# NATO MODELLING AND SIMULATION
## CENTRE OF EXCELLENCE
## ROME, ITALY

# Agenda v 2.6 NATOCA2X2 Forum 2023 (DRAFT)

| 2023 | Monday 02 OCT | Time | Tuesday 03 OCT | | | | | Time | Wednesday 04 OCT | | | | | | Time | Thursday 05 OCT | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Time | Rooms | Time | PR1 | R2 | R4 | R3 | R5 | Time | PR1 | R2 | R4 | R5 | R3 | R7 | Time | PR1 | R2 | R4 | R3 | R5 |
| | Set-up (Rooms; Exhibition Area) | 08.00 | Registration | | | | | | | | | | | | | | | | | |
| | | 09.00 | Plenary Welcome Messages | | | | | 08.00 | CX1 | ST1 | CT1 | | WI | AT | 08.00 | OD1 | AI1 | MO1 | WI | MW |
| | | | | | | | | 08.35 | CX2 | ST2 | CT2 | | | | 08.35 | OD2 | AI2 | MO2 | | |
| | | | | | | | | 09.10 | CX3 | ST3 | CT3 | EG1 | | | 09.10 | OD3 | AI3 | MO3 | | |
| | | 10.00 | Coffee break | | | | | 09.40 | Coffee break | | | | | | 09.40 | Coffee break | | | | |
| | | 10.30 | Plenary Keynote / Roundtable | | | | | 10.10 | CX4 | ST4 | CT5 | EG2 | WI | AT | 10.10 | OD4 | AI4 | MO4 | WI | MW |
| | | | | | | | | 10.45 | CX5 | | CT6 | EG3 | | | 10.45 | OD5 | AI5 | MO5 | | |
| | | | | | | | | 11.20 | CX6 | | CT7 | EG4 | | | 11.20 | | AI6 | ME1 | | |
| | | 12.00 | Group picture | | | | | 11.55 | CX7 | | | EG5 | | | 11.55 | | AI7 | ME2 | | |
| | | 12.20 | Lunch | | | | | | | | | | | | 12.25 | Break | | | | |
| | | | | | | | | 12.25 | Lunch | | | | | | 12.35 | Final Plenary | | | | |
| | | 13.40 | WI1 | CD1 | LL1 | | | | | | | | | | 13.00 | Lunch | | | | |
| | | 14.15 | WG1 | CD2 | LL2 | PG | | | | | | | | | | | | | | |
| | | 14.50 | WG2 | CD3 | ET1 | | | 13.45 | Cultural Event (optional) | | | | | | | | | | | |
| | | 15.20 | Industry coffee break | | | | | | | | | | | | 14.20 | | | | WI | MW |
| | | 16.20 | WG3 | CD4 | ET2 | WI | CT8 | | | | | | | | | | | | | |
| | | 16.55 | WG4 | CD5 | ET3 | | CT4 | | | | | | | | | | | | | |
| 18.00 | Registration | 17.30 | WG5 | CD6 | ET4 | | | | | | | | | | | | | | | |
| 19.30 21.00 | Icebreaker (informal) | | | | | | | | | | | | | | | | | | | |

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# Unknown

## Title: Intitial presentation - TBC

Author: Federico Mazzone

Track: WI

Abstract:

# Title: Wargaming on Protection of Strategic Offshore and Seabed Assets

Author: Agostino G. Bruzzone, Antonio Giovannetti, Marco Gotelli, Antonio Martella, Marina Massei, Andrea Reverberi, Wolfhard Schmidt and Anna M. Sciomachen

Track:        WG1

Abstract: The Authors present in this paper a new generation Wargame, titled CAPIAS and developed by SIM4Future a spin off of Genoa University as well as member of Simulation Team in synergy with other subjects; CAPIAS Wargame was created to be used for multiple purposes; indeed CAPIAS addresses main focus is on the protection of Strategic Assets at Sea, both offschore and on the seabed; these critical infrastructures include Underwater Cables (UW Cables), UW Pipelines, Seabed Fields, Offshore Platforms, Offshore Windfarms. Therefore this Wargames addresses also the Education and Training of Strategic Decision Makers in this field as well as the understanding of the second effects related to the attacks on these assets. CAPIAS Wargame reproduces many different entities operating on the Seabed, Underwater, on the Sea Surface, on Air, on Space and on Cyber Space.

The CAPIAS Wargame is characterized by very innovative elements including the fact that it relies strongly on the combined used of an advanced Simulation Framework integrating Artificial Intelligence (AI) to reproduce and direct many units (e.g. over 250 entities including divers, submarines, AUV, ROV, USV, UAV, vessels, patrols, SWATH, frigates, commercial ships, real and fake fishing boats, helicopters, satellites) to protect or attack over 200 targets (e.g. Pipelines, Cables, Oil Rigs) in physical or cyber way. CAPIAS uses Simulation Team IA (Intelligent Agents) to direct the actions of each Units on the operational and tactical levels while the Players operate on Strategic Issues. Therefore, the IAs cover both Red and Blue Players, acting and reacting autonomously based on the higher level tasks assignments provided by Humans on CAPIAS Chessboard, the Strategic Framework of the Game. In STRATEGOS Chessboards the Players consider the dynamic evolutions of the Scenario, new Events and Reports to take their Decisions. Indeed, CAPIAS Chessboard and Simulation interact each other within the Wargame through the ST N2HLA Gateway (Simulation Team New Networking and High Level Architecture) that support the creation of Simulation Federations even open to interoperate with other Models or Systems. The Players operate on a limited number of entities to simplify their decisions: 2 cyber entities, 2 on air level, 2 on surface and 2 underwater for each side. These CAPIAS Chessboard Entities are specifically devoted to define actions for red attacks and for blue defense; therefore these entities move over a main Offshore Chessboard reproducing 6 domains (seabed, UW, sea surface, air, space, cyberspace) where the entities movements correspond to high level tasks to multiple units or groups on the CAPIAS Simulation Framework; these tasks are acquired and executed as operational orders at that level; at the same time the actions on the Simulation Framework affect the Strategic Impacts on Short and Medium Terms and require the Players also to act on other Strategic Chessboards that represent the actual Critical Infrastructure Status, the current Economic Damages (i.e.Wind Power Generation, Oil & Gas Extraction, Pipelines, Cables, Overall Society), the Risk of Future Inducted Crises (i.e. Energy, Network & Communications, Finance, Jobs, Consumer Demand), the Catalyst Actions at Political, Intelligence and Media Level and the Military Escalation Status. The Escalation in current basic game of CAPIAS is fixed as "double take" exercise, preventing explicit actions as well as evident engagement of units showing up their flags. The two Players act on their Chessboards and register the situation evolution on the scenario and on Strategic KPI (Key Performance Indicators), while their perception results affected by Fog of War, including all complexities related to non conventional Naval and extensive UW Operation, as well as use of Autonomous Assets and Cyber Actions on multiple domains (e.g. hijacking a big cargo by gps spoofing to redirect the ship as a bomb against an offshore platform). By the way, Blue and Red are usually composed by 3-5 members and the Wargame Full Configuration includes extensive use of multiple platforms, from smartphones of Players that are federated with the main simulation, to Augmented Reality Hololens synchronized with the ongoing game, but also with a physical scenario in scale including some 3D Printed not moveable assets (e.g. oil rigs), big common sceens, personal screens for each players and multiple physical chessboards for sharing hypotheses as in a traditional board game aligned with the Simulation Framework; this very innovative approach allow to play this Wargame fully integrated with the computer simulation or just partially, allowing each single Player to visit the virtual world by XR (extended reality) with sophisticated headsets or basic smartphones thanks to the ST N2HLA Gateway that guarantees high performance in very flexible way over a very complex scenarios including several hundreds of advanced assets; by the way each one of this assets includes his own cyber components and corresponding vulnerabilities in terms of integrity, availability and confidentiality that propagate, or are corrected, by the Simulation Cyber Actions and Operations. The Basic Scenario of CAPIAS Wargame presents very dense and intensive situation to transmit the players the complexity and impacts of this context and to experience how to play in it. Multiple scenarios also including other entities, such as FPSO (Floating Production Storage and Offloading Unit) or very wide UW Pipelines and Data Lines; additional scenarios could be created on demand by users, while currently the Simulation Team is developing synergies with major Operators and Institutions for the use of this Wargame series. The CAPIA Wargame introduces the high level decision makers also in the innovative concept of Strategic Engineering: the new discipline that combines Modeling & Simulation (M&S), Data Analytics and Artificial Intelligence (AI) in closed loop with the field to support Decision Makers in better understanding and investigating the challenges and winning strategies. This is very important to learn how to deal with AI and IA as well as to transform the approach while playing the new warfare scenarios due to technology and context advances (e.g. autonomous systems, cognitive warfare, STRATCOM related to Strategic Assets attacks). So it is not surprising that CAPIAS Wargames resulted as one of most appreciated Wargames presented at recent NATO Wargaming Initiative organized in June 2023 based on final public debriefing.

# 56

## Title: Integration of Wargaming with Modelling and Simulations: Theory and Proof of Concept

Author: Peter Dobias

Track:        WG2

Abstract: Generally speaking, wargames are tools for exploring human decision-making in a complex environment, and with incomplete and imperfect information. They can provide important insights into military operations or can be used to generate novel ideas.

Traditional wargaming approaches, however, face potential limitations in representing cross-domain operations, especially if these span multiple distinct spatial and temporal scales across multiple warfare levels. In such a case, currently the only feasible approach would be to select the largest scope and the highest resolution to accommodate all the involved scales.

We have designed a multi-layered approach to wargaming based on the renormalization theory. The latter was designed specifically to deal with multi-scale problems in physical systems. This approach enables representing variety of warfare scales within a single wargame, while avoiding the overhead that would have arisen from trying to represent desired scenarios at the finest resolution required for all involved temporal and spatial scales. At the same time, this approach allows for, at least conceptually, integrating modelling and simulation within a broader context of a strategic game. The simplest case of such integration in the case of two distinct tabletop wargames was demonstrated in the course of developing a NATO Intermediate Force Capability Context; this was then followed by a proof-of-concept game combining again two layers of gaming, however, this time leveraging a constructive simulation for the operational scenario.

Currently, a research project is underway incorporating multiple distinct tactical vignettes represented through different wargaming and simulation approaches within a single strategic wargame representing a major crisis development between two power blocks. In our presentation we will summarize the theoretical frameworks, and then we will describe the three case studies of implementing the multilayered approach to practical problems.

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**Title: TBC**

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## Title: TBC

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# 22

## Title: Refining strength ratio estimation tools thanks to tactical simulation

Author: Aurélien Brucher and Mathis Mezin

Track: CD1

Abstract: Along the Military Decision Making Process (MDMP), the strength ratio estimation is still a relevant tool, in order either to compare courses of action (COAs) or to ensure that the own situation remains favorable at a critical point of the manoeuver. It is basically a guideline which avoids building nonsense COAs.

Currently, an excel workbook with reference data is used, but it dates back to 20 years ago. It is quite similar to a method used in the Royal Army at the same time. But the detailed computations yielding the reference data (points of strength, corrective factors) have been lost, and it has become too difficult to integrate new assets or new types of units or tactics.

The Strength-of-Ratio (RAPFOR) project, executed by the Digital office of the French Army general staff, is aimed firstly at comparing existing reference data with simulation results.

The simulation tool is SOULT, the french version of MASA's SWORD. This tool is already used to train Command Posts (with national parameters on main features of tactical assets and on behavioural models).

In a first time, it is intended to check whether the simulator generates results with a random range matching the expected outcome. It will also be controlled whether AI simulating units produce a sensible and low-deterministic behavior, so that the doctrine must not have a too strong influence on the computation (apart from modeling the reactions). This influence will be assessed with metrics.

Then, a set of basic scenarios (vignettes) will be created. They will consist only of major assets, without being influenced by other factors like logistics, engineers (obstacles, …), etc. …

This will allow, by choosing a reference equipment, to create a point of comparison. It will allow to measure a ratio estimation compared to other equipment or the effect it will bring on others, such as artillery on an attack maneuver.

The scenarios will be repeated N times in order to smooth the results on sets of values via some third-party tools.

As a result, a reference table similar to the existing one will be computed. It will be faced to results of real manoeuver outcomes, under control of the Army Doctrine Center.

Later, if this proof of concept is doing well, a more dynamic approach will be built, with an integration process of the results into the doctrine.

# 33

## Title: State of the art and future developments of M&S supporting ElectroMagnetic Spectrum Operations.

Author: Piergiorgio Ventura and Salvatore De Mattia

Track:        CD3

Abstract: The electromagnetic environment is an essential element for the understanding and conduct of future military operations. Its transversal characteristic permeates the operational scenario in a multi-domain perspective and, therefore, the comprehension and management of this physical dimension is crucial.

The NATO Modelling & Simulation Centre of Excellence (M&S CoE) has developed a project called "ELMO" (Electromagnetic Layer for Multi-domain Operations), which aims to create a synthetic environment for the virtualization of the so-called ElectroMagnetic Spectrum Operations (EMSO). In this context, M&S expresses flexible characteristics for the implementation of complex electromagnetic multi-domain scenarios, able to make visible in the scenario what is not visible or detectable in a real world environment. This feature would simplify the understanding of the main electromagnetic spectrum parameters and enhance the operational and informative characteristics that the electronic assets provide within the Electronic Warfare context.

The EM layer was built using the Software Tool Kit (STK), developed by the AGI Company, and MATLAB, developed by the Mathworks Company. The integration of the two tools was exploited to generate ad-hoc synthetic military components such as Jammers and Radar Warning receivers.

A specific scenario was then built in order to simulate a military EM environment, where the STK synthetic assets, such as satellites, radars and communication systems, interact with the military components developed in MATLAB. The EM layer generated by the MATLAB-STK integration successfully provides a comprehensive visualization over time of the entire electromagnetic spectrum on the battlefield.

The Future activities to continue developing the ELMO project will also be described. The general idea is to wider the use of the layer in terms of capability to exchange information with other tools within an architecture to use several M&S tools, including Computer Generated Forces tools and a cyber tool, and to exchange information with real systems (Hardware in the Loop – HIL). Another line of developing will be to include other different bands (Infrared and Optical) and develop digital twins of other military components. The approach :

• M&S interoperability with High Level Architecture (HLA);

• M&S interoperability with Application Protocol Interface (API);

• Develop the Electro-Optical and Infra-Red scenario;

• Develop the Cyber ElectroMagnetic Activities (CEMA);

• Hardware in the Loop and real signal use within the layer.

# Title: CBRN activities within Modelling & Simulation: state of the art and future developments

Author: Piergiorgio Ventura and Salvatore De Mattia

Track: CD

Abstract: CBRN Modelling & Simulation in support of military activities has not been fully exploited to its maximum potential; the pillar to be exploited are, namely, Education and Training (Exercises), Support to Operations, Planning (Course of Action Analysis), Execution (Decision Support), Mission Rehearsal, Concept Development & Experimentation (CD&E) and Procurement. The purposes of this work are:

• identify what could be provided by a comprehensive CBRN layer (nice to have) considering what the current technology could allow and considering the current doctrine;

• analyze the existing documents, tools and experimental activities related to CBRN modeling and Simulation, compare them with the needs identified and therefore identify the further improvements that should be arranged to cover the gap (gap analysis);

• identify what should be done to cover the gaps in terms of real experimental and practical activities, starting from this updated technological analysis.

This innovative approach, which would integrate the existing tools and provides those not yet developed, could represent a powerful M&S asset to fill the gap of this military problem. The purpose of this project is then, also, to identify a proof of concept to develop and test, in a synthetic environment, a CBRN layer, integrating the available tools, such as HPAC or Computer Generated Force Tools, to maximize their capabilities and to develop the requested Application Protocol Interface (API) and even develop new SW to perform missing CBRN related activities. Just to give an example, it should be possible to determine the effects of chemical compounds on military units or developing a plug-in software to integrate the existing database and perform specific computations.

# 39

## Title: Developing a Campaign Analysis Toolkit for Wargaming

Author: David Mickler

Track: CD4

Abstract: Northrop Grumman has developed a commercial simulation product called WarCat that provides campaign analysis support for wargaming and force structure level analysis. This capability has been developed by Andrew Turner, PhD, our Campaign Analysis Lead, and President of the Military Operations Research Society (MORS). His team has applied years of research and experience to develop a physics-based simulation that uses statistical computation methods to provide force-level analysis over campaign timescales. This includes the ability to compute logistics, basing, fuel, and mobility requirements for planning purposes. The team has combined the campaign analysis capability with commercial graphical user interfaces that enable multiple users to interact together in a simulation-supported wargame framework. This development enables users of WarCat to move from paper-based "table-top" wargames to simulation enabled events that employ modern compute power to increase the speed of learning for participants. Northrop Grumman has developed WarCat using open source-based code and computing language libraries like Python, Java, and SQL. The statistical models do not contain ITAR material. The proposed presentation will provide additional detail on the development of WarCat and step through user screen snap-shots that show how the capability could be used to improve the wargame and military planning experience across NATO and member nations.

# 42

## Title: Multiobjective Optimization of NAF Generated Simulation Architecture

Author: Omar Hammami

Track:       CD5

Abstract: The NATO Architecture Framework (NAF) provides a standardized way to develop architecture artefacts, by defining:

• Methodology – how to develop architectures and run an architecture project ,

• Viewpoints – conventions for the construction, interpretation and use of architecture views for communicating the enterprise architecture to different stakeholder,

• Meta-Model – the application of commercial meta-models identified as compliant with NATO policy. The NAF is intensively used for new defense programs allowing the design of new weapons architectures. However, the evaluation and comparison of various architectures cannot be done with NAF and requires a simulation step.

We propose in this paper an automatic generation of simulation architecture from NAF with multiobjective optimization.

**#        48**

## Title: High-Rate Software Simulation of Complex ELINT scenarios: technical challenges and possible solutions

Author: Giovanni Scialanca and Luca Pascale

Track: CD6

Abstract: ELINT is the Electronic Warfare discipline which aims at gathering intelligence information from the electronic surveillance of RADAR signals. The ability of simulating complex ELINT scenarios which include the electromagnetic activity of several multi-mode RADARs and ELINT systems and, the effects of weather conditions, terrain profile and platforms' dynamic is a key element for the design and validation of modern EW systems. Moreover such simulation capability allows performing immersive EW operator training and validation of EW libraries.

Traditionally the simulation of ELINT scenarios was performed using expensive and complex hardware-in-the-loop (HIL) architectures. Today, the availability of high performance computing platforms at a reasonable cost has opened the way to the implementation of Digital Twins of RADAR and EW systems, using a full software architecture. In this context LOG.IN engineers have been developing a software suite which will allow simulating dynamic ELINT scenarios with multiple multi-mode RADARs. The main technical challenge of the project is the development of the Pulse Sequencer, which is a software module that will enable the generation of Pulse Descriptor Words (PDW) at high-rate to simulate densely populated ELINT scenarios. The presentation shows from an engineering perspective the status of the development, the technical challenges and the possible solutions identified.

# 24

## Title: JTLS-GO At 40 - Case Study Of Extending The Lifespan Of A Simulation System

Author: James Southern and Ellen Roland

Track:          LL1

Abstract: The Joint Theater Level Simulation - Global Operations (JTLS-GO) started development in 1983 long before operational military commanders believed it was possible to conduct computer-aided exercises. It was the first joint wargaming system, capable of supporting the Operational Plans for a military theater of deployment. As part of this 40th development anniversary, the JTLS-GO Development Team has taken some time to stand-back and ask why JTLS-GO is still an active, forward-thinking, constantly improving simulation system.

Given the excessive cost of building a new simulation system from scratch, it is important that managers plan for extending the lifecycle of their supported projects. This presentation will assess what JTLS-GO has done right over these past 40 years and also review the development missteps from which the project still survived. Although many view the term "legacy" as a negative, the insights gained from JTLS-GO should be considered by other simulation projects to extend the lifespan of these simulation systems.

# 32

## Title: Modernizing the Synthetic Training Environment Ecosystem through Common, Standards, Architectures & Integration Patterns

Author: Amit Kapadia and Rick Osborne

Track: LL2

Abstract: The United States Army is accelerating the modernization of its systems to outpace rapidly evolving threats as part of Multi-Domain Operations (MDO). As part of the critical lynchpin to achieve advanced training readiness, the Army must employ innovative, agile and flexible approaches to dynamically instantiate effective, efficient immersive operational training environments. The Program Executive Office Simulation, Training, and Instrumentation (PEO STRI) is currently executing a novel holistic approach to rapidly design, develop, and deliver the Synthetic Training Environment (STE) which could be used as an exemplar for other Army and Department of Defense (DoD) organizations. Leveraging lessons learned from past programs, the STE reinforces a common core software architecture, infrastructure, and extensible integration framework to enable a more immersive and blended multi-echelon training environment that traditional Live-Virtual-Constructive approaches lacked. STE software is the "operating system" for the Reconfigurable Virtual Collective Trainer (RVCT), Soldier Virtual Trainer (SVT), STE Live Training Systems (STE LTS), and Next Generation Constructive (NGC) Army programs of record providing common capabilities, tools, models, behaviors, and architecture to prepare our Warfighters from Soldiers to Echelons Above Corps.

To rapidly and incrementally deliver STE, PEO STRI has speareded and is executing to the following multi-faceted approach:

* Tailoring agile/scrum processes to iteratively assess effectiveness and dynamically evolve the capability which includes recurring Soldier Touch Points (STPs) to ensure right-sized and prioritized development on time.

* Selectively licensing COTS based solutions and adapting them to an open architecture.

* Replacing legacy simulation middleware with cloud native solutions and technologies.

* Promoting reuse and leveraging validated legacy combat models and simultaneously "strangling" them to an open and modern architecture.

* Deploying STE services to modern infrastructures, to automate software delivery, scaling, and increase resilience to achieve Continuous Integration/Continuous Delivery (CI/CD).

* Monitoring STE with open-source observability software to automated collection and visualize time series metrics to proactively address software issues.

* Distribution of STE Platform Development Kit (PDK), providing co-developers with architecture, APIs, and code examples to rapidly integrate, extend and re-use STE core software.

This paper presents PEO STRI's trailblazing approach for rapidly developing and delivering the STE software to date. It provides details of the multi-faceted approach mentioned above as well as the challenges encountered, and lessons learned. The many innovative practices outlined in this approach can be adapted by other organizations, programs, and systems seeking a pathway towards their modernization objectives.

# 57

## Title: Advancing NATO's Modelling and Simulation Education: Exploring the NATO M&S COE's Courses, Tools, and Future Developments

Author: Dino Tropea

Track: ET1

Abstract: The NATO Modelling and Simulation Centre of Excellence (NATO M&S COE) plays a unique role in delivering modelling and simulation (M&S) courses. This presentation will provide an overview of the NATO M&S COE's current M&S courses, the resources, tools, and software used during the courses, and the expected changes in the development of existing courses and the organization of new courses according to NATO requirements. The presentation will also discuss the limitations of the NATO M&S COE's education and training efforts.

# 11

## Title: Educational Computer Assisted Wargaming (EdCAW) - Current Situation and Prospects

Author: Panagiotis Balaskas

Track: ET2

Abstract: The presentation will be focus on the educational computer assisted wargaming (EdCAW).

First will be analyzed the differences between CAX exercises and educational wargaming giving to the audience the opportunity to consider the prerequisites that they need during the preparation - execution and after-action review analysis.

There will be an analysis of different modes of EdCAW that we are capable to organize and run pointing to the possible asymmetric threats for each type.

Finally, there will be an available time of 5-10 minutes for questions.

# 16

## Title: Army Simulation Operations Officer Training and Education

Author: Jeffrey Hodges

Track:        ET3

Abstract: US Army simulation operations officers serve in various decision support, modernization and readiness positions across the Army and Department of Defense, at all echelons of command. These many positions are accompanied by different expectations within each organization that the simulation operations officer is assigned. Critical operational tasks that the commander expects the simulation operations officer to perform are constantly evolving. This requires the Army Modeling and Simulation Office (AMSO) to constantly reassess education / training courses and curriculum to ensure that the simulation officer is prepared to thrive at any assigned position.

This paper will discuss changes to three primary courses offered by AMSO: the Simulation Operations Course (SOC); the Intermediate Simulation Operations Course (ISOC); the Advanced Simulation Course (ASC). The paper will highlight how the school identified emerging education and training requirements, and how the staff and faculty designed and implemented the updated version of each of the courses. Finally, the paper will discuss how AMSO supports on demand learning for Army Modeling and Simulation professionals across the enterprise.

**#**     **36**

# Title: A Military Gamification Model

Author: Adriano Pantaleo

Track:     ET4

Abstract: As technology continues to innovate, training and education always seem to chase after the acquisition and diffusion of new skills involving human-computer interaction. As a contribution in solving the training/educational problem of military contexts about the lack of a culture of failure reported in a previous NATO CA2X2 paper produced by Wolfhard Schimdt, military gamification is proposed.

Military gamification is a predictive research product generated through a correlational study between the game-based motivational design elements belonging to Chou's 2015 Octalysis model and the military motivational factors belonging to Pakozdi and Bardos 2022 pyramid model. The military gamification model presented is intended for the design and/or analysis of training/education experiences in a military context.

#       5

## Title: Legal Play in Exercises and Wargames

Author: Erdal Çayırcı, Najla Haza Alhajri and Sara Mubarek Alhajri

Track:         CX1

Abstract: Legal advisers are among the key contributors in wargames and exercises. Their support is both to directing and conducting audience, and broadly categorised as legal advice and legal play. Legal advice can be related to real life issues, such as, about the legal implications of a memorandum of understanding and the compensation of various actions. Legal advice can also be about scenarios including main incident list, such as, the compliance with national and international laws. Controllers and players especially in operational and higher level command post wargames and exercises may very often seek for legal advice on their decisions. During the conducting stage, legal players have the following major roles, observer/trainer, protagonist and role play. In foundation training before the execution, a good coverage of the national and international law is typically necessary. In execution, various legal injects can be made as a part of main incident list, which requires role play. Apart from this, legal advisers can always bring up the legal issues and implications related to every action taken by the players/training audience even when the action is not directly related to a legal play. In this presentation, we first explain the significance of legal content. We elaborate on the international law and the law of war. Then, we focus on the tasks related to legal advice. Later, we give the details about the dynamics of legal play during the conducting stage. Finally, we conclude our presentation.

# 13

## Title: CAX issues/challenges – the JFTC M&S perspective

Author: Jacek Sumislawski

Track:    CX2

Abstract: The Joint Force Training Centre (JFTC) is, aside of Joint Warfare Centre (JWC), one of the two NATO's training establishments.

Since 2004 the JFTC has been conducting training and exercises for NATO Command Structure (NCS) as well as NATO Force Structure (NFS). The variety of events delivered by JFTC span from mission pre-deployment training to the NRF exercises. Many of them were conducted in the form of Computer Assisted Exercise (CAX) and therefore contributed to the knowledge base and experience of JFTC personnel. Although continuously improving the processes they still find some challenges when planning, preparing, and executing CAX events and it is worth of sharing some of the issues as well as discuss possible mitigations.

As CAX is a very complex project itself and may vary significantly one from another also the issues found in the process are different and have different impact on various occasions. They include things like CAX Databases development process and availability of Computer Information Systems (CIS) resources but also workforce is coming to the play when preparing a CAX.

Big role in the CAX design is falling on the educational activities prior to CAX execution to enable understanding of simulation use in an exercise and managing expectations.

The role of OPFOR and the way it is portrayed and played during an exercise is another big concern not only in CAX but in the military exercises in general.

While some of the issues/concerns were mitigated through the application of proper processes or modification of existing ones, some others still require a serious reflection and improvements to be applied.

Nonetheless all the improvements developed so far and those yet to come have to be properly stored and distributed to broader group of CAX planners. Thus, JFTC M&S personnel actively participate in working groups such as MSG-216 to review the AMSP-05 ("CAX Handbook) and contribute with inputs to the review of Bi-SC directive 075-003, Collective Training and Exercise.

It is obvious that not all the challenges can be addressed with the current state of technology available and therefore JFTC M&S personnel participate in activities like NATO Next Generation Modelling and Simulation Capability Program to provide NATO CAX perspective to the group. Also, two of the JFTC M&S personnel are conducting under the ACT sponsorship their doctoral research addressing possible future solutions to CAX-related issues.

# 17

## Title: M&S Support to the Ukrainian Land Forces

Author: Thomas Lasch

Track: CX3

Abstract: During the period of December 2022 through May 2023, a private, volunteer effort was initiated to provide M&S support to the Ukrainian Land Forces for the purpose of expanding its ability to provide trained combat formations to fight illegal Russian aggression in Ukraine. This presentation will outline what was provided and how it was provided to the different entities fighting the war on illegal Russian aggression and occupation of the Ukrainian national territory. The initiative, which was comprised of two persons, a Swedish citizen and a U.S. citizen provided limited free licenses for various simulation and tools for the purpose of expanding the Ukrainian Land Forces and National Defense University's ability to the provide low-overhead simulation support to Battalion and Brigade headquarters as well as military cadets. The desired end-state of this effort revealed a marked increase in simulation capability across the Land Forces as well as the National Guard of Ukraine and National Border Service forming similar capabilities.

# 54

## Title: Understanding complex Common Operational Pictures through Artificial Intelligence

Author: Hans ten Bergen

Track:        CX4

Abstract: Understanding complex Common Operational Pictures through Artificial Intelligence

Constructive simulation is providing the user with a lot of information. Complex information. This is clear to see when we look at the Common Operational Picture of a simulation scenario. There are vast numbers of entities represented on the map. There are all kinds of lines and objects drawn on the map. Units are engaging each other and there is much more information to be absorbed by the human brain to draw clear conclusions from this Common Operational Picture.

We are facing too much information to work with and to evaluate or analyze a certain situation. Both during the execution and the After Action Review of a training scenario, wargame or an analysis.

MASA Group has worked more than two years on developing something to solve this. This new approach is primarily meant to start making sense again out of the melee of information, out of a too complex Common Operational Picture, we are looking at.

An initial research project was started years ago. And this has now eventually led to the introduction of two new tools. This real introduction to the market is planned to take place before the end of this year.

The two new tools are basically centered around:

1. Making the Common Operational picture more 'readable' through extracting smart-layers. Smart layers are sub-sets or sub-pictures of the Common Operational Picture zooming in on a certain theme or aspect, such as direct-fires, local force ratio or sensor capabilities.

2. Scores or Key Performance Indicators that are extracting information from the lower level artificial intelligence and providing information about for instance availability of stocks, number of people wounded, damage to equipment, civilians and military contaminated by CBRN instances and so forth. They tell the story of what is happening. This information is available in numbers, that can be exported during a scenario and After Action Review, but they can also be shown in a graphic way to show the evolution of a training scenario or analysis. Scores can be combined and made visible in a dashboard.

# 27

## Title: Modeling and simulation in support of military decision-makers in the Romanian Army

Author: Cezar-Adrian Parascan

Track:       CX5

Abstract: Today's security environment presents a challenge that can change the way we approach the preparation and training of military leaders. In this sense, a good part of the future military activities represent changes in the way of preparing the commander and the general staff in the way of applying the tactics and procedures of conducting military actions. Thus, a good method of testing and validating new procedures is the use of modeling and simulation in identifying the possibilities of conducting military actions in an environment that does not respect doctrinal principles.

The most effective method in training and applying the new standards that define the strategic environment from an operational point of view is to organize and conduct a CAX-type command exercise using constructive simulation. The organization of such an activity is not a novelty, but the way of correlating the challenges and including them in the created synthetic environment is the key to understanding the new challenges regarding security environment.

In this context, we believe that the use of M&S in computer-assisted exercises is an effective method of training commanders and staffs in the application of new tactics and procedures used on the battlefield.

At the national level, the Romanian Army uses all types of simulation (real, virtual and constructive) for the preparation and training in the land, air and naval environment of national and multinational force packages.

Our presentation will focus on the Wargaming and Doctrine Experimentation Centrer's capabilities for organizing and conducting activies using constructive simulation.

# 38

## Title: Simulation use in training Ukrainian Armed Forces Leaders and Staffs

Author: William Schustrom and Mark Madden

Track:        CX6

Abstract: The use of simulations in military training is a proven force multiplier that enables units/organizations to meet their training objectives in an accelerated, efficient, and cost-effective manner. This presentation will explain how the U.S. Army Europe-Africa's Joint Multinational Simulation Center (JMSC) is using simulations to support and enhance the training of Ukrainian Armed Forces leaders and unit staffs. Specifically, the presentation will focus on the use of U.S. Army's low-overhead Division eXercise Training and Review System (DXTRS) to train battalion, brigade, and division staffs, as well as the use of Virtual Battle Space 3 (VBS3) to train artillery call for fire, land navigation, as well as small unit leader planning and tactical decision making. This presentation will also cover lessons learned and planned changes to make simulation use more effective in the future.

# Unknown

## Title: TBC

Author: Mr. Ivan Vianello

Track: CX7

Abstract:

#      6

## Title: "QUANTUM" Evolution in Europe - The Future of Cybersecurity

Author: Giovanni Gasbarrone

Track:      MO1

Abstract: 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.Next generation Cybersecurity : the reason why for Quantum Communication

• The cost of network attacks is doubling every few years

• An increasing need is envisaged for the development of disruptive applications in the areas of cryptography, cyber-security

• Finance transactions, public Telco Infrastructure and Defense communications may be secured with "quantum technologies" : Quantum key distribution (QKD) Quantum machine learning based on artificial intelligence application ;

• The EU strategy : the EuroQCI infrastructure

• It will integrate quantum cryptography and innovative and secure quantum systems into already deployed telecommunications infrastructures, enhancing them with an upper layer of security based on quantum technologies. The telco infrastructure architecture are already based on a terrestrial segment relying on fiber communication networks connecting strategic ICT nodes at national and European level. The space segment is based on commercial and defense satellites, and it will provide additional links for national and cross border quantum communication networks across the EU and worldwide

# Title: An interoperable generic tool for simulating attacks within the cyber domain

Author: Garratt Weblin, Jon Denny and Matt Tipper

Track:        MO2

Abstract: In today's world, the constant threat of cyber-attack has grown substantially. Creating the need for realistic cyber training, enabling trainees to practice different scenarios in the safety of a simulated environment. This could range from modelling cyber behaviours and how they affect simulated assets, to Red vs Blue cyber duels where teams battle for control.

To aid development of interoperable cyber simulations, a SISO study group has developed a new standard, Cyber Data Exchange Model (CyberDEM). An ontology that provides a common representation of cyber-attacks, events and objects to be used in simulation of the cyber domain.

As part of a Defence Science and Technology Laboratory (DSTL) research project, Pitch Technologies investigated the extent of the standards usefulness, given a specific use case based on real world scenarios. A high-level demonstration was created, using HLA, showing how the cyber domain could be simulated and integrated into existing simulations. This demonstration made use of multiple cyber-attacks to disrupt simulated government assets. A reusable generic cyber attacker was created, enabling cyber objects and interactions to be simulated inside a HLA federation. Future work with CyberDEM could involve linking Red vs Blue and cyber influences software, enabling collective training. As well as integrating CyberDEM into existing simulation solutions.

The CyberDEM standard enabled the modelling of the given use case, to a high fidelity. Some interoperability challenges remained, as the standard is open to interpretation, it could be implemented in different ways, giving different results for the same events.

CyberDEM and cyber attacker application only trigger cyber events, simulators must be able to react to these events. In most cases this would mean more development is needed to make use of the standard and tool. Due to the nature of open standards, plugins can be built for existing simulators expanding their scope and usefulness.

# 18

## Title: ICARUS: Enhancing Space Weather Protection for Orbital and Terrestrial Critical Assets

Author: Filippo Gemma and Valerio Amodeo

Track:        MO3

Abstract: The ICARUS project aims to provide a useful tool for protecting assets in orbit and on Earth from potentially harmful space weather phenomena, surpassing the limitations of currently available systems. The project focuses on maintaining expected service levels for the community in the presence of space weather events generated by solar flares, coronal mass ejections, and solar radio bursts. By studying the counterpart light emissions, the project aims to derive data on potentially harmful charged particles and issue early alerts. This approach allows for prompt reaction and subsequent confirmation, or cancellation of the preliminary alert based on real-time data from space probes. The project relies on data from various space-based and ground-based sensors and historical measurements to evaluate the impact of space weather on both orbital and terrestrial systems. By integrating information on solar disturbances, the ICARUS project seeks to develop an Early Warning System that can protect assets in space and on Earth, minimize downtime, and maximize service levels provided to humanity. The project's research involves identifying and classifying known phenomena, assessing their direct and indirect effects on orbital platforms and terrestrial networks, and studying the protective actions taken by operators in case of threats. The development phase includes system requirements analysis, architecture design, data acquisition interfaces, analysis metrics, module design, prototype implementation, and system testing. The ICARUS system will channel data on solar disturbances, analyze their impact, evaluate potential consequences on systems, and disseminate forecasts of adverse events to relevant operators, enabling them to take appropriate preventive measures. The business opportunities arising from the ICARUS project target national and international operators of space assets, power grid operators, TV and telecommunications companies, and entities responsible for community protection with both space- based and terrestrial assets. By offering accurate assessment capabilities for safeguarding strategic assets, the project contributes to the uninterrupted provision of services essential to humanity's daily activities.

#        31

## Title: Importance of Network M&S in Multi Domain Operations

Author: Pritesh Patel and Binu Parayil

Track:        MO4

Abstract: The advancement of military operations in the contemporary era demands robust and adaptable communication systems that can effectively support multi-domain operations. Tactical network modeling and emulation have emerged as vital tools for evaluating, optimizing, and validating these communication systems. This abstract highlight the importance of tactical network modeling and emulation using the Extensible Mobile Ad hoc Network Emulator (EMANE) in facilitating seamless and efficient multi-domain operations.

Multi-domain operations require the integration of various communication networks, including land, air, sea, and space domains. The complexity and scale of these networks necessitate the use of modeling and emulation techniques to assess their performance in diverse operational scenarios. Tactical network modeling allows for the creation of virtual representations of communication networks, enabling detailed analysis and experimentation in a controlled environment. By accurately capturing the characteristics and behaviors of different network components, such as nodes, links, and protocols, modeling helps identify potential vulnerabilities, bottlenecks, and areas for improvement.

Emulation, on the other hand, enables the realistic simulation of network behavior by reproducing the interactions and dynamics of actual operational environments. EMANE, a widely adopted open-source network emulator, provides a versatile platform for implementing tactical network emulation. It offers a comprehensive set of features, including realistic propagation models, network protocols, and mobility models, to accurately emulate the behavior of communication networks in multi-domain operations.

The importance of tactical network modeling and emulation using EMANE becomes evident in several key aspects. Firstly, it allows for the evaluation of communication systems under different operating conditions, such as varying terrain, weather, and enemy threats. Through extensive experimentation, network performance can be assessed, optimized, and validated to ensure robustness and reliability in challenging operational environments.

Secondly, tactical network modeling and emulation facilitate the development and testing of innovative communication technologies and protocols. New concepts, such as software-defined networking and cognitive radio, can be simulated and evaluated within the context of multi-domain operations. This enables the exploration of novel approaches to enhance spectrum efficiency, network resilience, and interoperability across domains.

Furthermore, these techniques enable the training and education of military personnel in realistic and dynamic environments. Through simulation-based training, operators and decision-makers can gain hands-on experience in managing complex communication networks, responding to dynamic threats, and adapting to changing operational requirements. This enhances their preparedness and decision-making capabilities, ultimately leading to improved mission success rates.

# 47

## Title: Exploring the Role of Space in Mitigating Climate-Related Security Risks and Enhancing Peacebuilding

Author: Walter David

Track:     MO5

Abstract: Climate change is happening quicker than we thought, linking with armed conflict and both challenges have significant impacts on peace and security. The interplay between climate change, security risks, and peacebuilding has garnered increasing attention in recent years.

This study explores, through literature review and case studies, the innovative application of space technology as a critical tool to address climate-related security challenges and foster peacebuilding efforts.

Satellite imagery, remote sensing and geographic information systems provides real-time critical data and insights on environmental changes and climate patterns, including rising sea levels, extreme weather events, natural resource management, and conflict dynamics. Space data enable early warning systems and informed decision-making to mitigate the impacts of climate on global security dynamics.

Furthermore, space-enabled communication networks facilitate rapid disaster response and coordination among humanitarian actors, enhancing disaster resilience and conflict prevention in vulnerable regions.

Space capabilities have become increasingly essential for the conduct of military operations, in particular for weather, surveillance, intelligence, communications, early warning, positioning, navigation, and timing services. Ukraine developments underscores the fact that modern warfare is now multi-domain, incorporating non-traditional domains such as cyber and space; even making it possible future conflicts in the form of purely cyber and space war.

On the other hand, space-based information supports conflict-sensitive development planning and demarcation of borders, and promotes transparency in resource management, thereby reducing potential triggers for disputes. Moreover, satellite imagery can contribute to building trust among parties by providing verifiable evidence of compliance with environmental agreements, security sector reforms or disarmament treaties.

The study acknowledges challenges, such as data accessibility, capacity-building, legal delimitation between airspace and outer space, and international cooperation, while emphasizing the need for comprehensive policies and governance frameworks to ensure equitable access to space-based resources. It underscores the importance of collaboration for addressing climate-related security risks and fostering lasting peace.

In conclusion, the study sheds light on the symbiotic relationship between space, climate security, and peacebuilding. It presents a compelling argument for integrating space capabilities into climate change adaptation and mitigation strategies, while emphasizing the potential for strengthening global security and stability through cooperative space-based efforts.

**#        26**

## Title: Simulation-Based Analysis of Dispatch Policies for Transportation in the Military Evacuation Chain

Author: Martijn Braam

Track:        ME1

Abstract: Current NATO planning relies on expert assumptions and historic data, but recent studies have shown the benefits of simulation in aiding decision-making for the military evacuation chain. In the context of military evacuation chain, dispatch policies regarding the transportation of patients are vital. These policies encompass the placement, routing and allocation of casualties to transporters. This paper analyses these processes in the military evacuation chain with the help of simulation.

The study focuses on the earliest steps in the military evacuation chain, specifically the transportation between casualty collection points (CCPs) and the first treatment facility, in alignment with NATO's golden hour guideline. The paper narrows down the system to two CCPs and one treatment facility. The waiting times of injured soldiers at CCPs are evaluated for various dispatching policies, and insights are gained to improve the evacuation of patients.

Our simulation results show that a dynamic policy outperforms established static policies in terms of average waiting times in certain situations where casualty arrival rates are low. The benefits of the dynamic policy decrease as arrival rates increase, but it still demonstrates better performance when there is a significant variation in arrival rates between CCPs. The insights gained from this study can contribute to improve decision making within the military evacuation chain and, ultimately, enhancing the chances of survival for injured soldiers.

# #    29

## Title: VALOR: Leveraging VR Medical Simulation to Develop and Sustain Austere Resuscitative and Surgical Care Capabilities for the Future Fight

Author: John Dorsch, Michael Barrie, Michael Poppe, Talia Weiss, Paul Mallon, Nora Carr, Jennifer Polson, Ryan Ribeira and Kathik Sarma

Track:       ME2

Abstract: The emerging landscape of future combat—characterized by near-peer competition, low-intensity conflicts, environmental preparation, joint and all-domain operations, and the looming threat of Chemical, Biological, Radiological, and Nuclear (CBRN) warfare—foretells a complicated future for operational medicine. The small, dispersed units operating across vast geographic expanses will be central to navigating this complexity, requiring support from Austere Resuscitative and Surgical Care (ARSC) teams. These ARSC teams, proficient in Damage Control Resuscitation (DCR) and Damage Control Surgery (DCS), will be key to mitigating both operational and strategic risk. The Department of Defense's Joint Trauma Service highlights the urgency of this advanced medical capability. Notably, this involves small teams utilizing limited resources to bridge gaps in care, often extending beyond traditional timelines, to empower military operations while reducing force risk. To ensure operational success, the critical components of the ARSC suite—DCR, and DCS—necessitate deliberate and consistent high-fidelity, team-based training. However, the maintenance of operational readiness confronts several hurdles, including resource constraints, a lack of clinical exposure, and limited access to high-fidelity team-based training. In response to these challenges, Virtual Reality (VR) simulation presents a compelling solution. This immersive, adaptable, and cost-effective modality allows the honing of complex decision-making at the individual level while also refining team dynamics and tactics, techniques, and procedures (TTPs) through effective, repetitive training. VR curriculum can also be uniquely tailored to replicate specific "high consequence, low occurrence" clinical scenarios that ARSC teams may seldom encounter outside of major combat operations. Moreover, VR can provide standardization in content delivery and objective evaluation across an organization or enterprise and can incorporate realistic environmental, operational, and psychosocial factors, thereby enhancing the efficacy of training for specific individuals, teams, or missions. Within this context, this briefing will delve into a current Virtual Advancement of Learning for Operational Readiness (VALOR) project. Funded by the US Air Force, VALOR focuses on operational readiness training for ARSC teams. As a comprehensive VR medical simulation platform, VALOR has advanced capabilities and has established training curricula in Tactical Combat Casualty Care (TCCC), En-Route Care, CBRN, Canine TCCC, among others. Specifically, the ongoing Advanced Resuscitative Care project encapsulates a diverse range of clinical scenarios, employs exclusive equipment and procedures, and includes relevant operational environments and subsequent test and evaluation stages for ARSC teams.

# Unknown

## Title: The Need for Speed in Competition, Crisis and Conflict

Author: Markus Murtinger, Chris Haarmeijer and Jakob C Uhl

## Track: CT1

Abstract: In today's rapidly evolving world, it is crucial for military organisations to be prepared for current and future challenges. In the analog ages, speed in acquisition was never considered a problem. Fast forward to today: the War in the Ukraine shows clearly how quickly a situation changes: in a couple of months, Ukraine managed to outfit unmanned sea drones with off-the-shelf Satcom technology targeting harbours previously considered safe by Russia. One path towards achieving speed is the adoption of innovative, more flexible approaches to technology acquisition and deployment – an approach that is starting to be adopted e.g. by the U.S. Department of Defense (Vergun, 2023). The planned presentation outlined in this abstract will explore the advantages and challenges of leveraging off-the-shelf solutions to accelerate deployment of state-of-the-art technologies while at the same time reduce risk and increase efficiency (Weiss, 2018 and Johnson, 2023). Challenges of the Traditional Approach The traditional approach of acquiring and deploying a new capability using bespoke development and cost-plus contracts is time-consuming and costly (Hastings, C 2020). While such development can create unique solutions tailored to an organisation's specific needs, it also causes great delays, inefficiencies and fragmented systems. This model is not by default practical for organisations tasked to protect nations like the military or other government agencies. Such considerations are also reflected in a report by the transnational institute, which has shown an increase in contracts with tech players such as Microsoft, indicating a growing adoption of off-the-shelf solutions (González, 2023). This new approach is rapidly enabled by start-ups, like those embraced by the Defense Innovation Unit (https://www.diu.mil/). These smaller businesses, that tend to be funded with private money, offer highly specialised and an 80% ready and offthe-shelf capabilities that offer great value for money (Block et al., 2017). The Viability of Commercial Off-the-Shelf Solutions Off-the-shelf solutions present a compelling alternative to traditional methods. Organisations can access a wide range of pre-developed applications and services, such as mission planning tools and training systems (Curry et al., 2016), through subscription-based models covering SaaS and hardware offerings. This approach minimises the overhead of RT&E costs and frees up resources from development to other critical endeavours, and accelerates the adoption of new technologies. Moreover, commercial technology enables interoperability and collaboration between NATO partners without the added cost of building proprietary interfaces between custom-built applications of different NATO partners. Ensuring Security and Compatibility A paramount concern for adopting off-the-shelf solutions pertains to security (Pradhan et al., 2016). Integrating off-the-shelf soft- and hardware in a secure environment requires a meticulous assessment of the service provider. Standards for security, compatibility, and interoperability need to be defined within the NATO framework to ensure a secure and seamless exchange of technologies between member nations (Doan, 2006). A system where one NATO partner "vets" off-the-shelf technology to other NATO partners after it received authority will lower the barrier to entry for startups, dramatically lowering cost and speed up adoption (McCaney 2020). In our presentation, we will therefore also focus on the challenges of off-the-shelf technology, with special attention to security and will present possible solutions to these challenges. Use Cases To illustrate the practicality of off-the-shelf solutions for the military, our presentation will outline two use cases. The first involves a mixed hardware and software system for training and mission planning utilising extended reality technologies. Originally developed for military purposes, it transitioned to an off-the-shelf system now in use by military, law enforcement and fire fighters. Development for one service now benefits the others and vice versa. The second use case pertains to speeding up authority to operate by offering an appin-an-app concept. In our planned presentation we will present the two use cases and how the purchasing and standardisation processes from the side of government agencies could work in the future. Conclusion Agencies that protect our nation are only relevant to that nation if they can keep that nation safe by "win" from the opponent or deterring it. Off-the-shelf technology, available for purchase or as a service, can help these agencies achieve those goals. Unfortunately, incentives for stakeholders in these organisations are not always wellaligned. Our presentation concludes by urging leaders in these entities to foster a culture of openness to commercial technology. Embracing commercial solutions does not imply abandoning existing capabilities; instead, it augments the traditional way of acquiring customised capability and facilitates the rapid adoption of emerging trends.

# 7

## Title: HLA on OMG DDS as a Cross-Functional Enabler

Author: J Schlesselman, Thijs Brouwer and Paul Tingey

Track:        CT2

Abstract: This presentation introduces an important new technological development: using the open international Object Management Group (OMG™) Data Distribution Service (DDS™) family of standards for Modeling, Simulation and Training (MS&T) as the Run-Time Infrastructure (RTI) for High Level Architecture (HLA). HLA-on-DDS overcomes well-known longstanding issues and shortcomings of HLA, and will help keep it modern and relevant far into the 21st century.

Significantly, this allows implementers to remain in compliance with the mandated use of HLA in NATO STANAG 4603 and make use of the Real-time Platform Reference Federation Object Model (RPR FOM) detailed in Modelling and Simulation Standards Profile AMSP-01. This new approach overcomes the fact that RTI versions do not specify a network wire protocol, are not data-centric, and are not guaranteed to be interoperable.

Both the DDS API and its Real-Time Publish Subscribe (RTPS) wire protocol are standardized, and OMG DDS products are routinely tested for interoperability between different commercial and open source implementations. There are over a dozen available implementations of DDS, supporting a large variety of programming languages, compilers, hardware architectures, operating systems, network transports, and so on. There are also many design, development, debug, visualization, adapter, routing, logging, visualization, and other tools from multiple providers.

Consequently, different HLA-on-DDS and native DDS implementations can communicate with each other, and also users will have access to a market of implementations and tools to choose from -- or alternatively they can implement it themselves if they wish.

We shall briefly introduce the concepts and technologies used in the OMG DDS and the Real-Time Publish-Subscribe (RTPS) protocol specifications, as well as describe related DDS companion specifications such as Security, Extensible Types (X-types), Interface Definition Language (IDL), and Time Sensitive Networking (TSN). We next will show the HLA over DDS architectural implementation. This includes the composition of the HLA RPR FOM, RTI abstractions, OMG DDS layer with discovery, Quality of Service (QoS) policies, security, data model, and transport layer considerations.

The data-centric MOSA-compliant qualities of OMG DDS are why organizations are investing in this new approach to an old problem. In the US, important M&S programs such as Joint Simulation Environment (JSE) and Simulator Common Architecture Requirements and Standards (SCARS) adopted OMG DDS for training simulators, and new distributed multi-level secure (MLS) simulations are now under development. We conclude the presentation by giving the latest updates and describe how interested contributors to the HLA-on-DDS specification can participate.

# 14

## Title: ANSYS STK: COTS software for multi-domain operations support

Author: Giuseppe Corrao

Track:        CT3

Abstract: In the last two decades we have been witnesses of a massive increment of interconnections among operational domains that were historically considered as separate. Land, maritime, air and space are now connected like never before. The advent of the large constellations era (such Starlink as OneWeb) allows real time data exchange worldwide, defining a common environment where each asset can be monitored an managed not just as an independent element, but instead as a node in the network.

Operating in such interconnected environment requires an adequate planning and execution activity; ANSYS STK is a Commercial Off The Shelf tool able to support all the following:

1) Operational mission planning: in this phase, the designers can evaluate the mission effectiveness by considering all the assets (which are defined in terms of performances) and their interconnections (e.g., link budget or sensor coverage analysis). Also, the environment and its effects can be considered in advance (e.g., orography, weather conditions, RF attenuation models etc.) to better design each single mission phase.

2) Mission execution: in this phase, data from the assets on the field are sent in real time over the network and published on the STK 3D window, that acts as Common Operational Picture. This also allows the superimposition of GIS (high resolution maps, terrain, shapefiles) and weather (clouds) data to augment situational awareness in real time.

3) Debriefing and post processing analysis – this last step allows to investigate on the outcomes of the exercise by adding analytical capabilities such as subsystem effectiveness analysis (e.g., navigational Dilution Of Precision or amount of jamming received). This also allows forensic analysis execution in case of events of particular interest.

Having all these capabilities available in the same COTS tool allows the definition of fastest workflows, complex tasks simplification and better ability to recognize bottlenecks and/or critical situations along the entire mission. The fidelity level of each system or subsystem modeled can be easily scaled up or down by introducing the concept of "Digital Twin", a virtual asset that accompanies the real one throughout its entire life, from concept development to operations. Being part of the ANSYS family, STK is completely integrated into this process, providing an unprecedent capability in simulating and analyzing complex multi-domain operations.

# 15

## Title: How MBSE enables Digital Engineering up to the Mission Definition

Author: Marco Bimbi and Alexandra Beaudouin

Track:        CT4

Abstract: The increasing complexity of modern systems, such as mission-critical applications in aerospace, defense, and other engineering domains, requires innovative approaches for managing the entire product lifecycle, from initial concept (i.e. the mission definition) to final delivery. Taking a Model-Based Systems Engineering (MBSE) approach provides benefits to Engineering organizations by enabling System of Systems Design, Ensuring Design consistency across all stages, reducing design cycle time and facilitating cross-discipline collaboration. Mastering the systems complexity is a key to successfully deliver a complex product, and it is a common challenge we hear from many customers.

Using an example, we will investigate the potential of MBSE as an enabler for Digital Engineering up to Mission definition. The paper discusses the concept of "Systems of Systems" and the challenges of system complexity in the digital age, highlighting the limitations of traditional systems engineering practices. By adopting the MBSE approach, the paper aims at demonstrating how engineering organizations can efficiently manage these complexities by providing a model-driven approach to system design, analysis, verification, and validation.

Moreover, we will explore the role of MBSE in mission engineering, how it can support the system architects in defining and modeling the mission requirements at the systems of systems level. Finally, some practical use cases and examples are presented to illustrate the benefits of MBSE in digital engineering up to the mission definition.

Finally, we will also see how we can leverage virtual simulation environment such as Unreal Engine or Flight Gear to perform realistic simulations.

# 25

## Title: Data Centricity as the Key to Integrated Simulations

Author: Thijs Brouwer, Paul Tingey and J Schlesselmann

Track:        CT5

Abstract: Over the past decade, different ministries of defence have recognized that they have become owners of a collection of very disparate and often geographically distributed simulation and training centers. The challenge they now face is that on the one hand, these simulations need to be connected to stay relevant and increase the effectiveness of the trainings. On the other hand, many of these simulations are based on HLA, and have not been designed with interoperability in mind. To address this challenge, most nations have created special departments. The German Air Force for example has set up the Simulations Zentrale Luftwaffe. These departments now face the formidable challenge of getting these systems to work together.

The key to enabling interoperability for all these simulations is data centricity. Data centricity decouples the application logic from how data is transported in the system. The interface consists of a very simple set of functions and a collection of data types called the data model. This design pattern allows for easy transformations between different data models, and hence between different simulations.

The open-standards based communication framework called Data Distribution Service (DDS) was designed with data centricity at its core. This is one of the important reasons why DDS is being adopted in more and more standards that require real-time communication combined with modularity and interoperability.

This presentation showcases how DDS is successfully used in a growing collection of standards and frameworks to accommodate competing requirements:

- Reduced total cost of ownership with systems that need to perform reliably for decades

- Ease of integration with both existing and new technologies

- Enable safety-critical real-time communication

We conclude that DDS is the perfect standard to define a common denominator for integrating disparate and distributed simulation and training systems.

# 28

## Title: Using COTS videogame environments to enhance wargames, education, and training at military academies

Author: Ioannis Kiakos, Girish Sreevatsan Nandakumar, Atin Basu Choudhary and Serge Da Deppo

Track:        CT6

Abstract: Wargames and simulations have been used in training and education at military academies for centuries but have not effectively leveraged technological advancements. This paper explains how commercial-off-the-shelf (COTS) videogame environments can enhance wargames and simulations by (1) visualizing scenarios and courses of actions, (2) representing potential impacts of emerging and disruptive technologies (EDTs) along with new capabilities, and (3) being fast and easy to deploy when designing games for emergent situations. Based on research and feedback from Disruptive Technology Experiments (DTEX), we present how low-cost commercial-off-the-shelf (COTS) games that offer high degrees of customization can be used to support wargames and simulations within classrooms and beyond. We show how videogame environments can simulate the effects of emerging disruptive technologies (EDTs) and introduce cadets to innovation and futuristic thinking. Popular gaming environments, unlike traditional tabletop games, are more appealing to cadets and young officers, and can therefore help military academies get more cadets interested in wargaming and simulations. We posit that NATO should develop an ecosystem connecting military academies around wargaming, similar to online gaming communities, with the goal of helping cadets learn about EDTs, future warfare, decision making, and teambuilding. Such an ecosystem can also support the generation and enhancement of new strategies, ideas, and capabilities that are relevant to the warfighter.

# 44

## Title: The Imperative for Digital Engineering in Defense

Author: Steven Bleymaier and Giulia Vai

Track:        CT7

Abstract: The aerospace and defense industries have long operated on the cutting edge to develop and deliver advanced capabilities across all warfighting domains. But today, adversaries are eroding many of the technological advantages long held by the U.S. and its allies. How? The simple answer is speed — they design, test, and deliver new capabilities faster. Dramatic changes will be required to deliver new and vital capabilities quickly enough to stay ahead of the threat, and the key to it all is digital engineering. In this keynote, Mr. Steve Bleymaier, a retired USAF Brigadier General and currently the CTO of Aerospace and Defense at Ansys, will discuss:

• Challenges in defense systems acquisition that impact cost, schedule, and performance

• Imperatives for digital transformation in the defense industry

• Latest approaches to overcoming these challenges with digital engineering

# Unknown

## Title: TBC

Author: Jan Mazal

Track: OD1

Abstract:

# 12

## Title: Simulation-Based Optimization of Air Force Mission Planning

Author: Mihaela Hanea and Alexander Roman

Track: OD2

Abstract: Mission planning consolidates the expertise of multiple specialists into a single, coherent execution plan. The quality of the plan directly influences the probability of success of a military operation. However, due to the complexity and uncertainty of the operating environment, the planning process is very time and resource consuming. Innovative concepts that support human decision-makers in this process hold the potential to simplify, accelerate and create more effective, less risky, and less expensive mission plans. We have developed a framework that facilitates the creation of military plans for air force missions by providing optimal solutions to the following questions: 1. What attack strategy should be carried out against each enemy position? (Task Assignment) 2. What assets need to be grouped when executing each attack and what order of attack to follow? (Scheduling) 3. Which trajectories are best to fly? (Route Planning). The approach is based on genetic algorithms, heuristics that mimic artificial intelligence (AI). In addition, hierarchical task networks (HTN) are used to include domain knowledge in the form of tactical doctrines in the solution. The simulation results show that the framework is able to generate feasible solutions to the three optimization problems in small to medium-sized scenarios.

# 21

## Title: AI enabled Logistics Intelligent Decision Support

Author: Robbie Phillips and Sreerupa Das

Track: OD3

Abstract: A-LIDS will enable operational commanders with informed logistics decision making for command and control of crewed and autonomous resupply operations. A-LIDS AI leverages simulation generated data lakes and future fleet wide data streams, to enhance the commander's ability to observe and orient to both the existing situation and future battlefield conditions.

A-LIDS relies on statistical techniques and AI services for decision support that:

• Provide overall readiness measures across all classes of supply

• Tracks and predicts key measures of effectiveness

• Provides LogScores: a comparative evaluation of logistics courses of action

Training effective AI for A-LIDS relies on data from many warfighting situations and platforms. To capture the logistics posture, data must be both broad and deep, capturing not just individual unit actions, but the entire logistics chain. To model the future fight, we train the AI using synthetic data from a U.S. Army validated simulation. This simulation exceeds the limitations of data quality not currently available in the real world.

The A-LIDS dashboards provide improved situational awareness through recommendations, predictions, and optimizations. The intent is to stimulate autonomy, reduce cognitive load of commanders, and improve mission success.

# 40

## Title: Modeling NATO's Strategic Level Decision-Making Process: A System Dynamics Application in the Resilience Domain

Author: Hilmi Ozdemir and Gokhan Ozkan

Track: OD4

Abstract: NATO deals with related strategic issues affecting member countries' security. Security is a complex system of intense interactions among tangible and intangible assets with dynamically interacting variables. Within this dynamic environment, many complex decision-making processes take place, in which even very intelligent and highly educated people may make poor decisions due to failure to grasp this complex system as a whole, and/or by using linear or deterministic methods. At this point, innovative approaches are inevitable. This study discusses, among such innovative approaches, the systems thinking approach and system dynamics methodology that can be used to develop and test strategic-level mental models and policies. To show the application aspect, we also touched upon the NATO Aggregated Resilience Model developed for ACT and used at NATO Wargame and Exercise.

Systems thinking focuses on revealing parts of complex structures and their relationships examining different perspectives on these complex structures, and addressing power relations and potential conflicts of interest among these aspects. The system dynamics methodology facilitates the policy determination process in the management of complex system behaviors over time and the policy application process for adapting to a complex environment. System dynamics models provide foresight about situational behavior changes in a system over time. System dynamics modeling is a method of modeling the dynamic behavior of complex systems by breaking down these systems into simpler interconnected components ("blocks") which are connected via links that as a whole exhibit one or more properties (i.e. behaviors) not obvious from the properties of the individual parts.

Systems Thinking and System Dynamics were used (through the Stella software) for structuring the complex resilience phenomenon, formulating the interrelationships among significant resilience factors, and developing the model through community-based modeling technique.

The model enables decision-makers to see the effects of strategic shocks and events on baseline requirements, capacities of resilience main domains, and risk levels. The model has a strategic-level cockpit where the overall situational picture and country-wise resilience and risk status are shown. With the model, users can develop response policies and strategies against a crisis by creating and testing limitless what-if scenarios.

By this approach and methodology, users can support the strategic decision-making process by providing an understanding of interdependencies across related domains and exploiting related data through visualization, analyzing alternative options, and understanding potential intended and unintended effects of decision.

# 52

## Title: A Comparative Analysis of Decision-Making Modes in the Modeling and Simulation Phase of a UAV-based Mission Environment

Author: Alex Vasegaard, Peter Nielsen, Oliver Rose and Tobias Uhlig

Track: OD5

Abstract: UAV-based missions are pivotal in modern military operations, demanding advanced modeling techniques that balance accurate representation with limited time and computing resources. This paper contrasts a priori and a posteriori decision-making modes in UAV mission modeling, crucial for future missions with diverse objectives and limited human oversight.

The a priori mode intrinsically incorporates decision maker preferences prior to the solution space exploration. Consequently, decisions are rooted in simulations preceding the mission, which undergo rigorous evaluations to ensure trust in the system.

In contrast, the a posteriori mode allows for a later and more accurate involvement of the decision maker, as the final decision happens after the solution search phase. Here the comprehensive array of solutions along the Pareto front, capturing the multifaceted trade-offs, undergo rigorous evaluation and the selection of a final solution is consequently difficult and time consuming.

One of the key considerations in the decision-making process of military operations is the balance between obtaining a solution that fit the preferences of the decision maker versus achieving a more accurate modeling to which the obtained solution fit. Investing computational resources in exhaustive exploration of solutions might lead to Pareto-optimal solutions; however, this may come at the cost of reduced accuracy in the problem representation. Conversely, investing resources in detailed modeling can enhance the understanding of mission dynamics but may limit or complicate the exploration of alternative solutions.

The fitting mode of decision-making in the M&S depend naturally on the mission environment, but the significance of the problem modeling in relation to the additional computational resources to potentially yield a more precise comprehension of mission outcomes can also serve as a significant indicator.

This paper emphasizes tailored decision-making and optimization's critical role in supporting military operations. It illuminates a priori and a posteriori modes, guiding informed choices amid UAV mission constraints.

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# Title: Challenges when using exercises for both man and machine learning

Author: Martin Schüler and Erik Bjurström

Track:          AI1

Abstract: Many organizations, including the military, are aiming to implement operational AI that can be integrated into command and control systems. However, the development of AI seems to be focused solely on technology, without considering the human interaction or questioning what the AI is actually learning, particularly from a military perspective.

This abstract aims to highlight some fundamental issues with AI and learning from military exercises. One recognized method of training military units is through exercises, often utilizing a two-sided live exercise as a tool in which a thinking opponent can test military methods. One issue with two-sided live exercises is that participants perceive them as a competition, triggering the desire to win at all costs, gamer mode. The integration of AI in units participating in exercises risks generating lessons that are only applicable during exercises. Another risk is that the lessons are derived from a biased perspective, as we only know why we do what we do, but we have no data on why our opponents do what they do.

Another issue is the need for reflection to learn from what participants have experienced, which detaches the actual learning from the exercise. This creates an issue for the AI, which can only learn from collected and processed data. While AI integration may be suitable for predicting and answering questions about our own units, many data points have historical anchoring, distorting the data. This raises the question of whether the AI is better at predicting the past than the future.

Therefore, it is crucial to consider the limitations of AI when integrating it into military command and control systems.

Additionally, it is important to gather data from unbiased sources and to recognize that the AI may not always provide accurate predictions referring to specific context (in time and space). By addressing these issues, we can ensure that AI integration in the military enhances rather than hinders the learning process for both man and machine.

**#          4**

# Title: Generative AI-Powered Live, Virtual, and Constructive Training Events

Author: Michael Mearn and Shah Hossain

Track:          AI2

Abstract: Pytho AI's goal is to provide NATO and the Intelligence Community (IC) with the ability to design and execute the most impactful live, virtual and constructive (LVC) training events to maintain readiness and prepare warfighters for the challenges of modern conflict. Our generative AI platform is the perfect human-machine teaming solution that significantly improves warfighter readiness through:

- Generating Realistic and Dynamic Scenarios: No more stale or reused scenarios. Pytho generates novel and realistic scenarios that reflect the complexities of modern warfare and can adapt to the participant.

- Making Better Decisions: Data is synthesized and summarized immediately. Commanders will get key information quickly to reduce the fog of war.

- AI Education and Training: Warfighters engage with and learn the principles of artificial intelligence with an AI copilot in a training environment.

- Saving Time, Capital, and Resources: Reduce the time, effort, and resources needed to design and execute LVC training.

Our generative AI platform will allow NATO forces and the IC to leverage disruptive AI to significantly enhance the effectiveness of training in this complex and unpredictable environment in order to be ready to preserve or restore, peace, security, and stability.

Please see team bios in the attached white paper.

# 19

## Title: Lessons learned from working with an AI-driven battlefield digital twin for data farming

Author: Armando Geller and Francesco Sponchiado

Track:        AI3

Abstract: Designing tomorrow's armed forces requires the right decision support tools today, such as powerful high-fidelity simulations of the modern battlefield. OPTIMA is a lightweight AI-driven multi-agent adversarial constructive simulation for data farming serving as a digital twin of joint all domain operation (JADO) environments. OPTIMA represents state of the art systems and concepts in which engagement outcomes emerge from interactions of BLUE and RED courses of actions. OPTIMA simulations routinely include force packages consisting of 1000s of RED and BLUE systems, from ground to air, air defense, electronic warfare, operating autonomously or within C2 networks. OPTIMA arrives equipped with a library of tactical AIs, from powerful, self-learning adversarial AIs to less sophisticated AIs calibrated to represent human and machine behaviors. OPTIMA is currently in use in government and industry for force planning and concept of operations (CONOPS) testing.

In our talk we will briefly introduce OPTIMA by presenting its design concepts and explain how it works, especially its AI. The main part of our presentation will focus on selected lessons learned for verification and validation of AI-driven multi-agent simulations. These lessons have been learnt over the last years while using OPTIMA; and are the focus of an ongoing research project we are currently involved in together with armasuisse Science + Technology. We will conclude our talk with preliminary recommendations and an outlook for future work.

#      <span style="color:blue">35</span>

## Title: AI and M&S integration in support of decision making

Author: Piergiorgio Ventura and Salvatore De Mattia

Track:       AI4

Abstract: Artificial intelligence (AI) is an emerging technology that has been progressively developing in the last period. In particular, the branch of machine learning (ML) is finding substantial use within digitized contexts, favouring the development of innovative concepts and solutions in the IT sector. In a context of emerging technologies exploration, the integration of AI, including any possible technical solution such as Deep Learning and Supervised Learning, with Modelling & Simulation (M&S) assumes a fundamental technical and operational value for the benefit of military operations and concept / capability development, with the aim of supporting the decision-making process.

In this context, it should be noted that the fundamental peculiarity inherent in the main AI / ML applications lies in the deductive programming mode, in contrast to conditional algorithms, which are structured on an inductive logic. The aforementioned deductive logic represents the primary piece on which to express an initial concept, or rather an adequate integration of the AI / ML with the M&S.

In particular, the proposed integration provides an architecture based on the bi-directional connection between a neural network and M&S tools, in order to extend the peculiarities and results provided by a synthetic environment with algorithms based on deductive logic. The technological coherence of the proposed integration is essentially based on the main characteristics of the computational processes put in place by a constructive / virtual simulator, which refer to stochastic results. The computational engine of the main simulators is based on databases (physical and / or behavioural) that define the models of the units.

The final result would be an integrated system able to "predict" the best behaviour (Course of action) in a specific situation, based in its experience in similar situation, to be applied for decision making support within training activities or, ideally, even for real operations, at least in the planning phase. This new concept and a project to investigate its practical implementation to define a proof of concept is described in this presentation.

# 37

## Title: Developing Autonomous Artificial Intelligence to Replace Human Role-Players

Author: Peter Morrison

Track:        AI5

Abstract: Artificial intelligence (AI) has been a fundamental capability of computer games since the late 1970's and has been used to support military simulation for over 30 years. The military has leveraged AI for many purposes; from command and staff training through to wargaming. Game-based training products like Steel Beasts and VBS use tactical AI to provide human trainees with synthetic adversaries, however the nature of this AI is "semi-autonomous", requiring a highly trained administrator to give precise orders to AI entities to achieve the desired training outcomes. "Semi-autonomous AI" is not limited to game-based training. All popular entity level constructive simulations (OneSAF, VR Forces etc.) expect an administrator to tightly control the actions of entities in any given scenario. To overcome the limitations of semi-autonomous AI, Bohemia Interactive Simulations, in collaboration with several premier military organizations, has recently been working on a new implementation of AI. The new technology aims to reduce administrator workload through the provision of more autonomous tactical AI that behaves in a believable and doctrinally correct manner. A secondary benefit is to reduce in the number of

human role-players when running complex VBS scenarios. This presentation describes the new technology and how it builds upon best practice in modern computer games to deliver a capability that is fundamentally different from the industry standard "semi-autonomous" AI. The presentation will describe the next steps in developing this technology including cloud scaling to support an order of magnitude increase in the number of high-fidelity entities. The presentation will also describe how this new tactical AI is being used to augment traditional military wargaming in the USMC.

# Title: Estimation of the Direction of Arrival Using Deep Learning: A Modeling and Simulation Approach

Author: Simone Bianco, Luigi Celona, Paolo Napoletano and Pietro Vinetti

Track:        AI6

Abstract: Estimation of the Direction of Arrival Using Deep Learning: A Modeling and Simulation Approach

The estimation of the direction of arrival (DOA) of signals is a crucial problem in various fields, including wireless communication, radar systems, sonar applications, and microphone arrays. Traditional DOA estimation methods often rely on mathematical models and signal processing techniques, but they can be limited by their sensitivity to noise, complexity of real-world scenarios, and the need for prior knowledge of the signal characteristics. In recent years, deep learning has emerged as a powerful approach in various signal processing tasks thus motivating researchers to explore its use in DOA estimation.

This paper presents a novel approach to estimating the DOA using a using deep learning multi-task approach, with a specific focus on modeling and simulation. The proposed methodology, indeed, leverages on a synthetic dataset generated through modeling and simulation to train and evaluate deep learning models for accurate DOA estimation.

For the training of the neural model, three training sets were generated, differing in the associated SNR value and the maximum number of sources/signals, thus providing diversified data sets, representing extremal cases of the real-world scenarios. In particular, two training sets are characterized by a maximum of two incident signals and a have fixed Signal to Noise Ratio (SNR) value: −10dB (poor signal level) and 10dB (high signal level), respectively. In contrast, the last training set has a variable SNR, varying in a wide range [−13dB,+13dB], while the maximum number of impinging signals is 3.

In addition to the aforementioned training sets, a series of test sets were also generated with setups similar to those of the training sets. Finally, to evaluate the generalization capability of the developed neural model, test sets characterized by scenarios not included in the training set were used.

The performance of the proposed approach is compared with traditional DOA estimation methods, such as MUSIC and R-MUSIC. The results demonstrate that the deep learning models consistently outperform traditional methods, especially in noisy and dynamic environments, where the latter struggle to maintain accuracy.

In conclusion, this paper shows the potential of deep learning in DOA estimation, offering a viable alternative to conventional methods. The proposed approach proves to be robust, accurate, and capable of handling various challenging scenarios, positioning deep learning as a valuable tool for future advancements in DOA estimation and related signal processing tasks.

# 49

## Title: BrightEarth: AI-Assisted Reconstruction of 3d Environments from Satellite Images for Exploitation in Virtual Reality

Author: Yuliya Tarabalka, Nicolas Girard, Sebastien Tripodi, Cedric Larrosa, Jean-Philippe Bauchet, Vincent Madelain, Nicolas Duboys and Pascal Couchat

Track:        AI7

Abstract: To support the preparation for the engagement of forces (future preparation, operational preparation and operational support), it is essential to develop and utilize increasingly realistic and high-performing simulation capabilities. We have developed an operational pipeline BrightEarth, which enables automatic artificial-intelligence-assisted reconstruction of 3D environments from satellite images. From several satellite images, it generates digital terrain models and orthoimages. The generation of additional 3D vector assets needed for the geometric description of masks (buildings, trees) are also available from multi-stereo imagery but as well from a simple ortho-image. Furthermore, our innovative approach combines the power of AI and procedural modeling to recognize roof shapes and automatically texture buildings, making the process highly efficient and effective. Provision of optimized 3D tiles format (OGC standard promoted by CESIUM) generated in an automatic way enables massive dissemination of the generated information in various visualization engines, while the support of CDB format simplifies the integration of the generated 3D environments within the simulators, such as RAPAS and XERUS of LVCim. These advancements represent a breakthrough technology that enables the quick and cost-effective production of expansive terrains on a large scale. This level of precision is essential for the automatic generation of scenes in simulation.

## Title: MSaaS briefing - TBC

Author: Robert Sigfried

Track:          ST1

Abstract:

## Title: MSaaS briefing - TBC

Author: Robert Sigfried

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## Title:  MSaaS demonstration - TBC

Author: Robert Sigfried

Track:        ST2

Abstract:

# 23

## Title: Kubernetes as a SaaS Platform

Author: Daniel Seufferth, Heiderose Stein, Falk Stefan Pappert and Oliver Rose

Track:          ST3

Abstract: Kubernetes is a cornerstone of the modern microservice-based internet. Various service providers – like Spotify, Netflix, etc. – use Kubernetes to distribute their workload and ensure high-availability of their services. Leveraging the capabilities of Kubernetes and containerization is, therefore, the obvious step for creating a scalable and highly available Simulation-as-a-Service (SaaS) platform. This paper discusses the different aspects and difficulties of using containerization for simulation workloads, which must be considered. Furthermore, it describes the setup of the SaaS-cluster of the University of the Bundeswehr Munich and shows the first results of performance gain based on an example of a civil simulation application.

# 10

## Title: MSG-191 status update on AMSP-04 EdC (NATO FOM v4.0)

Author: Björn Löfstrand

Track:        ST4

Abstract: The NATO Federation Object Model for Distributed Synthetic Training (NATO FOM) is the proposed new name of the NETN FOM modules currently defined in NATO AMSP-04 Ed B. MSG-191 is tasked with updating AMSP-04 to Ed C and in doing so, transforming the standard to take full advantage of HLA4 standard currently being edited by the Simulation Interoperability Standards Organization (SISO) for publication by IEEE.

This next-generation Federation Object Model builds on the success of the NATO NETN standard (STANREC 4800) and includes, among others, several new modules that bring additional capabilities of sharing and representing simulation data and concepts in a federated distributed simulation. This presentation will highlight some of the new modules and features you can expect in the NATO FOM v4.0, expected to be released in early 2024.

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## Title: What can, what could, what should… ...simulation supporting delivery of enhanced effectiveness of JFS training in a live environment?

Author: Florian Göttinger, Maximilian Jakob and Pascal Dornstädter

Track: CT8

Abstract:  In an in-depth exploration of modern military training, the research delineates the advancement of simulation and debriefing software integral to NATO exercises and the German armed forces' Joint Terminal Attack Controller (JTAC) training. Utilizing precision-based modeling, the software enhances the fidelity of indirect fire simulations involving modern weaponry and environmental contexts, primarily in air-to-air combat scenarios. The study reveals an untapped potential in Joint Fire Support (JFS) training missions, including air-to-ground and ground-to-ground interactions, emphasizing the necessity for live, virtual, constructive (LVC) environments for genuine, efficient training experiences. It further elucidates the software's critical role in enriching debriefing sessions, facilitating comprehensive performance assessments, and improving operational readiness and training efficiency. This encompasses capabilities for handling diverse Tactical Data Links (TDLs) and integration of emerging protocols. The paper underscores the economic and strategic advantages of LVC environments, providing case studies that validate the approach. It also calls for collaborative efforts to accelerate the Technology Readiness Level (TRL), advocating a concerted movement towards a new era of technologically sophisticated, internationally standardized military training.

# #            51

## Title: Professional Simulations and Gaming - Establishing and Exploring Boundaries

Author: Mark Pfeiffer

Track: PG

Abstract: The modern era has witnessed the confluence of technological advancements with the intricate demands of military aviation training, leading to the emergence of flight simulators as essential components in both civilian and military development and training. This paper explores the trajectory from the advent of personal computer flight simulators, such as subLOGIC's Flight Simulator in 1979 and Microsoft's versions, to sophisticated military-themed simulations like Digital Combat Simulator (DCS) and Military Flight Simulator. Civilian simulators have progressively enriched the fidelity in aerodynamics, environmental conditions, thermal conditions and layers, sub and super refraction and other weather phenomena, and visual realism. This evolution facilitated the transition to military applications, presenting both opportunities and challenges. The paper delves into the complexities of simulating military flight scenarios, highlighting aspects such as Probability of Kill (Pk), which involves nuanced modeling of various physical and electronic variables. The representation of weapon impacts, electronic warfare, and human behavior further adds to the complexity, often requiring multi-disciplinary efforts and intricate modeling. Concerns regarding security, accessibility, cost, and the quest for realism also come to the fore, underscoring the challenges in developing and utilizing these simulators effectively. The interplay between commercial off-the-shelf simulators and highly specialized tools further adds to the complexity of training methodologies. This paper aims to provide a comprehensive understanding of the intricate landscape of flight simulation, recognizing its crucial role in shaping the future of military aviator training while acknowledging the inherent complexities and potential risks involved. It sets the stage for a more profound exploration and discussion on the convergence of technology, entertainment, and military application in the context of aerial warfare. The insights are use cases differentiating between weapons simulation and crew training.

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Track: CT9

Abstract:

## Title: SAS-MSG-180 (Modelling & Simulation-Wargaming Integration for Intermediate Force Capabilities (IFC)

Author: Federico Mazzone

Track: WI

Abstract: closed workshop followed by a digital wargame open to observers (TBC)

## Title: Defence Universities Workshop

Author: Uwe Gartner

Track: AT

Abstract: Defence Universities Workshop, in support of an inaugural meeting of an academic military simulation community. This will be a closed workshop with limited seats. If your Defence University is interested in participating, please contact us at natoca2x2forum@mscoe.org

# Unknown

## Title: COTS MSG-210 Workshop

Author: Wim Huiskamp

Track: MW

Abstract: MSG-210 18th Workshop on Commercial Technologies and Games for Use in NATO and Nations will be embedded in the Forum on 5 October 2023. To register for this workshop, please visit the STO Events Website for details.

## Title: Computer Assisted Experimentation and Wargaming for Emerging Technology Assessment

Author: Erdal Çayırcı, Sara Salem Alnabet and Alhanoof Mohammed Althani

Track:      EG1

Abstract: Breakthroughs in technology impacts on warfare. Therefore, future advancements in technology are key drivers in the transformation of military instrument. Expectations from emerging and potentially disruptive technologies are typically very high when they are first introduced, and the challenges related to practicality, applicability and doctrines leads to disillusionment in time. The investment, operations and maintenance costs are also difficult to figure out at the early stages in research and science. Aggressive application during hypes can end up with significant waste of resources. On the other hand, delayed acceptance due to disillusionment periods may create invaluable vulnerabilities in time. Computer assisted wargaming is very useful in gaining deeper insight into future technologies and their potential military applications. Computer assisted experimentation help to further investigate and validate them. In this presentation, we first introduce how computer assisted experimentation and wargaming can be employed to assess emerging technologies. Then, we share our results from our study on swarm intelligence and human machine teaming technologies.

# 30

## Title: 6G technology ecosystem vision:: a dual use approach in defence and sovereignty of countries

Author: Giovanni Gasbarrone

Track:        EG2

Abstract: A new global race has started in the defense industry in US , Europe and China for the 6G technology ecosystem. http://www.anutei.it/index.php/8-conferenze

Digital technologies are also becoming a fundamental and essential means of ensuring the sovereignty of countries. The development of European-based 6G infrastructure and solutions is one of the keys to ensuring European sovereignty in critical technologies and systems.

For this strategic and vital objective for the survival of the industry, the EU has launched a first research program of 240 million euros for 6G, thus hoping to maintain technological sovereignty after 5G also in 6G references: ( World Economic Forum, EU , and Advisory board : IOTHINGS World)

Next generation 6G and "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. The 6G network will manage billions of devices, thanks to quantum computing and artificial intelligence platforms. Digital technologies are also becoming a fundamental and essential means of guaranteeing the sovereignty of countries. The development of 6G infrastructure and solutions based in Europe is one of the keys to ensuring European sovereignty in critical technologies and systems.

Today about 40% of tecnolgies in 6G ( IPR, chipsets ) are under the full property of China : this means that China accounts for 40% of 6G patent ICT applications

# 43

## Title: Modeling Multi-modality for Earth Observation

Author: Mirko Paolo Barbato, Paolo Napoletano and Flavio Piccoli

Track: EG3

Abstract: Remote sensing (RS) is a valuable tool for Earth Observation (EO), allowing us to gather information about the Earth's surface and atmosphere from a distance using satellites and other sensors, which aids in various applications such as land security, environmental monitoring, agriculture, urban planning, and disaster management.

In recent years, Deep Learning (DL) has emerged as a powerful tool in EO. By leveraging neural networks and large-scale data processing, deep learning algorithms have significantly improved the accuracy and efficiency of various Earth observation tasks, such as land cover classification and segmentation, object detection, change detection, and digital soil mapping.

Moreover, the integration of multiple sensing modalities, commonly known as multimodality, has revolutionized the field of remote sensing, enhancing its capabilities and applications significantly. The fusion of different modalities can provide complementary information, allowing for a comprehensive understanding of the Earth's surface. Multimodal EO involves the fusion of data from multiple sensors, such as

optical, thermal, radar, LiDAR, and hyperspectral sensors, each capturing unique information across different regions of the electromagnetic spectrum.

This paper discusses the most recent research activities carried out in our laboratory regarding the use of DL for multimodal RS. Two use cases involving semantic segmentation and digital soil mapping will be presented with simulations and experimental validations. Semantic segmentation is a computer vision task that aims to classify each pixel in an image into specific object classes, thus providing a detailed and meaningful visual representation of the scene. Digital soil mapping is a process that uses geospatial technologies, statistical techniques, and soil observations to create spatially explicit maps of soil properties and classes, thus providing valuable information for land management, agriculture, and environmental studies.

To conclude, the experimental findings validate the effectiveness of employing multimodality and Deep Learning in Earth observation, thereby confirming the value and guiding the further development of mathematical models for monitoring Earth's surface.

# 50

## Title: Autoencoder-based anomaly detection model for serial data buses

Author: Michael Bearss, Ben Etheredge, Tristan Perry and Tilghman Turner

Track: EG4

Abstract: Intrusion detection systems often leverage Artificial Intelligence (AI)/Machine Learning (ML) techniques to detect anomalous behavior on a variety of networked systems. These AI/ML-enhanced systems are commonly used on IP-based networks and are beginning to gain traction on non-IP-based networks such as the Controller Area Network (CAN) bus and MIL-STD-1553. Detecting anomalous network behavior allows operators to detect attacks on a system as well as potential undesired system behavior during operation or testing.

The US Army Redstone Test Center (RTC) is developing a tool to classify anomalous data sent over a serial data bus. This tool, named the Serial Anomaly Detector, can classify data using a variety of serial data bus standards, such as MIL-STD-1553 and ARINC 429. Unlike IP-based network traffic, serial bus traffic is often dominated by periodic messages consisting of similar data. This has the potential to increase the false-positive rate of classification when the system under test (SUT) is operated in a different environment than where it was trained.

In contrast to prior research, this system uses an autoencoder-based model to improve performance and reduce the false-positive rate of classification. The model also has the potential to label certain data fields without an available interface control document (ICD). This paper discusses the performance of the autoencoder-based Serial Anomaly Detector when applied to a MIL-STD-1553 data bus. The results of an investigation to determine the data format and ranges of unlabeled serial data are also presented.

# 53

## Title:Obstacle and threat avoidance under uncertainty, a trade-off between long-time prediction and short-time reaction simulation based study

Author: Aurélien Desoeuvres

Track: EG5

Abstract: With the emergence of autonomous vehicles and use of UAV, a lot of effort have been done considering the obstacle avoidance problem. However, most of them consider static obstacles or predictable behaviors. In this study, we focus on the uncertainty, both in positions, sizes, and speed, of the discovered obstacles or threats, and look for the trade-off between avoiding it far in advance and avoiding it at the latest moment. The trajectory of each obstacle is mainly affected by different threat levels (the obstacle is known static, move somewhere, is random, or target you), but is unknown to the autonomous vehicle. Putting all these uncertainty with several parameter ranges lead to different behaviors. The main goal of this work is to study the trade-off in several simulations with different algorithms and learn the different situations that can happen.

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