

Bold Quest (BQ) is a Joint Staff J6 coalition capability demonstration, and assessment event focused on improving joint fires interoperability in a coalition environment. It provides a rich operational environment for assessing new training and simulation technologies, both as stand-alone demonstrations and integrated with live command and control systems.

During BQ21.2, Live, Virtual and Constructive (LVC) mixed reality simulation operations provided new opportunities to demonstrate and assess methods to create multinational interoperable simulation capabilities. BQ21.2 was conducted at the Indiana National Guard's Muscatatuck Urban Training Center (MUTC) in central Indiana. The MUTC allowed many opportunities to experiment with LVC environments and demonstrate new technologies that address current LVC shortfalls, such as Augmented Reality (AR), Virtual Reality (VR), and simulated Digitally-Aided Close Air Support (DACAS). The distributed simulation scenarios included several participants connected via different networks, spanning from the Iowa Air National Guard Distributed Training Operations center to the USAFE/AFAFRICA Warfare Center; these distributed participants were augmented by constructive forces from the Royal Netherlands Army and Canadian Army ground forces using the Netherland's Tactical Engagement Simulation System (TESS) to integrate into the LVC Environment.

This presentation describes the lessons learned in conducting mixed LVC events, proposes some long-term implications of this kind of distributed mission training, and outlines future ways to improve coalition force interoperability and readiness.

9 Cancel

The US Army Wargaming Continuum of Education

[Jeffrey Hodges](#)

The US Army Modeling and Simulation School, in partnership with the US Army War College and US Army Command and General Staff College, has developed a wargaming continuum of education that is preparing the next generation of US Army professional war gamers.

The Army War College (AWC) and the Army Command and General Staff College (CGSC) offer elective wargaming courses available to all students that attend those institutions. These elective courses include wargaming fundamentals, wargame selection and wargame design. In addition, the Army Modeling and Simulation School (AMSS) offers an introduction to wargaming course where the student learns to teach a rigid wargame to support staff education and training. The follow on course, to be piloted in 2023, the wargame practitioner course, will teach the student how to modify a semi-rigid wargame to support staff education and training. Both courses also include Military Decision Making Process (MDMP) wargaming modules. Both of the AMSS courses will be soon be available to NATO allies and partners.

The USA Fight Club, a franchise of Fight Club International, provides a persistent environment that allows both military and civilian wargamers to think-fight-learn-repeat. Within the Fight Club, members are encouraged to 'wrong think', try different approaches, and take the time to repeat an event in order to fully learn from the experience.

10 ET2

An Opportunity to Evolve Army Aviation Learning and Performance with Future Vertical Lift

Jason Caldwell and Christina Parker

As the United States Army's Future Vertical Lift (FVL) program moves closer to its inception, considerations turn to questioning what impact new platforms will have on the look and structure of Army Aviation learning and performance. The following paper seeks to explore areas of required training reform based on projected FVL capabilities. By reviewing human-machine interaction, information-processing, cognition, learning science, and instructional design principles and theories in conjunction with identified platform technology advancements this paper will identify what instructional shifts in focus should occur and how the FVL platforms make those shift possible. The authors pose the questions: What currently makes up the preponderance of an Army Aviator's cognitive load/burden? Can the FVL platforms alleviate the identified burden? What does the Army Aviator have the capability of doing if the FVL platform has a greater capability of piloting itself? Can training focus less on coordination requirements and aircraft operation? Can attention shift to decision negotiation in high threat environments like tactical mission execution? What will it take to increase the cognitive weaponry of aviators to the mission through training and education within FVL platforms? The authors argue that the resultant discussion within this paper can lead to significant alterations to current aviation training structures by refocusing the cognitive load from technical to tactical aircraft operation. Ultimately, the discussion generated by this paper can impact what is trained, how it is trained and for how long, and can improve mission readiness and overall performance.

11 OD1

VALORENS, predictive analysis : capturing the enemy's mind

[Aurélien Brucher and Quentin Liguori](#)

A major challenge for land forces is to understand and anticipate the tactical situation. The project focus on the ability to exploit more information in a highly constrained time, in order to provide decision making elements for tactical leaders.

The ValoRens project is included into an operative context which started in 2021 with a study lead by MASA Group and the French Digital office of the Army headquarters service. This study aimed to produce a tool able to estimate the future enemy positions based on a report of enemy detections, goals, movements and capacities. This project mainly focusses on battalion and company levels.

This study relies on the simulation software SWORD and on artificial intelligence algorithms. It also generates initial data and display the analytics results used to test our solution.

Later, it will be integrated as an analytic component into the informative combat system SCORPION.

First, we will remember the doctrinal bases, hypothesis, and used cases we considered. We will detail the work achieved and the results of the first evaluation. Later, we will explain the next steps of the project, especially enemy's ORBAT recognition and behavior analysis.

12 LL2

Moving CAST into a secure cloud environment: Lessons learnt

Peter Meyer zu Drewer, Ralph Michel and David Sonntag

Information security is an increasing challenge in today's computerized world. This applies to computer systems 'on premises' and even more to cloud-based environments. A security incident can have a wide-range of negative impacts, including loss of data, loss of trust in data and organizations, injection of false data and many more.

Security, sovereignty and resilience are key words to describe reliable IT systems that meet the highest data protection requirements. Exactly for these demands, secunet and IBM, together with Red Hat, have developed a cloud solution for classified information. It is the first and currently only cloud platform that is in the approval process by the Federal Office for Information Security (BSI) in Germany.

Integrating simulation for training in such an environment is a logical step. By optimizing the use of hardware and personnel, the cloud-based simulation supports a more economical execution of training. Sensitive data on the other hand is optimally protected in a secure cloud.

The presentation outlines the lessons learnt from integrating CAE's constructive simulation system GESI in the secure cloud environment developed by IBM, secunet and Red Hat. The presentation provides a quick overview of the technologies being used, the steps to integrate GESI CAST in this cloud environment and the new capabilities and use cases that such a setup can support.

At the end of the presentation, an overall lessons learnt summary will be provided including challenges and solutions and the way forward.

13 LL1

Imperfect Storm - Lessons Learned From A Difficult Exercise

[Ellen Roland](#)

Putting on a successful Computer Aided Exercise (CAX) is a monumental task. It requires weeks of coordination and planning between the exercise audience, supporting commands, and the simulation experts responsible for the model that will be used to create the realistic decision environment. Part of the planning function includes developing the processes and procedures needed to handle catastrophic failures, whether these incidents are model crashes, communication interruptions, or hardware malfunctions. What lessons can be learned from an exercise that experienced all three failures at once.

No organization wants to admit non-success, but failures exist, and it is imperative that an honest evaluation of the entire process is accomplished. This talk will look at the lessons learned from a difficult exercise and hopefully provide insight to others. Only through an honest and complete lessons learned evaluation can everyone involved in the exercise move forward and correct the underlying causes to create a more successful environment for the next CAX.

14 ET3

DESIGN, IMPLEMENTATION AND PRELIMINARY TESTING OF A VIRTUAL REALITY SYSTEM USED TO TRAIN MILITARY PERSONNEL ON A SIMULATED BATTLEFIELD

[Gl.Bg.Prof.Univ.Dr.Ing. Ghita Barsan, Vesa Dumitru Claudiu and Gaitan Marius](#)

In this article, we present the design, implementation, and testing of a virtual reality-based training solution for military personnel. The aim of using virtual reality instead of traditional training processes is to simulate battlefield conditions as realistically as possible and to save financial resources that could be directed to other educational processes. The system was implemented using the Virtual Battlespace 4 (VBS4) virtual simulation software application, interconnected with Virtual Reality Headset and Controllers, to provide an enhanced simulation training experience. A wireless network has also been set up and tested for increased flexibility and quick setup during multiplayer simulation. Cost and time savings, the ability to conduct training remotely, motor skills practice, simplification of complex situations and creative experiences make virtual reality training an increasingly suitable tool to replace traditional training processes, even for the military. The main contribution of this paper is a comprehensive study analysis of the unique challenges and potential solutions for VR networks connected via wireless for military training. This work represents a preliminary stage and a source of research into optimizing solutions for virtual reality using wireless networks.

15 CT2

The Case for Defence Use of Commercial Gaming Solutions

Jason Jones

Commercial gaming software provides effective, low-cost and easily accessible tools that can support, augment or replace government provided modelling and simulation (M&S) tools.

Despite the availability and ease of use of commercial wargames, skepticism about their value persists. While there is validity for some of that skepticism, not every defence activity requires a defence-provided solution. Defence-provided M&S solutions focus on training critical warfighting tasks and principally supporting either individual skill or large-scale staff training. And that is where this skepticism is poorly aimed. It disregards the fact that many defence tasks, including the areas of education, training, and analysis, are poorly or not at all supported by those defence-provided tools.

Commercial gaming solutions can fill those gaps without incurring a lengthy procurement process and bringing the advantage of supporting a specific need. It is incumbent on the requirement holder to identify commercial products and assess them for fit to the task. And once selected, users find commercial products are easy to use and require little to no external support; have little to no additional costs beyond licensing; are purchased only if they meet the need; and can provide capabilities that don't exist in defence-procured tools.

Commercial gaming solutions provide a low-cost, high-value return that fills designated M&S gaps with an investment far lower than a defence-procured simulation.

Key Takeaway for Attendees: Strategies to make the case for using commercial gaming solutions for defence organization needs.

16 CY1

"QUANTUM" EVOLUTION IN THE FUTURE OF TELECOMMUNICATIONS & CYBERSECURITY: A DUAL USE APPROACH

[Giovanni Gasbarrone](#)

Next generation "QUANTUM" technologies represent a revolution in military operations that will change in the future the way of operations, from cybersecurity to communications in tactics, operational and warfare strategies in modelling & simulation. Quantum technologies are dual-use technologies, and therefore are of interest to the defence and cyber security industry and military.

A fundamental role in this new scenario is "hyper connectivity" in the military framework as a digitization of the battlefield where all military elements are connected. The Defense Science Board (DSB), an independent Department of Defense (DOD) board of scientific advisors, has concluded that three applications of quantum technology hold the most promise for DOD: quantum sensing, quantum computers, and quantum communications. Today, European critical infrastructures and public safety communications and cloud are vulnerable to cyber-attacks. The recent RADAR systems and the 5G and 6G antennas have contiguous or even overlapping operating principles that allow the development of solutions in a dual use perspective.

The convergence between radar and telecommunications can be glimpsed in the use of electronically scanned antennas that for 5G and 6G transmissions use "smart antennas" MIMO - Multiple Input Multiple Output. In the future, we begin to glimpse the evolution towards quantum radar while the "quantum" revolution in 6G with cognitive radio will be the next generation architecture thanks to quantum computers that already allow in 5G the optimal cellular planning of frequencies and transmission network. We are now working on the fusion of technologies with Quantum Machine Learning for 6G networks.

17 WG3

Computer Assisted Wargaming

Panagiotis Balaskas

"Computer Assisted Wargaming" is a special type of wargaming that differs from other types. The most significant difference is the usage of the simulation systems that provide advantages but also limitations.

During the CAX Forum, the organization of a roundtable discussion or workshop gives the opportunity to NATO - national specialists and companies to share their ideas about this domain.

The discussion will be focus in three separated phases: Preparation - Execution - After Action Review, considering the most important factors: People - Systems - Information.

There will be initial slides from the author side that will guide the whole discussion.

18 CT3

MANAGEMENT OF MODELLING AND SIMULATIONS SYSTEMS FOR TRAINING AND EXERCISE MANAGEMENT

David Paterson and Duncan Parkinson

NATO's next generation modelling and simulation (NG M&S) capability will want rapid user uptake, ease of management, self-service options, global collaboration, and the ability to programme and plan multiple M&S events through a common interface. Based on this understanding, it is our firm belief that an appropriately integrated, and capable, management tool is critical to ensure the qualities of usability that will make NG M&S successful.

We will illustrate this with our Exonaut Training and Exercise Management System, a commercially available, highly adaptable, and easily configurable product. With a 22 year pedigree supporting militaries delivering programming and scheduling, exercise management, evaluation, lessons, wargaming and experimentation solutions, Exonaut is well placed to provide a common management interface to support NG M&S.

When integrated into an M&S federation, Exonaut becomes an exponentially powerful tool with the capability to manage multiple simulations, models, and/or scenarios in a persistent and collaborative way – ultimately providing the flexibility and efficiency necessary to deliver a dynamic M&S ecosystem.

Exonaut architecture has been designed to work as part of an M&S federation through standards-based integration (e.g. DIS or HLA); but can also work in a wider platform-based architecture where a more extensive Open API approach may be appropriate. This will provide interoperability and simplify/de-risk future changes as models and simulations are updated. Additionally a data stream based backend will increase the potential richness of integrations and enable performance and scalability to handle large numbers of concurrent users across simultaneous training events.

Two-way integrations can now be used to specify and verify a wide range of parameters (e.g. PMSEII or weather) that can be passed to models and simulations during initiation and can be altered during execute to vary the difficulty of training audience experience.

Authoritative data, such as national force and capability structures, can be pulled in from other live systems. Live simulation data can be collected, transformed and stored in raw or aggregated formats. All of this data can be contextualised alongside objective and subjective observations used within wider ETEE evaluation and validation processes. This approach provides a step change from traditional 'observing' and opens up many possibilities to add AI/ML automation to significantly increases the overall training value.

The presentation will look at NG M&S from the perspective of a training management tool in the context of an integrated and interoperable NATO M&S capability and seeks to inform the development of requirements in that regard.

19 AI1

APPLICATION OF TRANSFORMER MODELS ON UNSTRUCTURED MILITARY ASSESSMENTS

David Paterson, Duncan Parkinson and Daniel Smith

A 4C Strategies led research project investigated the application of Generative Pre-Trained Transformer (GPT) models for summarisation tasks relating to performance observations recorded during historic UK MoD Collective Training events. GPTs are a family of Machine Learning (ML) models which have exhibited state of the art performance when used for a number of Natural Language Processing (NLP) tasks. GPT models are supplied 'pre-trained' on large, unstructured text datasets in order to achieve baseline language comprehension. By conducting further 'fine-tuning' training steps model performance on domain specific language (in this example - military collective training) can be dramatically improved.

During this research the open source GPT-Neo family of models were successfully trained using a dataset containing ~12000 training examples, consisting of Observations (Inputs) mapped to Assessments (Outputs) in a hierarchical Entity (military unit) and Objective (training objective) structure. Evaluation of these models for summarisation tasks using industry standard metrics illustrated that the performance of the trained models met, and in some cases exceeded, state of the art model performance. Of particular note was the ability of the trained models to use military language, acronyms and mnemonics in their correct context even when trained on the relatively small dataset available.

The findings of this research have immediate application to summarisation tasks in the Military Collective Training domain, and 4C Strategies intend to continue development of these trained models in order to provide functionality improvements to the Exonaut platform, as used by the UK MoD's Collective Training Group (CTG) to record unit performance during all major collective training events. Exploitation paths include:

- Providing descriptive (qualitative) outputs of quantitative inputs (such as those generated by Modelling and Simulation (M&S) systems
- Alleviation of time-intensive text generation tasks (for example report writing)
- Summarisation of very large doctrinal publications in order to answer dynamically posed questions.

Generation After Next (GAN) applications of the GPT family of models or their successors could include contribution to Artificial Intelligence (AI) in military exercise management and enable automation and control of these exercises.

The presentation will present our findings in detail and illustrate the unexpectedly positive outcomes based on the sample data used in the study. Such a capability has clear utility in supporting NATO's Evaluators, Capability Development and Experimentation, and Lessons management domains.

20 WF1

Training for Modern War – Incorporating Trends From Recent Conflicts into Training

Jay Ballard

By incorporating the most impactful trends of recent conflicts with different simulation/training methods a military or organization will be able to prepare a more agile and combat effective force. This presentation will identify those trends and align them with different ways to train for success in major combat operations.

The topics will include: Will to Fight; Major Combat's Impact on Logistics; Inability to Hide from the Enemy; Why Air Superiority Will be Hard to Achieve; Social Media - incorporated into all aspects of war fighting; the Urban Fight; and finally, Fighting an Opponent Who Seeks to Increase Civilian Casualties Instead of Avoiding Them.

21 OD7

MODELLING AND SIMULATION SUPPORT TO GEOSTRATEGIC ANALYSIS AND DEFENCE PLANNING

Erdal Cayirci, Ramzan Alnaimi and Alhanoof Mohammed Althani

The contemporary setting is characterized with volatility, complexity, uncertainty and ambiguity; therefore, it becomes more and more challenging a task to develop strategic foresights and scenarios for which defence capabilities are transformed. New modelling and simulation tools and approaches are required for geostrategic foresight development, defence planning, concept and doctrine testing.

We use an extensive form Bayesian geostrategic game with imperfect information to quantify the state vector (i.e., political, military, economic, social, infrastructure and information) and instruments (i.e., diplomatic, information, military, economic, financial, intelligence and law enforcement) of state and non state actors. We also wargame with these actors. A set of strategies are available to actors when they satisfy the required conditions. As new strategies are employed by the actors, the setting changes and when the conditions for predefined scenarios are met, the game generates warnings about the potential future scenarios.

These scenarios become the input for a static and deterministic computer model, which calculates the optimum set of military capability requirements to counter hostile capabilities. The model also supports the analysts with sensitivity analysis.

Finally, a constructive, continuous, dynamic and stochastic model is used for computer assisted experimentations where concepts and doctrines for the future settings can be tested.

We introduce our models and give results from the experiments with them.

22 ED1

ELMO (Electromagnetic Layer for Multi-domain Operations)

Salvatore De Mattia

The electromagnetic dimension is an essential element for the understanding and conduction of future military operations, in which the use and interconnection of complex systems take on a significant value for operational advantages. The transversal characteristic of the electromagnetic dimension permeates the operational scenario in a multi-domain perspective and, therefore, comprehension and management of this physical dimension is a crucial point.

The NATO Modeling & Simulation Center of Excellence (M&S CoE) is conducting a project called "ELMO" (Electromagnetic Layer for Multi-domain Operations), which aims to create a synthetic environment for the virtualization of the so-called EMSO (Operations on the electromagnetic spectrum). In this context, M&S is a fundamental technology that expresses versatility characteristics for the implementation of complex electromagnetic multi-domain scenarios, able to virtually characterize the dimension and make visible what in the real environment is not directly perceived by our senses. This factor would make it easy to understand not only the main electromagnetic spectrum parameters, but would also enhance the characterization of the operational and informative technical impacts that the electronic assets provide within the context of Electronic Warfare.

23 OD3

Automated terrain assessment to accelerate the military decision-making process

Jens Schetelich and Rene Streifer

Ground forces of the future will be able to operate with fewer personnel in much larger spaces, at a higher operational tempo and with drastically shorter decision cycles under multidimensional threats. However, all technological innovations to achieve these capabilities will ultimately be ineffective if they are paired with today's decision-making and command process. Supporting the military decision-making process with intelligent assistants will neutralise this potential bottleneck.

The German Army Headquarter is working with industry partner Rheinmetall and the Fraunhofer IOSB research institute on possible solutions as part of the R&D study "Automated terrain assessment to accelerate the military decision-making process"

The project is characterized by its holistic view of the military decision-making and command process. A core task is the identification of process steps that are invariant to the technological development of the armed forces per se (e.g. terrain assessment), can be bottlenecks in the decision-making process (e.g. information management) or represent a high mental burden without significant creative potential (e.g. calculating the availability of forces according to time and space).

Assistance functions will be developed for the identified sub-steps and tested together with military users as early as possible in order to gain feedback for further development and to mitigate the risk for development of applications with low usability within the decision making process. In each case, the entire spectrum of the operation of the combined forces is taken into account.

In the current phase of the project, the following military tasks are addressed in this way:

- Operation planning in the intermediate tactical command level,
- battle management in the intermediate tactical command level,
- interaction with the assistance system in the lowest tactical command level as well as the individual vehicles,
- and the use of the procedures as a tactical autonomy function in unmanned systems.

The core function in the current project phase is the automatic assessment of the terrain using digital geodata in order to provide immediately usable tactical information.

24 SN2

Modeling, Simulation & Training (MS&T) and Operational Technology (OT) Interoperability

[J Schlesselman and Thijs Brouwer](#)

This presentation will describe and demonstrate advances in open standards-based interoperability between Operational Technology (OT) and Modeling, Simulation and Training (MS&T) systems. In this case, OT refers to functional production systems that are intended for deployed use. We shall highlight an air domain use case, showing interoperability between applications based on Unity and Epic Unreal gaming engines, flight simulators, the Future Airborne Capability Environment (FACE) and Sensor Open System Architecture (SOSA) specifications, and applications using the RTI ConnexT TSS. ConnexT TSS is the first certified conformant FACE Transport Services Segment (TSS) based upon the open Object Management Group (OMG) Data Distribution Service (DDS™) standard. OMG DDS is an important standard used across many MS&T and OT domains such as radars, electronic warfare, missile defense, satellites and ground vehicles.

This particular demonstration consists of two drone simulators, one using the Unity gaming engine and the other using the Epic Unreal gaming engine. The drone flight simulator publishes location, video and Lidar through a SOSA aligned plugin using the SOSA Interaction Binding to publish data. The Lidar data is displayed using the RVIZ, a ROS2 application. Location is fed into different User Interface (UI) applications and the Ansys FACE conformant A661 server. Interoperability of the RTI ConnexT TSS product is proven between an Ansys Cockpit Display Systems (CDS), an ENSCO IData CDS, and a Presagis CDS.

The goal of this demonstration is to show the utility of using the same NATO-mandated standards-based technology used in operational systems to connect distributed next-generation MS&T systems enabled with security, quality of service, application portability and wire-level interoperability.

25 CT4

Introduction to the DDS databus for multi-domain simulations

J Schlesselman and Thijs Brouwer

This tutorial covers the fundamental technologies, terms and concepts of the Object Management Group (OMG) Data Distribution Service (DDS™) for Modeling, Simulation and Training (MS&T).

Integrating simulation and training systems can be a formidable challenge. Legacy systems often use differing standards for data, voice, and video, while modern data centric architectures demand the use of cloud-based and/or distributed assets. Additionally, new security requirements force system integrators to become experts in information assurance.

Attend this tutorial to learn how the OMG DDS can ease integration, while also delivering tested security for distributed training systems over any transport.

DDS also is used in many hundreds of deployed operational technology (OT) systems. DDS seamlessly stitches together legacy simulations, while adding humans and hardware in the loop, to create new secure Live Virtual and Constructive (LVC) environments that can share real, augmented and virtual realities. These environments can run in a single lab or across multiple sites and due to its peer-to-peer nature, DDS is still able to deliver physics-speed response times.

This tutorial gives a solid introduction to the DDS and DDS Secure standards. Attendees will learn how to use DDS Secure to secure real-world Hardware-In-Loop (HIL) systems that already communicate over DDS to distributed LVC Simulations. The tutorial will further describe how to integrate DDS with existing simulation-based standards like HLA, where DDS adds a wide range of Quality of Service (QoS) settings to tune performance and scalability, while also providing robust security. Finally, the tutorial will highlight recent user experiences with DDS, and offer an overview of deployed systems using DDS in simulators today. This tutorial is intended for all audiences, though some familiarity with distributed computing is recommended.

The proposed format is two classes of 90 minute each. The first 90 minute class introduces DDS core concepts plus DDS Security. Short presentations outlining the main concepts will be interlaced with a fun downloadable demo used as a training aid. Attendees may use their downloaded demo or watch the instructor. No programming is required for the first class.

In the second 90 minute class, attendees will build small test applications to get a 'hands on' feeling for what DDS and DDS Secure offers. For the optional 90 minute 'hands-on' class, an x64 laptop with Windows OS and .NET framework 5 installed, or Ubuntu Linux 20.04 with the 'build-essential' packages installed as well as download and install of the <https://rti.com/free-trial> are recommended.

26 CD5

Wargaming-Simulation Synthetic Environment SWORDOM (RAS use case)

Vincenzo Brucato and Salvatore De Mattia

Analytical Wargames and Simulations usually address different categories of data analysis with their focus more on quantitative data or qualitative data. They are both crucial to the success of any data research and analysis and their collection methods are focused/oriented respectively more on Simulation or more on Wargaming.

In order to capitalize the NATO Modelling & Simulation Centre of Excellence experiences on Wargaming and Simulation it has been proposed SWORDOM, an Integrated Synthetic Environment between two tools, WISDOM and MASA SWORD. The first one has been used to enable digital traditional wargaming activity and the latter has been used to develop a proof of concept simulation for conceptual and capacitive development of RAS within the future operational context. To enable a technical integration between the two tools, High Level Architecture (NETN FOM) and Application Programming Interface have been used.

The presentation is about the proposed SWORDOM (SWORD- WISDOM) Synthetic Environment that can use and leverage assets from both MASA SWORD and WISDOM in order to enhance and create a positive circle between Modelling & Simulation and Wargaming for concept development and for exploring new doctrines with a focus on RAS.

27 CD6

From tactical to operational simulation

Roelof Jansen

Developments in the military domain are largely driven by technological innovations. A constantly changing world demands new methods for analyzing threats and possible reactions, and preparing personnel in the defense against these threats.

Recent events have emphasized the need for NATO defense forces to become more flexible and innovative, with a focus on multi-domain operations and having strong information positions (see, e.g., [1]).

The Royal Netherlands Aerospace Centre (NLR) aims to support this transition by means of simulation and wargaming tools/techniques. So far, simulation support has focused on the tactical level of warfare: e.g., platform maneuvers and weapon performance/effects. Over the last decades, detailed, realistic models have been developed to enable tactical training and concept development & experimentation (CD&E) for the tactical domain.

Moving towards operational simulation, we are gathering current knowledge and insights on the operational level of warfare and available simulations and simulation techniques within this field. A main point of focus is the operational planning cycle. On the technical/conceptual side, we are investigating questions such as (a) how could wargames be supported by means of simulation, and, building on the existing tactical models, (b) what kind of models are needed for simulation on the operational level, and with what kind of fidelity?

In our talk, we aim to present our views and ideas on this subject, and welcome discussion with the audience about their solutions and experiences.

[1] Defence Vision 2035. <https://english.defensie.nl/downloads/publications/2020/10/15/defence-vision-2035>

28 WG2

Wargaming

Thomas Tabaka

Wargaming is the artificial replication of a situation in competition or conflict not involving actual military forces, and is characterized by human decision making which impacts the course of events throughout the game. Wargames usually revolve around the interaction of two or more opposing forces guided by predetermined objectives, rules, data, and procedures designed to depict an actual or assumed real world situation. It is important to note that wargames are not validation tools [1].

Wargaming tests and evaluates courses of action associated with a plan and are further evaluated and validated in planning for and executing of exercises.

Wargaming is a key step in force development. Wargaming is very different from exercises and experimentation. Wargaming is fundamentally about decision making in the context of a conflict. Wargaming provides a venue to examine new and untested ideas without having to invest substantial resources or put personnel and equipment at risk. Wargaming can be utilized for multiple purposes, including training and course of action analysis but is most often employed to assess and refine new concepts, identify capability requirements, and inform priorities and strategies. Results inform further concept development, experimentation, or additional wargaming, all of which contribute to innovation [2].

(1) Perla, P., The Art of Wargaming (2012)

(2) Marine Corps Gazette (2016)

29 OD2

The Military Metaverse. Decision Support, Planning and Operations using XR at a recent NATO event.

[John Nicol](#)

The presentation provides an overview of the use of the BridgesXR framework to visualize and interact with operational data during the NATO CWIX 2022 event at the Joint Force Training Centre. We examine the use of a 3D collaboration environment that allows users to visualize C2 and other information from remote locations as an aid to situational awareness in a multi-domain framework. It is a part of what we have called the Military Metaverse.

30 OD6

Enhancing Resilience: Model-based Simulations

D'Artis Kancs

Enhancing resilience by strengthening the capacity of societies to absorb the full range of threats and hazards is becoming an integral part of the NATO's deterrence and defence posture (DDA). A broader, more integrated and better coordinated approach to resilience is acknowledged in the resilience seven baseline requirements, placing resilience at the heart of the NATO's future strategic approach.

The kinetic adversary Russia has explicitly linked resilience to the possibility of war, reflecting a close integration of the political and military aspects of security. The autocratic regime has sought to instil among the Russian public a degree of resilience to the possible impact of a military conflict. In democratic societies, political leaders need to take responsibility for being fully open with citizens about the changing character of future threats. There needs to be a full transparency regarding the costs and sacrifices that will be needed to defend the security in the face of future warfare.

Ensuring resilience and meeting the resilience seven baseline requirements regarding the core functions of continuity of government, essential services to the population and civil support to the military – which must be maintained under the most demanding circumstances – requires a mobilisation of resources. Resource mobilisation is inherently interdependent with society, critical societal needs must be included within defence capability planning.

The study aims to answer the question how to 'achieve the necessary resilience' while doing as little damage as possible to the society's socio-politico-economic fabric by applying a simulation model for decision support. Analytically, the challenge is framed as a constrained optimisation problem with two constraints – a deterrence & defence constraint and a society's tolerability constraint. Modelling results provide interoperable and credible simulations of the positive and normative effects of counterfactual resilience and mobilisation choices.

The study builds on and complements to the existing STO activities, including the Multi-Dimensional Data Farming, Causal Reasoning and the Aggregated Resilience Model. The study adds value and contributes along several dimensions to the existing modelling and simulation at the Joint Warfare Centre (JWC) that uses the Joint Theatre Level Simulation (JTLS). First, it integrates several Political, Military, Economic, Social, Information, and Infrastructure (PMESII) dimensions in one meta-modelling framework. Second, model-based simulations enable a better understanding of the complexities and provide insights to decision support. Third, the adopted multi-model, multi-element, multi-operation approach facilitates the understanding of the uncertainty and complexity of future military and societal challenges.

31 OD5

Force Comparison to Support Decision

Joseph Merrill and Gerald Thompson

In the winter of 2021, as Russia built up forces on the Ukrainian border, much of the world was busily analyzing the situation. As we worked to apply rigor to the analysis to support planning and leader decision, we found that despite the advancements in the simulation tools available, none had the flexibility to be adjusted as quickly as conditions were changing. Furthermore, the available tools had not been developed to consider engagements between forces both using former Soviet equipment.

Work on a solution to support operational planning had been underway for some time in our headquarters. It focused on simplifying the analysis of combat forces to focus on easily measurable criteria to provide a basis for comparison that could be altered quickly. The tool compares firepower at the system level and aggregates it to the unit level, providing a consistent basis to compare combat potential of units. Due to its simplicity, we were able to adapt it to include Ukrainian forces and provide a correlation to support planning and Commander decisions.

32 AI2

Artificial Intelligence in AirC2 Planning & ETEE

Deniz Yilmaz

As a part of the NATO ACT Autonomy Programme, we have been finalizing a multinational project called "AI in AirC2 Planning and ETEE". The primary goal of the study is to develop concepts which utilize Artificial Intelligence (AI) technology to support AirC2 planning and Education Training Exercise Evaluation (ETEE) processes. The methodology of the study is based on the Human-centered AI canvas, which requires to identify the jobs-to-be-done and achieving human reinforcement by collaborating human activities with machine activities. During the ideation phases of the concept development, Design Thinking principles were followed. A workshop about these principles were demonstrated in a NATO workshop called "Methods to Develop Artificial Intelligence in ETEE" in NATO International Concept Development & Experimentation Conference, in Madrid 2019. In addition, NATO Architecture Framework (NAF) 4.0 has been used to create architectures of the proposed AI concepts of the project.

The project has started with creating an AI portfolio with a two-step search strategy. The first step was identifying the human activities performed during the planning and ETEE processes. Then, the second step was collecting the AI technology literature correlated with these activities. In addition, a major set of foundations for AI systems to be utilized was identified.

Totally nine AI concepts were developed, three per each distinct area; Planning branches in the Combat Plans Division (CPD), the opposing forces cell in the Exercise Control (EXCON), and the training branches for preparing exercise-ready trainees with identified competencies.

As a part of the project, an AI demonstrator was developed to support the human planner. The position to be assisted with AI technology was determined by structured surveys and observations conducted in a NATO exercise. An AI training environment was developed by using a powerful AI training hardware, and an off-the-shelf software with adequate air operation simulation fidelity. Together with the Subject Matter Experts (SMEs), training scenarios were developed and utilized within the AI training environment which contains two distinct AI algorithms; Supervised Learning (SL) and Deep Reinforcement Learning (DRL). After the training period, the AI agent containing both algorithms was deployed in a multi-national NATO exercise. It has showed very promising results, and praised by the human planners.

Finally, the project is concluded with a roadmap, and a vision for a broader future considering the potential emerging technologies with AI technologies to provide new (or enhanced) capabilities for the AirC2 planning and ETEE processes.

33 CD7

The role of M&S to support introduction into service, V&V and training of modern EW systems

Giovanni Scialanca and Luca Pascale

Modern warfare systems and warfighting doctrines rely on the usage and availability of the Electromagnetic Spectrum (EMS). The primary role of Electronic Warfare (EW) is to dominate the EMS.

The lifecycle of a modern EW system includes identification of the operational requirements, design, prototyping, development, Verification & Validation (V&V), training and operational support. All these phases require the ability to generate complex EMS environments that emulate medium to large exercises with multiple emitters, receivers and EW assets, operating at different levels of command, in different potential operating terrains, environments and scenarios. On the other hand, such a complex EMS cannot be generated and transmitted Over-The-Air (OTA) as it would interfere and disrupt signals used every day by commercial and military users. It would also provide opponents with highly valuable information about the technological status and the operational doctrines of its own forces and EW assets. In other words, Operation Security (OPSEC) would not be maintained.

The scope of the presentation is to show the Modelling and Simulation (M&S) framework developed by LOG.IN to simulate complex EMS and EW assets in high-fidelity operational scenarios. The presentation analyses, from a scientific and engineering perspective, the technical challenges faced and the solutions identified for generating in real-time several independent signals; for modelling the electromagnetic propagation and the effect of the 3D terrain; for modelling large operational scenarios with multiple assets. Moreover, the presentation shows the Hardware-In-the-Loop (HIL) architecture implemented using distributed simulation standards, such as the High-Level Architecture (HLA).

Note for the Reviewer: in order to provide a wider operational content to the audience, it is the intention of LOG.IN to add to the presentation a summary of the Lessons Learned from a Five Eyes Country which has recently introduced such an EW M&S COTS capability in its EW branch. This part of the presentation must be vetted first by the Country's Government before LOG.IN can disclose it to the public. For this reason it has not yet been included in the abstract.

34 CD8

Battlespace Visualization & Interaction as a Service

Nico de Reus, Tom van den Berg and Charles Amburn

The Battlespace Visualization and Interaction (BVI) architecture is a US Army Combat Capabilities Development Command (DEVCOM) project focused on researching and developing improvements and innovations in the way humans understand, interact with, and share complex data. BVI leverages commercial off-the-shelf hardware such as projectors, mixed reality devices, tablets, and physical sand tables to display interactive geospatial visualizations in the domains of military training, research, and mission command. The architecture can be run locally or accessed via a cloud-based environment, and is extensible, supporting collaboration through the integration of externally-provided modeling and simulation technologies. BVI can be provided from the cloud by using various client modalities, such as the browser-based 3D viewer and mobile tablet.

BVI provides services for importing all kinds of data, for example, weather forecasts, maritime traffic data, and military unit data into its displayed scenarios allowing for different layers of data. Example layers include weather data with temperature, humidity, and wind velocity, and layers with maritime traffic. BVI imports weather data from the Army Research Lab (ARL) Military Information Sciences (MIS) provided weather model and is able to import maritime traffic from external providers, such as the Netherlands' TNO Institute for Applied Physics.

In a collaboration between DEVCOM, ARL, and TNO to investigate the M&S as a service concept by integrating the ARL weather service and the TNO maritime traffic service with BVI. In this collaboration the maritime traffic service provides Automatic Identification System (AIS) data, which is produced by a simulator (VR-Forces), running in a cloud environment. In this way, two innovations are realized, namely the as a service provisioning of maritime traffic to BVI, as well as the fact that BVI is enabled to view AIS traffic data and weather data using different client modalities. The BVI system, as well as the weather and maritime traffic services, will be presented and demonstrated.

35 WF2

Intelligent operational decision support for the military engineer

[Maarten Schadd and Nico de Reus](#)

This paper describes a proof-of-concept application that aims at providing timely decision support for the military engineer. Abstracting the characteristics of the terrain and integrating these elements into a simulation environment enables the use of AI methods such as genetic algorithms and Monte-Carlo simulations for finding optimal (opponent) behaviour. The experiments show that a good obstacle location strategy can be found that exploits weaknesses of the opponent. Further development should investigate co-learning, vary additional opponent aspects such as the intent, and investigate adequate visualisation of the results.

36 ST3

Scalable Simulation-Based Training with JCATS and JLOD

Mark Piscotty

The demands for computer-aided training for national and multinational conflict and peacetime operations continue to grow in complexity and scope, while budgets and implementation times are simultaneously being reduced. The Joint Conflict and Tactical Simulation (JCATS) and the JCATS Low Overhead Driver (JLOD) systems developed at the Lawrence Livermore National Laboratory (LLNL) provide entity-based simulation capabilities that enable training from the low-level tactical fight up through operational and strategic levels. This presentation will present recent advances in JCATS and JLOD that are enabling training exercise planners to develop and execute effective training scenarios at small and large scales with current and future military systems. Among some of the advances to be discussed are the JCATS web-browser client, a collaborative scenario data generator, and multiple HLA federation support features provided through JLOD. Potential future modeling and simulation features to be discussed include new kinetic and non-kinetic effects across multiple domains such as space, cyber and directed energy systems.

37 OD4

M&S in Operational Decision Support

Jan Mazal

The contemporary highly dynamic operational environment brings many new challenges, which were not apparent before. One of today's significant trends in the military is the continuous pursuit of effectiveness and its improvement in the context of a lack of qualified personnel. Increasing dynamics and complexity of the operational environment will seriously impact human performance in various decision-making tasks, which were intuitively solved in the past with vast application of the human experience and estimation.

Operational problem complexity depends on a variety of other assumptions and criteria, which could be mathematically described and modeled. This gives the motivation for the generic solution development, which could be further optimized and automated, saving human effort and increasing effectiveness in mission management.

38 CC2

NUMERICAL SIMULATIONS TO PREDICT THE DIFFUSION OF CHEMICAL-BIOLOGICAL-RADIOLOGICAL AGENTS IN CASE OF INTENTIONAL OR UNINTENTIONAL RELEASES: THE USE OF FREE LICENSE CODES

[Alba Iannotti](#), [Riccardo Quaranta](#), [Daniele Di Giovanni](#), [Federico Baldassi](#), [Piergiorgio Ventura](#), [Pasquale Gaudio](#) and [Andrea Malizia](#)

Emergency and crisis situations causing the intentional or unintentional diffusion/dispersion of Chemical, Biological or Radiological substances in the atmosphere nowadays is increased because of the industrialization, the flux of people all around the world due to the globalization, the national and international conflicts, and the risk of terrorist actions. The international scientific community, involved in the safety and security aspects related to those events, is requested to work on the reduction of the related risks. To reduce risk, it is necessary to operate on the reduction of the magnitude related to an event and to the probability that a certain event can become real. These aspects can be approached by predicting release scenarios through numerical simulations. In this work, the authors have used: the HotSpot code, which is a free license code to predict the consequences of a radiological release, Aloha, and Marplot codes to predict the consequences of a chemical release, and the SpatioTemporal Epidemiological Modeler (STEM) code to predict the spread of pandemics, and the Infectious Diseases Seeker (IDS) application, developed by the Quantum Electronics and Plasma Physics group of the University of Rome Tor Vergata, for biological events. The results of several case studies as well as the advantages and disadvantages of using those free codes to simulate dispersion/diffusion scenarios will be presented by the authors to demonstrate that, with the proper expertise, the support of these instruments can be remarkable in reducing risks for the population.

39 CC3

UAV measurements to detect CR agents in case of intentional or unintentional releases and to predict their diffusion

Pasqualino Gaudio, Andrea Chierici, Francesco d'Errico, Daniele Di Giovanni, Francesca Fumian, Luca Martellucci, Andrea Malizia, Riccardo Rossi and Piergiorgio Ventura

In the last decades, we have assisted in the rapid evolution of UAV technologies. Many civil and military applications support the first responders in critical areas and these technologies' dual-use can be useful also in environmental applications. The combination with UAV and the use of Chemical and Radiological sensors can certainly solve many environmental monitoring problems in case of CBRNe events.

The use of UAVs and ad hoc sensors box to detect C/R threats developed by Quantum Electronics and Plasma Physics Groups (QEP) of the University of Rome Tor Vergata and the University of Pisa contribute to reducing human exposure to the “red zone” environment. Data collection is important both to detect and identify threats and to determine the hot spot and it is helpful to determine the diffusion of contamination through numerical simulations. These data (experimental and numerical) give a prospect of the contamination helping the advisors to select the proper PPE for the first responders entering the contaminated area with an impact on the risk reduction during the rescue operations

The multi-sensors mobile platform for application in the civil and military environment will be presented with the possible use of swarm drones to improve the capability to identify the emission point of C/R and track the plumes.

40 CC4

VERTIgO project – A PUBLIC-PRIVATE INITIATIVE FOR THE IMPLEMENTATION OF VIRTUAL ENHANCED REALITY FOR THE INTEROPERABLE TRAINING OF CBRN MILITARY AND CIVILIAN OPERATORS

Daniele Di Giovanni, Grace Xerri, Alba Iannotti, Riccardo Quaranta, Andrea Malizia, Piergiorgio Ventura and Pasquale Gaudio

In the last few decades, an increasing number of threats associated with Chemical Biological Radiological Nuclear (CBRN) agents, has driven the need to develop new tools to improve the safety and security of societies and those who employ their protection.

In the context of CBRN scenarios, improving the preparedness of First Responders (FRs) represents the first and most fundamental strategy in pursuing risk mitigation.

Therefore, the definition and development of targeted training activities that are as immersive and realistic as possible is a key objective in improving the future of CBRN protection and response measures. Recent advancements in-game engine technology and in the development of Virtual Reality (VR) hardware and software components, can significantly improve CBRN training through realistic simulations specifically designed for both military and civilian FRs.

In this work, the authors presented the VERTIgO project (Virtual Enhanced Reality for the Interoperable Training of CBRN Military and Civilian Operators), a project funded under the EU's European Defence Industrial Development Programme (EDIDP). Project VERTIgO aimed to develop and implement a multinational training platform for disseminated use among both military and civilian FRs across Europe.

The work presented by the authors discussed the steps followed in the VERTIgO project to perform the study, design, and validation of a European Exercise Simulation Platform (EESP) for the application of VR to CBRN training, complemented by the prototyping of an ad-hoc hardware solution which integrates a VR headset and CBRN mask for enhanced realism and user experience.

41 ST4

Unmanned Aircraft System, Command and Staff Training via Modeling and Simulation in Support of Military Exercises

[James Bowman](#)

The need for training via modeling and simulation continues to increase for militaries around the globe. The increase of technological advancements such as parallel processing and increased memory on Graphic Processor Units has enabled high fidelity and high resolution products which supports immersion for the trainees, thereby increasing operator efficiency. The intent of the presentation will be to share with the audience how technologies have been leveraged to support training for the US and its partners and how modeling and simulation not only reduces costs but allows for After Action Review capability as well as training of specific emergencies and situations that could not otherwise be trained.

42 SP1

Global stability and security pass through space SDA, SSA and SST to safeguard people and resources

Filippo Gemma

Defending the population, maintaining democracy, and preventing conflict also comes through stability and security in space: both to preserve and prevent threats to orbiting objects.

The development of space technology and the exponential growth of objects in orbits around Earth has not been accompanied by adequate regulation of the use of space, especially regarding the management of orbits and space debris. This issue, together with the increase of institutional and commercial actors able to access space and interested in using it, could lead to dramatic scenarios and conflicts, inhibit future access to space and limit the expansion of humankind beyond planet Earth.

In the scenario of instability and challenges for NATO member countries and partners, we need to manage this resource as best we can: identify who populates it, understand how it changes, and save our strategic resources in orbit, also considering that some of the most critical activities in planning and executing military operations take place nowadays in space itself.

GMSPAZIO deals with Space Domain Awareness (SDA) and its declinations: Space Situational Awareness (SSA) and Space Surveillance and Tracking (SST), which are essential to locate, track, identify and assess threats that affect the security of on-orbit assets and their performance, to help safeguard, in the short and long term, space infrastructure, assets and services of strategic importance to the nations involved. A complex challenge but necessary for protecting our future and the investments made in this direction.

Knowing space objects, identifying them, establishing their orbits, measuring their operations, and predicting their future positions in space and time are necessary actions to acquire, evaluate and calculate all information inherent to the space environment. Thus, the first requirement is the need to accurately monitor orbiting objects to assess whether they should be maneuvered to safety or avoided by saving fuel on board and consequently extending the operational life of the mission to which they belong. Without forgetting, however, that it is also necessary to work to counter the proliferation of space debris, keeping track of the effects of collisions or explosions so that we have an updated real-time map of potential hazards during the increasingly frequent launches of space launchers and monitor uncontrolled re-entries into the atmosphere.

Our mission is to support our stakeholders in managing complex situations to ensure the maximum efficiency of their systems while protecting the community's safety against potential risks from the uncontrolled use of space resources.

43 ED4

Rapid Development of Terrain Databases for Use in Synthetic Scene Generation

Matthew Rigney, Thomas Etheredge, Brad Seal and Christopher Porter

High-fidelity, physics-based modeling and simulation for imaging sensor systems requires data inputs and scene generation capabilities of sufficient fidelity to support accurate evaluations of sensor performance. Additionally, the proliferation of AI/ML based algorithms has increased the need for synthetic imagery to augment existing datasets for training. Traditionally, agencies have used empirically collected scene data for both EO/IR and RF system development and performance assessments. However, this limits the developer to scenarios where data can be collected, both temporally and spatially, leading to datasets lacking the high degree of real-world variability of scene data needed to support system design and evaluation.

To address this limitation, the US Army's Combat Capability Development Command (CCDC) Aviation & Missile Center (AvMC) has developed a unique suite of data and scene generation software tools. First, a rapid terrain generation toolset allows for the quick development of large-scale (> 100 km²), high-resolution (0.25 meter, with higher resolution insets) terrain databases for any location in the world and includes terrain geometry, vegetation and manmade objects, and material descriptions. Additionally, CCDC AvMC has developed the Highly Optimized Terrain Thermal Solver (HOTTs), a novel, physics-based thermal solver that includes numerous environmental models, comprehensive shadowing capabilities, and dynamic material variability. This tool allows the rapid generation of background clutter, manmade objects, and target signatures at large scales. Finally, these tools provide the inputs and data for use in CCDC AvMC's Common Scene Generator (CSG). CSG is a multi-spectral, co-registered scene generator with additional libraries including an IR sensor model, countermeasure capabilities, source reflections, maritime capabilities, as well as a simulation framework that allows integration of external component models to create closed-loop simulations.

CCDC AvMC designed each of these tools to work in concert with one another and address the current physics-based modeling and simulation needs for sensor based systems. They have been designed to run on platforms ranging from a local desktop machine to large high performance computing clusters. This paper will outline the unique contributions that CCDC AvMC's suite of tools provides to the modeling and simulation community. These unique capabilities include massive, high-fidelity terrain databases, rapid signature generation for any available terrain database, and the ability to leverage a co-registered scene generator in applications including hardware-in-the-loop, all-digital closed-loop system performance assessments, and AI/ML dataset generation.

44 WF3

Should we be fully committed to Multi-Domain Integration?

Philip Penney, Martin Reinhardt, Roland Bals and Marija Kukolj

As the complexity of the modern battlespace becomes increasingly complex, Global Armed Forces admirably continue to make adaptations in order to perform in the most difficult of circumstances. More must be done to meet the challenges of the developing and changing landscapes however: traditional approaches to both training and operations must be modified.

Historically, platforms work separately. Units plan in isolation. People train alone.

This individualistic mindset restricts military potential: information is being gathered on every platform including satellite; aircraft; drone; ship or land-based systems however we are not leveraging the collective benefits of the data gathered. This data stream must be brought together to produce a single, simplified, yet complete picture of the battlespace. Integration is not about using every capability, every time an enemy is engaged. Integration is about giving a Commander detailed knowledge and awareness of their options so that they can make a fully informed decision when prosecuting operations.

Available technology now enables Multi-Domain Integration. However, for this integration to work, militaries need to support behaviour change. They must begin to integrate by instinct. When staff are training, planning, or conducting operations, a collaborative approach must be sought.

We are best when we think beyond the single platform constraints in which we have worked for far too long.

Emerging technologies with Computer Assisted eXercises containing Artificial Intelligence driven support to decision making, can be developed to re-train the warfighting functions. A single synthetic training platform enables full virtual mission rehearsal. The interoperability between heterogenous simulators can be built upon to allow all the assets involved to be fully prepared and unified. The singular aircrafts; tactical command and control units; and cyber systems will combine to become a fully integrated warfighting machine.

Education and training across all Nations, Services and specialities must ensure that the future warfighter has all the tools to be able to combine the right capabilities, at the right time, to achieve the mission intent. That is why we should all be fully committed to Multi-Domain Integration.

45 AI3

How Model-Based Engineering is Enabling Digital Engineering

[Beaudouin Alexandra and Petrella Vincenzo](#)

Modelling and Simulation enable the virtualization of the system design as well as the system environment, from the component or sub-systems levels, and can be expanded up to the system and higher. It is this higher level where we usually hear about digital engineering. The expected benefits of digital engineering include better-informed decision making, enhanced communication, and increased confidence in the system design, aiming at an overall more efficient engineering process.

Following the path of digital engineering, we can envision new challenges but also communication channels to enable the right choices and increase understanding and confidence in the system design. Using Model-based System and Software Engineering offers an engineering process based on two main pillars: automation and having an authoritative Source of Truth – those pillars can define what is the truth, and who is responsible for it and how it produces the required artifacts automatically.

46 WG4

Distributed Wargaming for a COVID 19 World – A best practises guidebook for NATO (SAS-170)

[Uwe Gaertner](#)

The output of NATO SAS-170, a best practices guide for distributed wargaming, is presented. Since the start of the COVID 19 pandemic in early 2020, NATO and allied wargamers have had to focus on the use of distributed wargaming to continue their work. With members from xx countries and yy NATO organisations, SAS-170 has endeavoured to collect and consolidate best practices for distributed wargaming from the wargaming community. Ideas for best practices have been analysed and fit into a framework that describes the elements of distributed wargaming covering the domains of (1) Communications (2) Environment (3) Control and (4) Engagement. This presentation discusses SAS-170, how its data was collected and how the ideas for best practices have been written into a best practises guidebook for NATO.

47 CC5

Refinement of risk assessment models: toward a more sustainable management of contaminated sites

[Renato Baciocchi, Iason Verginelli and Daniela Zingaretti](#)

Risk assessment is a useful and widely applied tool for the management of contaminated sites since it provides a rationale and objective starting point for priority setting and decision making. Its application in most advanced countries has been prompted by applying the Risk-Based Corrective Action (RBCA) framework, based on the corresponding ASTM standards. The main strength of the RBCA procedure relies on its capacity to evaluate risks to human health through relatively simple fate and transport and exposure models. However, the experience and the increasing knowledge gained over the years have highlighted some critical issues of the RBCA application to contaminated sites. In particular, it is well known that the ASTM fate and transport and exposure models are often too simplified, leading to an overestimation of the risks. In this work, we propose some simple possible refinements that, while keeping the intrinsic simplicity of the ASTM-RBCA approach, could allow a more realistic risk assessment and thus more sustainable management of contaminated sites.

48 CD1

Technology, gameplay and human streams; a framework to support the development of simulation-based wargames

Thomas Mansfield, Pilar Caamaño, Alberto Tremori, Serge Da Deppo and Girish Nandakumar

The Dynamic Messenger (DYMS) operational experimentation exercise, scheduled September 2022, marks a new era in NATO's approach to assessing the effectiveness of emerging and disruptive technologies. As part of this new approach, DYMS22 will utilise the latest version NATO's Disruptive Technology EXperimentation (DTEX) approach to provide an immersive, scalable and adaptable M&S based wargaming capability to support decision making in complex and uncertain environments by blending human, technology and data aspects.

DTEX's ability to be rapidly configured, deployed and made available to support wargaming in DYMS22 stems directly from the project's long-term focus; to reduce configuration time while increasing scalability. This paper documents the design, development, implementation and refinement of a versatile framework that supports the rapid deployment of M&S based wargames in NATO.

The development framework focuses on three parallel lines of effort; the technology stream, the gameplay stream and the human stream. The technology stream focuses on the implementation of tool-sets that not only allow the technologies of interest to be simulated, but also on the agile and incremental design and development of scalable interfaces that allow the players to configure the scenario and analyse data in a range of formats. The gameplay stream focuses on providing players with the right information at the right time, balancing motivation and a desire to win with the need to encourage discussion and elicit insights into the decision making process. Finally, the human stream recognises the fact that the motivational and communication elements of each event need to be tailored to optimise engagement among diverse player communities.

Using DYMS22 as an example of the latest application of the DTEX in NATO, the structure, content and observations that led to the development of a robust wargaming development framework will be presented, discussed and made available to enhance the wider field of M&S based wargaming in NATO.

49 ED2

Combat Model Experimentation on US DoD HPCs

Charles Timm

As part of the broader cloud efforts within the US Army, The Research and Analysis Center (TRAC, of Army Futures Command), is investigating methods to efficiently and economically run their combat simulations in cloud architectures. Additionally, increasing TRAC mission requirements are pushing TRAC to seek larger and more capable classified computing resources to meet demand for increasing study scope and decreasing time available for execution. One promising architecture are the US Department of Defense (DoD) High Performance Computing (HPC) assets. The DoD HPCs are multi-core supercomputers available to all US DoD organizations and select partners. This presentation will provide an overview of an effort to efficiently conduct experimentation using two combat models, the Combined Arms Analysis Tool for the 21st Century (COMBATXXI) and One Semi-Automated Forces (OneSAF), on DoD HPC assets by a team of TRAC and Army Research Laboratory (ARL) analysts. The results of the testing showed a significant time and resource savings over traditional on-premises servers through dynamic load balancing across the HPC's more numerous computer cores. These results will have implications for how TRAC and the US Army will potentially conduct studies and analysis in the future.

50 CT5

Game-Like Terrain, On-Demand: Solving Terrain Challenges Through Enterprise Terrain Management

[Peter Morrison](#)

Traditionally, making terrain for high-fidelity simulation is challenging. Acquiring good source data, storing that data, building correlated terrain for multiple runtimes, synchronizing data between different simulation clients (e.g. dynamic terrain updates) and editing data “on the fly” are all difficult terrain-related tasks that, historically, have resulted in expensive development and long lead teams for delivering high fidelity terrain data to the point of need. New, cloud-enabled technologies are solving these problems, funded through initiatives including the US Army's One World Terrain (OWT) program. Mantle ETM (Enterprise Terrain Management) is a custom-built platform based on proven COTS components and expert design/development services for creating simulated terrain for training, mission rehearsal, visualization and terrain analysis. This presentation will describe how Mantle ETM solves terrain challenges and will present several case studies showing how terrain development is moving to the Cloud.

51 CC6

CBRN decision making

[Erik Juel Ellinghaus and Luca Pinciarelli](#)

A look at the use of simulation to train decision making in a CBRN environment

CBRN – chemical, biological, radiological and nuclear – defence is often equated with respirators and sensors. These are indeed important tools of the trade, but the effects of a CBRN incident, be it weapons based or of a toxic industrial nature, have an impact far wider than what can be solved by correct use of the tools at an individual level.

To limit the operational impact of a CBRN event the training must also address the decision making at higher levels. What are the procedures that are initiated when the first sensor alarms, how is the alarm validated, how should the recce assets be deployed? These decisions and a myriad of others can be played out in the context of software-based table-top exercises where the CBRN effects are only gradually becoming apparent to the players just as they would in real life and where the player actions taken determine the extent to which the true situation is realised, and operations can be adapted and continue.

A case study based on Bruhn NewTech's commercially available CBRN-Sim software is used to describe how realistic CBRN effects can be added to exercises and result in better preparedness.

52 ET1

Extended Reality, Cloud Connectivity and Simulation for Digital Transformation of (Remote) Training

Giovanni Tonelli

In the increasingly demanding sectors of Aerospace, Defense and Security, the objective of guaranteeing the operation and excellence of the systems cannot be achieved regardless of the quality of the training process of both instructors and operational and maintenance personnel who must guarantee such goals.

The technology can heavily help in reaching this excellence: new paradigms promoting full interconnectivity, such as Modeling & Simulation as a Service (MSaaS) and Training as a Service (TaaS), can be implemented to guarantee efficiency, effectiveness and associated cost reduction, while emerging technologies such as virtual, augmented and mixed reality (VR/AR/MR) provide a revolutionary approach to training.

Leonardo, driving the digital transformation of the Group, is developing innovative solutions adhering to these new concepts. Morpheus XR and OCEAN, are examples of interesting solutions to satisfy highly standardized procedures and complex tasks allowing both instructors and operators to have access to increasingly complex and varied content in which simulations and simulators play a great role.

In fact, distributed simulations and shared simulators, managed by OCEAN to provide Virtual Constructive capability, give a great boost to training, enabling new learning methods (both for operational and maintenance purposes), where operators are immersed in a secure immersive virtual scenario using Morpheus XR. The results of simulation, exploiting the HLA / DIS architecture, is used to recreate normal conditions or also extreme situations in which operators learn to operate in single or collaborative ways being fully assisted in operation by remote connection with experts and accessing all relevant documentation stored and referenced securely on a cloud.

Moreover, the success for implementation and operation of such dedicated solutions is predicated on considerations including full connectivity, data ingestion and processing, cloud computing and cybersecurity, artificial intelligence to name a few.

53 SN3

MsaaS supporting interoperability and experimentation activities

Martina Bini

This year NATO M&S CoE provided services for CWIX M&S Focus Area and its international partners through Leonardo's MSaaS cloud Platform: OCEAN.

We worked to settle up a session, where all the provided services by COE were automatically installed, configured, launched and federated.

In particular during the NATO exercise CWIX 2022 we supported the activities within the NATO STO MSG-201 Research and Study Group,

that actually [PROPRIO] aims to introduce M&S services within NATO "Federated Mission Network" (FMN).

Creation, configuration and management of all the assets necessary for tests' preparation and execution were managed by OCEAN.

Its use to support planned activities and interoperability tests between the CoE and its partners brought many advantages:

- Time advantage. We could prepare in advantage. The biggest effort was to build the session: we use this term to indicated the synthetic environment

- that is automatically provisioned and the software deployed on the top of it. Once this environment was correctly setup we just had to use it as many times as we needed.

- every day we would have a totally brand new environment. Since everything was automated by OCEAN, every day with a minimal effort we would

- create from scratch the environment and after tests we would just destroy it. So any mistake would therefore not affect or compromise anything.

- Freedom to risk. Since any mistake would have not have any negative consequences it was possibile to push forward experimentation limit because it would have always been

- possibile to come back and restart everything in few minutes.

- Reuse. Everything that was prepare can be reused next years. Following activities will start from that point, there will be no need to setup everything

- again, we can start building next activities from that.

Interoperability and experimentation activities can be improved thanks to the new MSaaS paradigm which exploits cutting-edge technologies in order to provide

on-demand services.

54 ED3

VR/AR/XR and Metaverse Technologies for Defense and Aerospace

[Seppo Aaltonen and Cassie Syfrett](#)

This presentation will cover the latest developments in virtual (VR) and mixed reality (XR) for defense and the "military metaverse". Key points include:

- Recent case studies of VR/XR implementation in defense and aerospace
- How VR/XR generates superior results in training over traditional methods
- Latest lessons learned and best practices
- Key benefits to be leveraged within the next few years
- Why metaverse technologies are important for M&S
- Market trends

55 ST5

Training Simulation for JOINT FIRES EXERCISE at Brigade Level

The main topics:

The Joint Fires Training Simulation in ITA Arty HQ;

The JFX CAX MEDUSA for BDE JFSE;

The JOINT FIRE EXERCISE STRUCTURE and ORGANIZATION;

PROBLEMS AND SOLUTIONS & Bi SC 75/3 ADJUSTMENTS;

56 OD8

Strategic Wargaming for Senior Decision Makers

[Dr. Kathleen Robertson](#)

Strategic Wargaming can be an invaluable tool to force the critical discussions that need to occur among the senior decision makers. Often the senior people are isolated from the reality of required decisions, not fully recognizing the potential impact on other organizations/stakeholders, and the financial consequences of decisions.

Use cases will include a Port of New York/New Jersey Security wargame which involved senior leadership from the government, to include Coast Guard, Department of Homeland Security, FBI and industry (energy, rail, trucking, financial, pharma) which highlighted the importance of Supply Chain challenges that industry must manage while restricted by government decisions, or lack thereof. Second use case involves the true cost of sustaining a weapon system such as the F-35. As the Services focused on the production and delivery of the platform, the cost of sustainment accelerated to a level not anticipated by the Services and Partner Countries.

57 SP2

ELINT Simulator for detection and localization of a RF signal sources using a swarm of Cubesats

[Ernestina Cianca and Mauro De Sanctis](#)

The presented simulator has been developed for assessing the performance of a swarms of Cubesats in terms of detection and localization capabilities of RF signals. Such RF signals could be:

- radar signals or unintentional RF interferers
- intentional interferers such as jammers, located in territory that are not under our control
- occasional unintentional interferers for terrorism attacks

Using a swarms of cubesats for ELINT applications has the following advantages:

- The possibility to work in swarms allow to have better localization accuracy than with a single satellite, and also higher redundancy (case of failure of one satellite);
- Less complex sensors are distributed over different spacecrafts rather than having one single complex spacecraft; data fusion can be performed on the ground in post-processing. This allows a reduction of the marginal costs with same aggregated performance and higher availability;
- possibility to launch them rather fast.

The simulator has been developed to assess the performance of a specific type of swarms, with specific characteristics, but it is flexible enough to be use also for constellations. As a matter of fact, it could be a useful tool also for the design of a constellation as it allows to assess quickly the performance of different type of constellations, with different orbital parameters, number of satellites etc.

The presentation will first explain the context in which it has been developed and then it presents the simulator, its main characteristics, limits and flexibility.

The simulator has been developed in Matlab and implements a satellite propagator. It takes in input:

- Orbital parameters (position and speed);
- Target information (position on the Earth, randomly generated);
- An error model for the orbital parameters;
- An error model for the synchronization of satellites;

In each step of the propagation, it runs detection algorithms, estimate the target position using TDoA or FDoA or hybrid TDoA/FDoA algorithms; it calculates the error in the target position estimation. At the end of the propagation, an average of the positioning error is provided. The presentation will also show some of the achieved results in different application scenarios.

58 ET4

Explaining Simulation to NATO: The Exercise Use Case

Ryan Squires

Military leaders and staff officers outside of the computational simulation realm often do not have a strong understanding of computational simulation. These individuals often bring strong uninformed biases and fundamental misunderstandings, leading to wasted effort and dissatisfaction with simulation. How can we better explain simulation and the differences in its use cases to leaders and their staff? Focusing on the exercise use case, we propose the concept of the virtual environment. Finally, we offer a few operational level examples as a means to explain key computational simulation processes.

59 CT6

Lockheed Martin - Prepar3D, Extended Reality, & Training at the Point of Need

[Adam Breed](#)

Leveraging the best gaming technologies, commercial software, and defense-oriented integrations - Lockheed Martin is developing new ways to train anywhere and anytime. By combining an open architecture and by building on an advanced simulation engine foundation, a new generation of training devices are emerging that support Extended Reality with an unprecedented level of technical fidelity. Presentation will highlight Prepar3D and how it is being used around the world to develop point of need training devices. Topics include introductions on how to integrate real subsystems, how to get started collecting data to support artificial intelligent integrations and virtual instructors, and how to begin creating immersive training scenarios. By using these concepts and their backing technology, developing high-fidelity training at the point of need is now possible.

60 ED5

Innovative Computer Vision techniques for person reidentification

Gianluca Pompei

The Decision Support Systems, originally based on a-priori knowledge and operational research models, are moving toward the use of data-driven approaches, developed through machine learning techniques. The performance of such systems is thus proportional to the volume of available data and the ability to collect it in a real-time manner to make early decisions. However, a common issue in DSS lies in a restricted vision of the ordinary world's complexity: each system specializes in a particular area of interest, processing its own domain of data and is unlikely to exchange valuable insights with other components. In this paper, a holistic approach to the problem is introduced, where several computer vision models, each having different scopes, are applied on-edge to video streams from both standard fixed cameras and moving devices, in order to interpret a massive amount of data and give a complete understanding of what is happening in a given environment, from a real-time perspective. To achieve this, computer vision models need to operate in at least three domains: the detection of people and their re-identification across different cameras and contexts (People-Focused); the analysis of objects, infrastructures, and their surroundings (Things-Focused); the identification of particular events or behaviors performed by people (Actions-Focused). Moreover, there is a need for a single, high-reliability central system designed to receive and interpret data and make reasonable decisions. The paper illustrates three examples of models applied to the above areas, proving the importance of such a multi-domain approach, and shows an innovative approach for the reidentification in a multi camera environment, with different lighting, point of view and overall conditions.

61 WF4

The use of simulation and C2 in the Danish Army

Per Klembo

The Danish Army uses a variety of different simulation models to train individual soldiers and up to Brigade level leader training. For most of the training, the simulation connects to a C2 system to stimulate it with BLUEFORCE tracks.

This presentation will describe how The Danish Army uses and integrates simulation models and C2 systems.

62 CD9

Using Simulation to Better Inform Decision Making for Warfare Development, Planning, Operations and Assessment. A New Approach to Sharing Models and Simulations Across the Alliance

[Wayne Buck](#)

Using Simulation to Better Inform Decision Making for Warfare Development, Planning, Operations and Assessment. A New Approach to Sharing Models and Simulations Across the Alliance

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Modelling and Simulation (M&S) has been successfully used to support decision-making within NATO for decades. M&S is used in many areas, including, advanced operational planning, capability-based planning, capability and concept development, and to support experimentation and wargaming. M&S takes many forms, from large complex Campaign Simulations designed to be used repeatedly over many years, to simulations built quickly for a single purpose. M&S is a key tool for NATO, but it can be costly to develop and maintain, and requires specialist expertise that is in short supply. M&S is an area where the Alliance's collective capabilities and willingness to collaborate should give NATO the advantage