

# Technical Evaluation Report MSG-197

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## ABSTRACT

*The NATO Modelling and Simulation Group MSG-197 “Symposium on Emerging and Disruptive Modelling and Simulation Technologies to Transform Future Defence Capabilities” took place in Bath, United Kingdom on 20-21 October 2022. MSG-197 explored how M&S can take advantage of emerging or disruptive technologies to provide future cost effective capabilities to prepare an agile force at a very high level of readiness and enable it to make the right operational decisions in a complex multi-domain future operating environment. The audience was diverse and comprised attendees from the military, government Research and Development (R&D) laboratories and a significant representation from industry. The symposium included the presentation of 30 papers including one invited paper and two keynotes. An audience of approximately 100 persons attended the workshop, with representatives from NATO, NATO/Partners-for-Peace (PfP) and other nations. This Technical Evaluation Report (TER) provides a summary of the themes presented at MSG-197, draws associated conclusions and provides recommendations for further action.*

## 1.0 INTRODUCTION

Emerging technologies and capabilities in both the military and civil domains have the potential to disrupt Modelling and Simulation (M&S), stimulating new use cases and improving the efficiency and effectiveness of existing applications. NMSG-197, “Symposium on Emerging and Disruptive Modelling and Simulation Technologies to Transform Future Defence Capabilities” was held in Bath, United Kingdom on 20-21 October 2022, and intended to explore how disruptive technologies could impact the M&S domain.

Papers were invited on how M&S can take advantage of emerging or disruptive technologies (e.g. Mixed Reality, Generative Artificial Intelligence (AI) and Machine Learning (ML), Autonomy, Quantum Computing and the Cloud, Digital Twins (DTs), Metaverses, Data Exploitation, Human Augmentation, Gaming, Cybersecurity, Distributed Enterprise, Live-feed Integration etc.) to provide future cost effective capabilities to prepare an agile force at a very high level of readiness and enable it to make the right operational decisions in a complex multi-domain future operating environment. Four of NATO’s current innovation focus areas<sup>1</sup>: AI, Data, Autonomy, and Space were covered by symposium papers.

NMSG-197 supported the requirement for M&S education in NATO while providing attendees a forum to advance M&S in the Alliance. The blend of government, military, industry and academic attendees served to stimulate fresh ideas for the advancement and effective use of M&S in NATO. At a time of significant geopolitical uncertainty, NMSG-197 also provided an opportunity for NATO, NATO/Partners-for-Peace (PfP) and other nations to come together to consider how M&S applications could be used to reduce uncertainty and strengthen alliances. Appendix A lists all the papers.

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<sup>1</sup> [https://www.nato.int/cps/en/natohq/topics\\_184303.htm](https://www.nato.int/cps/en/natohq/topics_184303.htm)

## 2.0 SYMPOSIUM PROGRAMME

The symposium opened on 20<sup>th</sup> October 2022. An invited presentation was given by Dr Keith Ford (Thales, United Kingdom) on Day 1, followed by a keynote speaker. A second keynote speech was delivered on the morning of Day 2. The symposium comprised nine sessions as shown in Table 1, with presenters delivering their presentations both in-person and remotely via video conferencing. The presentation proceedings can be found at: <https://scienceconnect.sto.nato.int/apps/102322>

**Table 1: MSG-197 Symposium Programme Sessions.**

Day 1 – 20 <sup>th</sup> Oct 2022	Day 2 – 21 <sup>st</sup> Oct 2022
1. Next Generation M&S Opportunities	6. Next Generation M&S – Disruptive Technologies
2. 3-D Environment Modelling	7. Next Generation M&S – Mission Planning and Rehearsal
3. Next Generation M&S – AI	8. Interoperability Standards and Validation
4. Next Generation M&S – DTs for Engineering	9. Next Generation M&S - Metaverse
5. Next Generation M&S - Training	

## 3.0 EVALUATION

This section summarises the key themes observed during presentations and discussions that took place during the keynote addresses and the nine sessions. In broad terms, almost everything presented could be considered disruptive. In particular, the combination of a period of considerable geopolitical uncertainty with an ongoing war in Europe, a developing post-pandemic economic crisis and looming threat of climate change, plus increasingly short technology cycles, provided both opportunities and threats to the alliance’s M&S practitioners. This evaluation report does not intend to provide a detailed critique of each paper, nor to appraise them in any way. The fact that they had been selected for dissemination in the face of strong competition is sufficient to say that they were all of very high quality and technical interest.

### 3.1 M&S Enduring Challenges

The Symposium’s opening paper, delivered by Dr Keith Ford (Thales, United Kingdom)<sup>2</sup> demonstrated the value of looking back to help shape the future. Dr Ford presented a summary of his decades of experience in the industry and associated observations on the employment of technology during his career. He noted that many of M&S current challenges, such as the requirement to balance fidelity versus cost, the need for Verification and Validation (V&V) of M&S systems and the opportunity to leverage Commercial off the Shelf (COTS) technology had in fact been re-visited by the M&S industry several times over previous decades. The impact of COTS hardware and software in reducing the form factor, cost and support footprint of M&S system were presented as a long-term trend dating from early Image Generation (IG) systems to modern mixed reality systems, and highlighted that the M&S industry should continue to explore opportunities in this area (see below). The presentation recommended that M&S practitioners should avoid re-inventing the wheel as they explore disruptive technologies and should always begin a new task by reviewing previous studies in an area, or risk duplicating effort.

<sup>2</sup> “Looking Forward to Look Back”, Dr K Ford. Thales UK Ltd

Some papers also referred to specific, and sometimes long-understood, challenges such as identifying the optimal balance between training in the live, virtual and constructive (LVC) domains. Papers covering the military metaverse<sup>3,4</sup> identified the transfer of 3D assets and personal data between 3D worlds and simulations and system complexity and urgency to develop M&S solutions as key challenges too.

### 3.2 Application Areas for M&S

The symposium presented a wide spectrum of application areas using extant capabilities, Generation After Next (GAN) simulation and bespoke, problem-specific applications and techniques. These were supporting areas such as using AI techniques to develop 3D terrain models; digital twins for engineering analysis [Paper 20]<sup>5</sup> and military training – both procedural and mission-specific; XR applications; military metaverses; and analysis of ‘Big Data’ sources, e.g. national military preparedness [Paper 07]<sup>6</sup> or understanding global supply chains [Paper 12]<sup>7</sup>. These highlighted that the breadth of use cases for M&S continue to increase, as does the use of technology to improve the efficiency and effectiveness of M&S environments. The symposium saw M&S used for war-gaming [Paper 18]<sup>8</sup>, to develop enhanced Lanchester models to support war-gaming [Paper 21]<sup>9</sup> and to help detect, attribute and characterise information derived from social media sources [Paper 22]<sup>10</sup>.

### 3.3 Harnessing COTS Technology

In recent years important contributions have been made through the use of COTS simulation systems (e.g. games engines), particularly where visualisation is required. However, it was recognised that these often come with the cost of extra development required for realistic behaviours, physical representations of equipment/capabilities and domain-specific requirements such as supporting data capture and After Action Review (AAR) [Paper 3]<sup>11</sup>. The use of COTS hardware is very common nowadays and complements bespoke equipment including various display technologies including XR, haptic and other immersive capabilities.

Commercial platform services are also becoming widely used subject to the constraints of security, safety, accreditation and cost. Paper 19<sup>12</sup> provided some insights into the complex, high performance, high fidelity simulations being built using heterogeneous mixes of game engines, digital twins, AI, M&S as a Service (MSaaS) architecture, etc. The need to use open M&S interoperability standards such as Simulation Interoperability Standards Organization’s (SISO’s) High Level Architecture (HLA) 4 was emphasised and some of the current technical work to make them suitable for these new challenges was also described [Paper 19].

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<sup>3</sup> “Military Metaverse CONOPS” Mr Andrew FAWKES, Vedette Consulting

<sup>4</sup> “Unlocking the Military Potential of the Metaverse” Ms Jennifer MCARDLE, Mr Rob SOLLY, Improbable

<sup>5</sup> “Enabling Elements of Simulations Digital Twins and Its Applicability for Information Superiority in Defence Domain” Mr Kapish AGGARWAL, NeutronStar Systems

<sup>6</sup> “M&S support to operationalization of NATO Principles of Responsible Use of AI”, Dr Jan HODICKY, NATO ACT

<sup>7</sup> “SIMSIA: Study of the Contribution of Simulation for Intelligent Autonomous Systems”, Mr Jean-Yves DONNART, Thales AVS France

<sup>8</sup> “A Synthetic War-game Environment to Assess Emerging and Disruptive Maritime Technologies in NATO Exercises”, Mr Giovanni Luca MAGLIONE, *et al*, NATO CMRE

<sup>9</sup> “Modelling a Multi-faction Conflict in Multi-domain Operations”, Mr Chris ROLFS, Cervus

<sup>10</sup> “Fighting Disinformation, Malinformation, and Misinformation in Influence Operations Campaigns”, Mr Mark HOFFMAN, Lockheed Martin Corporation, Advanced Technologies Laboratories

<sup>11</sup> “Leveraging Digital Era Technologies for a new Synthetic Environment – A Panacea?” Mr N Giannias, CAE Inc

<sup>12</sup> “Enabling Disruptive Technologies Through Open Standards” Mr T Gray, Pitch Technologies Ltd

COTS provision also covered the use of proprietary data analysis tools and techniques.

### 3.4 M&S Standards

Standards underpin the whole M&S domain and the days when the industry was dominated by commercially developed systems using proprietary standards should be history. NATO recognises this through the Allied Modelling and Simulation Standards Profile, AMSP-01. While SISO standards are well known in the M&S community, it was a welcome reminder that other public technical, security, process and management standards exist such as those supported by the British Standards Institution (BSI) and other International Organization for Standards (ISO) members. Evolving AI and ML programmes have led to the development of AI standards such as ISO/IEC DIS 42001. This was explained in the symposium's second keynote talk given by Emelie Bratt from the BSI<sup>13</sup>.

Standards validation at Coalition Warrior Interoperability Exercise (CWIX) formed a key part of the work reported by members of MSG-201 who are working towards the use of M&S in NATO Federated Mission Networking [Paper 23]<sup>14</sup>. The open Object Management Group's (OMG) Data Distribution Standard (DDS) was presented as a practical way to integrate disparate Live, Virtual and Constructive (LVC) M&S systems [Paper 24]<sup>15</sup>. NATO Exploratory Team (ET)-053 reported on the use of interoperability standards to support the development of digital twins, citing general and specific use cases such as frigate design and testing. This ET activity has led to a three year MSG activity, MSG-205 to study interoperability and standardisation for digital twins [Paper 25]<sup>16</sup>. Open Geospatial Consortium (OGC) standards such as Common Database (CDB) underpinned the work described to develop 3D terrain databases [Papers 03<sup>17</sup>, 04<sup>18</sup> and 06<sup>19</sup>].

Paper 07<sup>6</sup> identified a need for M&S standards to be developed to support AI artefact sharing, M&S metadata, AI and Big Data. Paper 09<sup>20</sup> used ISO Series 8000 and 55000 (data quality and asset management respectively). Paper 12 identified the continuing need to evolve standards to support Verification, Validation and Accreditation (VV&A) processes for the use of Big Data in MSaaS environments.

Participation in common interest groups such as the Metaverse Standards Forum and the Digital Twin Consortium, and the use of standards developed by the Khronos Group, Cesium, ISO MPEG-V<sup>xvi</sup> and Disney's Universal Scene Description were named as important for the development and implementation of military metaverse systems.

It was stated in the invited presentation that successful standard development requires:

- A need / champion
- Funding
- Breadth of experience

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<sup>13</sup> "How AI standards can drive cross sector innovation" Ms E Bratt, BSI Ltd

<sup>14</sup> "Validating M&S Standards Interoperation in CWIX 2022" Dr M Pullen, George Mason University

<sup>15</sup> "Standards-Based Interoperability Between M&S And Operational Technology (OT) Systems" Mr P Tingley, Real Time Innovations Inc

<sup>16</sup> "Taking Simulation Interoperability Standards to the Next Level with Digital Twins", Mr S Skinner, Thales UK

<sup>17</sup> "Leveraging Digital Era Technologies for a new Synthetic Environment – A Panacea?" Mr N Giannias, CAE Inc,

<sup>18</sup> "Reconstruction of 3D Environments from Satellite Images by IA and Computational Geometry for Exploitation in Mixed Reality" Dr Y Tarbalaka, LuxCarta Technology.

<sup>19</sup> "Close to Real-time Object Detection Training and Detection to Provide Synthetic Environments Including Georeferenced Representations of Detected Objects of Interests for Time-critical Mission Planning" by Mr A Hollosi, Blackshark.AI

<sup>20</sup> "Data quality - the foundation for effective modelling & simulation", Dr Tim King, Babcock International Group

- Industry/Government/Academia involvement
- Recognised organisation to develop and maintain it

These requirements are not always met and standards development and evolution is then delayed or even prevented, however this is an area where NMSG can assist.

### **3.5 Architectures**

A number of the papers described different simulation architectures and concepts: message-based (e.g. DIS or HLA) and data-driven simulation platforms vs loosely-coupled federations, open architectures vs proprietary frameworks. Specific architectures referred to at the symposium included the NATO Mission Training through Distributed Simulation (MTDS) reference architecture [Paper 14]<sup>21</sup>.

Digital twins (referred to in nearly half the papers) were an important theme. Several presenters gave alternative definitions for digital twins but the consensus was that a digital twin is a virtual representation, (e.g. providing a degree of human interaction such as visualisation) of a system or real world objects. Digital twins will increasingly be composed of a heterogeneous collection of LVC simulation capabilities and so open interoperability and other simulation standards will be required. Composition of M&S systems is an ever present and sometimes difficult challenge to which the MSaaS approach is one solution.

As well as creating models which can be used for simulation within a digital twin it is important that, where possible, real world engineering, environmental and performance data is consistent between the digital twin and its real world counterpart. This was identified as another of the major challenges facing developers.

### **3.6 Enablers**

A number of technologies were identified as enablers. Some of these were also seen as challenges for a number of the presenters. Enablers included cloud computing, both commercially provided and delivered in-house; network provision together with associated security, encryption and access control; software design and implementation; the use of COTS capabilities; better Human-Machine Interfaces (HMIs), especially when using proprietary game engines (also COTS), would be beneficial. Techniques for identifying and processing Big Data, AI, ML and computer vision were also considered as enablers.

### **3.7 Methods of Collaboration**

Although presented on the morning of Day 1, a keynote presentation by Professor Deeph Chana, of Imperial College London, provided a glimpse into the future for collaboration between government, industry and academia. Professor Chana presented the vision for NATO's Defence Innovation Accelerator for the North Atlantic (DIANA). As M&S practitioners and stakeholders seek to exploit novel technologies and capabilities, collaboration between industry, government and academia will be increasingly important. Particularly novel was the vision for DIANA to exploit Venture Capital (VC) funding, vetting investors to ensure de-risk adversary influence. New approaches to share knowledge and experience, combine expertise to work together on collaborative projects and accelerate opportunities will benefit the community. These need to be balanced against the risks of vendor lock in or other disadvantageous commercial approaches.

The vision for DIANA also highlighted that the M&S community needs to encourage increasing diversity through the participation of a wider range of both organisations (such as start-ups and Small to Medium Enterprises) and individuals. This will be essential in ensuring that M&S has access to the best talent, private and government funding and new ideas. It was noted by several presenters that the M&S community faces a demographic challenge and difficulties attracting new talent to the industry. New entrants to the industry will provide both increasing impetus and new ideas.

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<sup>21</sup> "LVC for Joint and Combined Air Power", Mr Arjan LEMMERS, Royal NLR

Paper 07<sup>6</sup> identified NATO interest in developing a collaborative AI computing environment.

## 4.0 SUMMARY

MSG-197 highlighted the overall health of the alliance's M&S community and the breadth of innovation and exploitation activities currently being undertaken in the domain to harness emerging and disruptive technologies. Although the industry has always used COTS technologies and capabilities to improve the efficiency and effectiveness of its offerings, as highlighted by Dr Keith Ford in his keynote presentation, current activities have seen a step change in the adoption of COTS systems. In particular, the use of AI and ML to improve the representation of complex systems, and to accelerate the speed at which M&S environments can be built and delivered.

MSG-197 showcased the innovative employment of disruptive technology for emerging use cases such as DTs, and commodity modelling. However, it also highlighted the perennial nature of long-running M&S themes such as V&V, fidelity vs cost trade-offs and the use of standards. As M&S applications seek to support mission rehearsal, operational decision support and digital twinning, where M&S supports mission and safety critical tasks, the bar for V&V will be higher. This should result in a renewed focus on this area.

Standards have always been a cornerstone of the M&S community. MSG-197 highlighted that standards from outside of the M&S domain may also be relevant. It also illuminated the potential divergence between a platform-based approach to simulation, as has recently emerged, and the traditional federated approach.

MSG-197 also highlighted that the M&S community faces similar challenges to other Science, Technology, Engineering and Mathematics (STEM) based industries in terms of attracting and retaining talent. In particular, several attendees noted that the M&S community needs to improve its diversity in order to harness new ideas. Engagement with private sector technology organisations through accelerators such as DIANA may assist in supporting this goal.

## 5.0 RECOMMENDATIONS

Based on the evaluation of workshop material, the presentations that were given and the discussions that took place, the following recommendations are made:

1. NMSG should understand how M&S activity may contribute to, or be a topic for, the DIANA initiative.
2. Given the current debate on the benefits of a platform based versus a federated approach to simulation, NATO may wish to consider running an event to encourage discussion and better understand where one or both of these approaches would best be used.
3. NATO should consider monitoring of standards from outside of the M&S domain, in particular those that relate to AI, ML and metaverse applications but also potential civil standards (e.g. those generated by BSI and similar organisations in other nations).
4. NATO should continue to be involved in the development, adoption and validation of M&S standards in order to maintain and develop capability.
5. Given the high level of interest and engagement in digital twinning, NATO should consider reinforcing or accelerating its existing efforts in this area, including NMSG-205. A specific event or call for papers may be an appropriate vehicle for this.

6. Composition of M&S environments remains a 'hot topic' within the domain relevant to both established and new use cases (e.g. Digital Twins). MSG-195, MSaaS Phase 3 should continue to advance work in this area.

## **6.0 COPYRIGHT STATEMENT**

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## Appendix A – Summary of Papers

Table 1-1: Summary of Papers

Paper Number	Title	Presenter	Comments
INV	<b>Invited presentation</b> Looking Back to Look Forward	Dr Keith FORD, Thales UK	Challenges: Composition, V&V (especially of AI systems), Simulation of non-kinetic effects, security
KN1	<b>Keynote speech</b> NATO's Defence Innovation Accelerator for the North Atlantic (DIANA)	Prof Deepthi S. CHANA, Imperial College	Provides a mechanism for supporting new research activities within NATO
<b>Session 1</b>	<b>Next Generation Modelling and Simulation Opportunities</b>		
1	Generation After Next for Defence Simulation and Synthetic Environments	Jon LLOYD, Dstl James KEARSE, QTSL	Transform now, accelerate innovation, identify GAN capabilities
2	Transforming Future Defence Capabilities through Anticipatory Innovation	Dr Anthony J MASYS, DRDC	The intersection of futures thinking, systems thinking and design thinking facilitates the defence and security communities with the mind-set, tools and methodologies to explore, understand and prepare for the future defence and security operating environment in order to navigate, adapt, and shape the future.
3	Leveraging Digital Era Technologies for a new Synthetic Environment – A Panacea?	Mr Nick GIANNIAS, CAE Inc	Games engines, cloud computing and AI hold the promise of improved synthetic environments.
4	Reconstruction of 3D Environments from Satellite Images by AI and Computational Geometry for Exploitation in Mixed Reality	Dr Yuliya TARABALKA, LuxCarta Technology	Using AI to help create mixed reality 3D terrain databases from imagery
5	Withdrawn		
6	Close to Real-time Object Detection Training and Detection to Provide Synthetic Environments Including Georeferenced Representations of Detected Objects of Interests for Time-critical Mission Planning	Mr Arno HOLLOSI, Blackshark.ai GmbH	End-to-end geospatial pipeline that feeds current geo-data into a 3D digital twin environment for mission training and rehearsal. Possible use in an MSaaS environment.

Paper Number	Title	Presenter	Comments
<b>Session 2</b>			
<b>3D Environment Modelling</b>			
7	M&S support to operationalization of NATO Principles of Responsible Use of AI	Dr Jan HODICKY, NATO ACT	An example of different AI models being used to help analyse 'big data' in support of understanding national military capabilities.
8	Artificial Intelligence applied to cyber modelling	Dr George SKROBANSKI, QTSL	Example where Statistical Forward Planning AI is used to develop and understand cyber defences for a network.
9	Data quality - the foundation for effective modelling & simulation	Dr Tim KING, Babcock International Group	Achieving quality for data is not an end point but a journey of continual improvement.
<b>Session 3</b>			
<b>Next Generation Modelling and Simulation: AI</b>			
10	Framework for Developing Digital Twin Prototypes	Dr Vilius PORTAPAS, University of Nottingham	DT used to support design for electric aircraft.
11	Enhancing Resilience: Model-based Simulations	Dr d'Artis KANCS, Science Research Innovation	Uses Model-based Simulations to represent and study resilience and vulnerabilities in Global Supply Chains. This can then help drive NATO policy making.
12	SIMSIA: Study of the Contribution of Simulation for Intelligent Autonomous Systems	Mr Jean-Yves DONNART, Thales AVS France	<ul style="list-style-type: none"> <li>• Characterize the requirements by identifying and analysing the most likely utilization of simulation.</li> <li>• Analyse the solution alternatives and produce technical recommendations for each solution.</li> <li>• Detail two solutions and build a roadmap proposing the evolution of the corresponding simulations.</li> </ul>
13	How Digital Mission Engineering will shape your future defense systems, to increase effectiveness and efficiency	Mr Roberto GEMMA, Ansys	Using digital modelling, simulation, and analysis to incorporate the operational environment and evaluate mission outcomes at every phase of the life cycle.
<b>Session 4</b>			
<b>Next Generation Modelling and Simulation: DTs for Engineering</b>			
14	LVC for Joint and Combined Air Power	Mr Arjan LEMMERS, Royal NLR	Integrated LVC environment for Joint & Combined Air operations – paper covers: <ul style="list-style-type: none"> <li>• Training concepts</li> <li>• Architecture</li> <li>• Technology</li> </ul>

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Paper Number	Title	Presenter	Comments
			<ul style="list-style-type: none"> <li>• Operation</li> <li>• CD&amp;E opportunities</li> </ul>
15	Virtual Advancement of Learning for Operational Readiness with Non-Collocated Cross-Role Medical Simulation Training	Dr Karthik SARMA, SimX, Inc	Deployable VR sim for training medical staff and first responder teams – deployed operationally world-wide with reach-back capability
<b>Session 5</b>	<b>Next Generation Modelling and Simulation: Training</b>		
16	Maximising the Impact of Immersive Technologies for Training and Education	Ms Samantha BLACK, QTSL, Mr Mayowa OLONILUA, Dstl	<ul style="list-style-type: none"> <li>• Generated evidence that supports the use of XR for certain use cases, using the XR4TE approach</li> <li>• There are some significant gaps in our understanding that need to be addressed</li> <li>• Rapid technology advancement and changing strategic proprieties require a change in research focus</li> </ul>
17	How the Spanish Military Health School is Revolutionizing Medical Training in CBRN Environments with VR	Mrs Maria MADARIETA, Virtualware	Use simulation-based manikin training in complex scenarios and extreme stress situations with VR Immersive Rooms
KN2	Keynote speech How AI standards can drive cross sector innovation	Ms Emelie BRATT, BSI	BSI standards for AI should be considered by NATO M&S community
<b>Session 6</b>	<b>Next Generation Modelling and Simulation: Disruptive Technologies</b>		
18	A Synthetic War-game Environment to Assess Emerging and Disruptive Maritime Technologies in NATO Exercises	Mr Giovanni Luca MAGLIONE, NATO CMRE	Disruptive Experiment – maritime war-gaming federation looks at distributed toolsets, human interfaces and war-gaming tech
19	Enabling Disruptive Technologies Through Open Standards	Mr Tom GRAY, Pitch Technologies Ltd	Overview of open interoperability standards for evolving LVC M&S capabilities
<b>Session 7</b>	<b>Next Generation Modelling and Simulation: Mission Planning and Rehearsal</b>		
20	Enabling Elements of Simulations Digital	Mr Kapish AGGARWAL,	A number of aspects of DT design and use are discussed

Paper Number	Title	Presenter	Comments
	Twins and Its Applicability for Information Superiority in Defence Domain	NeutronStar Systems	drawing on experience gained developing DTs of space satellite systems.
21	Modelling a Multi-faction Conflict in Multi-domain Operations	Mr Chris ROLFS, Cervus	Developed a multi-faction, multi-domain Lanchester model for use in traditional OA-type war games
22	Fighting Disinformation, Malinformation, and Misinformation in Influence Operations Campaigns	Mr Mark HOFFMAN, Lockheed Martin Corporation, Advanced Technologies Laboratories	LM's approach to a number of DARPA Influence Operations projects – interesting approaches to 'soft factors'
<b>Session 8</b>	<b>Interoperability Standards and validation</b>		
23	Validating M&S Standards Interoperation in CWIX 2022	Dr Mark PULLEN, George Mason University	C2SIM/HLA/NETN FOM/MSaaS for FMN at CWIX, CIAV process covered (for VV&A) – integrating M&S with OpCIS
24	Standards-Based Interoperability Between M&S And Operational Technology (OT) Systems	Mr Paul TINGEY, Real-Time Innovations, Inc	Use DDS for complex M&S integration – alternative to HLA
25	Taking Simulation Interoperability Standards to the Next Level with Digital Twins	Mr Simon SKINNER, Thales UK	A Digital Twin is a virtual representation of a connected physical asset Several use cases given – NMSG ET-053 described
<b>Session 9</b>	<b>Next Generation Modelling and Simulation: Metaverse</b>		
26	Military Metaverse CONOPS	Mr Andrew FAWKES, Vedette Consulting	Aiming for: A Vision for a Future Defence Integrated M&S Ecosystem
27	Unlocking the Military Potential of the Metaverse	Ms Jennifer MCARDLE, Mr Rob SOLLY, Improbable	Explores ways in which metaverse technologies could affect traditional M&S

