MODELLING AND SIMULATION AS A SERVICE – AN EMERGENT CONCEPT THAT SUPPORTS THE MILITARY EDUCATION AND TRAINING PROCESS CONTINUITY

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Abstract: *In the last years, the NATO Modelling and Simulation Group (NMSG) has started to develop and put into practice an emergent concept named "Modelling and Simulation as a Service" (MSaaS) with the purpose to provide a permanent service and cloud-based modelling and simulation (M&S) ecosystem to be used by NATO and partner nations. The new M&S ecosystem will help to project and expand the ways of using M&S capabilities for achieving interoperability between participating simulation systems and ensuring credibility of results. This paper presents, on one hand, the development phases of MSaaS, the benefits and steps that have to be done in the future for its implementation at NATO level, and on the other hand, it makes an extrapolation between business continuity concept and MSaaS concept in terms of ensuring the military education and training process continuity when a crisis situation occurs.*

Keywords: modelling and simulation, cloud computing, service-oriented architecture, education and training process continuity

1. Introduction
As a key enabler in military domain, the modelling and simulation (M&S) provides innovative solutions, saves resources and supports military education, training and exercises, mission rehearsals and decisions related to acquisition processes.

Recent technical developments in the information and communication technology (ICT) domain related to *cloud computing* and *service-oriented architecture* (SOA) offer opportunities to exploit the M&S capabilities in a better way in order to satisfy the NATO critical needs. In fact, during military education and training process, the M&S can be viewed as a critical asset and supporting technology for coalition and its nations. "Cloud computing is a model used for enabling convenient and usage-based network access to configurable computing resources (e.g., networks, servers, etc.) that can be provided and used rapidly" [1]. Serverless computing, Infrastructure-as-a-service (IaaS), Platform-as-a-service (PaaS), and Software-as-a-service (SaaS) are some service categories provided through cloud computing. In other words, cloud computing could be seen as a specific environment with physical resources and digital components that facilitates the delivering of computing services (data storage on servers, databases, networking, software, data management, analytics, etc.) over the internet ("the cloud"). Using cloud computing technology results in reducing the operating costs, providing an easier access to all users, ensuring the running continuity of software applications, and scaling the services provided ("delivering the right amount of

IT resources – for example, more or less computing power, storage, bandwidth – right when they are needed, and from the right geographic location" [2]).

A major role for development and integration of applications through cloud is played by SOA. It "defines a way to make software components reusable and interoperable via service interfaces. Services use common interface standards and an architectural pattern so they can be rapidly incorporated into new applications" [3]. The technology referring to service-oriented concept represents a new generation computing platform that encompasses the service-orientation paradigm with the purpose to create and assembly many service inventories for providing flexibility and adaptation to the increasing needs of any organization. (Figure 1)
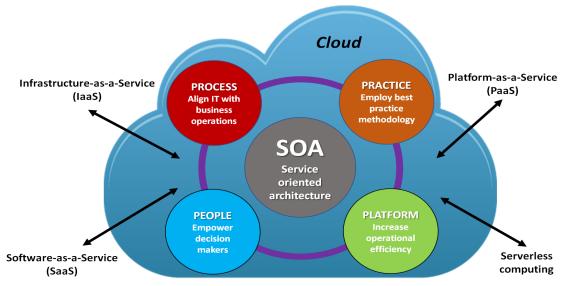

Figure 1: Cloud computing and service-oriented architecture (SOA)

Taking into consideration the critical needs related to increasing the interoperability of armed forces through training and exercises, NATO has developed a new training concept that includes the service orientation and the provision of M&S applications by using the *as-a-service* model and employing the cloud computing. This new concept, known as Modelling and Simulation as a Service (MSaaS), enables the composable simulation environments and supports the rapidly and on-demand deployment of simulation environments based on armed forces training needs. "Achieving interoperability between participating simulation systems and ensuring credibility of results still requires large expenditures with regards to time, personnel and budget" [4].

Starting with 2020, the volatility of COVID-19 crisis evolution has created lots of ever-changing organizational challenges in the majority of work domains. Consequently, all organizations from every field of activity were forced to find suitable solutions for ensuring *continuity of businesses*. As a result, for this unpredictable period of time linked to uncertain evolution of the coronavirus pandemic that mirrors real conditions of a crisis situation, the majority of organizations have been focusing on *digitalization of the services provided* to their customers by over-using the internet environment. Also, in the military field many training events were postponed or cancelled due to preventive health measures imposed by national and international health authorities to stop the spread of pandemic. From this perspective, it is

brought into discussion the availability of any suitable, flexible, and on-hand tools that can support the *continuity of military education and training process*. In this regard, the implementation of NATO MSaaS concept can provide a suitable solution to partner nations in order to support the training events of their armed forces at a high level of interoperability.

The research methodology used in this article was based on reviewing the specific websites, publications, and official documents provided by NATO M&S working groups. Also, we have extrapolated the understanding of Business Continuity concept within NATO MSaaS concept in order to emphasise an operational model of *military education and training process continuity* (METPC).

2. Modelling and Simulation as a Service – an overview

The implementation in an integrated manner of the NATO M&S instruments and products (simulation systems, simulation networks, training scenario data repositories, web-based applications used for managing exercise's information flow, specific intel-gathering software, etc.) by using a federative architecture, provides a valuable and efficient training environment for armed forces to meet their training objectives. The possibilities regarding the integration of simulation systems along with M&S products in working federations has led the specialists from NATO MSG (Modelling and Simulation Group) to carry out a deep research for better understanding of the MSaaS concept. In order to support the military education and training process, no matter the armed forces' geographical locations, the appropriate experimentation, verification and validation activities were conducted with the purpose to implement and test a functional architecture relevant to "as a service" paradigm. The new emergent concept of MSaaS has started to be developed and put into practice based on a specific timeline. (Figure 2)
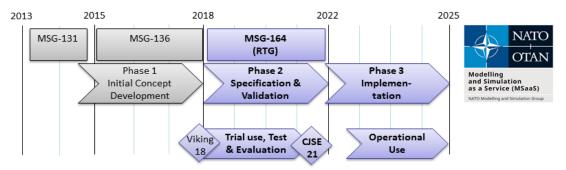

Figure 2: The timeline for development and implementation of MSaaS concept [5]

The first official NATO M&S working group started its activity in 2013 by developing the STO-TR-MSG-131 (Science and Technology Organization - Technical Report - Modelling and Simulation Group - 131) called "Modelling and Simulation as a Service: New Concepts and Service-Oriented Architectures". The TR-MSG-131-ES states that "M&S solutions have to be integrated seamlessly in future computer information systems capabilities to ensure increased efficiency, affordability, interoperability and reusability. Technical developments in the area of Service-Oriented Architectures (SOAs) may offer opportunities for providing M&S solutions that address current NATO critical shortfalls" [6]. The general approach of MSG-131 was based on collection of experience and expertise from Member Nations related to use of cloud solutions and service-oriented approaches within the M&S domain. As main conclusion, it was stipulated that "M&S is a critical

technology for NATO and the Nations and service-based approaches to M&S offer many potential benefits".

The STO-TR-MSG-131 conclusions and recommendations guided the *1st Phase (Initial Concept Development)* to have been set off. STO-TR-MSG-136, the next NATO M&S activity linked to MSaaS, initiated in 2015 with working subgroups comprised following parts:

a. TR-MSG-136-Part-I (MSaaS – Rapid Deployment of Interoperable and Credible Simulation Environments);
b. TR-MSG-136-Part-II (MSaaS Concept and Reference Architecture Evaluation Report);
c. TR-MSG-136-Part-III (Operational Concept Document/OCD for the Allied Framework for MSaaS);
d. TR-MSG-136-Part-IV (MSaaS, Volume 1: MSaaS Technical Reference Architecture);
e. TR-MSG-136-Part-V (MSaaS, Volume 2: MSaaS Discovery Service and Metadata);
f. TR-MSG-136-Part-VI (MSaaS, Volume 3: MSaaS Engineering Process);
g. TR-MSG-136-Part-VII (MSaaS, Volume 4: Experimentation Report).

NATO MSG-136 investigated the new concept of MSaaS with the aim of providing the technical and organizational foundations to establish the Allied Framework for M&S as a Service within NATO and partner nations. There were many recommendations and conclusions during the development of STO-TR-MSG-136. "The Allied Framework for Modelling and Simulation as a Service is the common approach of NATO and nations towards implementing MSaaS and is defined by the following documents" [7]:

• Operational Concept Document;
• Technical Reference Architecture (including service discovery, engineering process and experimentation documentation);
• Governance Policies.

Furthermore, there were various experiments during the development of STO-TR-MSG-136 and the "results and initial operational applications demonstrated that MSaaS was capable of realizing the vision that M&S products, data and processes are conveniently accessible to a large number of users whenever and wherever needed. The technical guidelines, recommended standards, architecture building blocks, and architecture patterns that should be considered in realizing MSaaS capabilities were provided. The Technical Reference Architecture uses the NATO C3 Classification Taxonomy as a tool for describing capability concepts and as a repository for architecture building blocks and patterns" [8].

Specialist Team participating in the development of NATO MSG-136 investigated a number of use cases for M&S as a Service, such as:

- Synthetic Environment Service (SES) to enable rapid initialization of participating simulation systems with correlated synthetic environment data;
- Scenario management services to reduce development time by using a library of typical scenarios that may be re-used with minimum efforts;
- Weapon Effects Services and Communication Effects Services to improve fair-fight conditions;
- Establishment of a Defence cloud (e.g., nation-wide, NATO-wide, coalition-wide);
- Certification and compliance testing services;
- C2 Planning Support Services to provide decision support to C2 planning activities.

The *2nd Phase (Specification & Validation)* has started in 2018 with the development of NATO MSG-164 RTG (Research Task Group) and it is scheduled to be accomplished by 2022. This 2nd phase is developed by aiming three main objectives:

1. To advance and promote the operational readiness of M&S as a Service;

2. To align national efforts and to share national experiences in establishing MSaaS capabilities;
3. To investigate critical research and development topics to further enhance MSaaS benefits.

In fact, the trial use, test and evaluation will be conducted during MSG-164. For this phase of implementation, it is expected that the working groups to meet a series of achievements: service discovery/metadata; data services; cloud federation and infrastructure; simulation architecture and protocols; composition/ decomposition; cyber security in cloud environments; service management and control.

MSG-164 will mature MSaaS concept from a lab environment to an operationally relevant environment and conduct necessary research and development efforts. Through close cooperation with the operational user community and participation in exercises, this activity contributes to realizing the MSaaS vision that "M&S products, data and processes are conveniently accessible and available on-demand to all users in order to enhance operational effectiveness" [9].

The *3rd Phase (Implementation)* is expected to begin in 2022 and should be accomplished by 2025 with the final goal – the operational use of MSaaS.

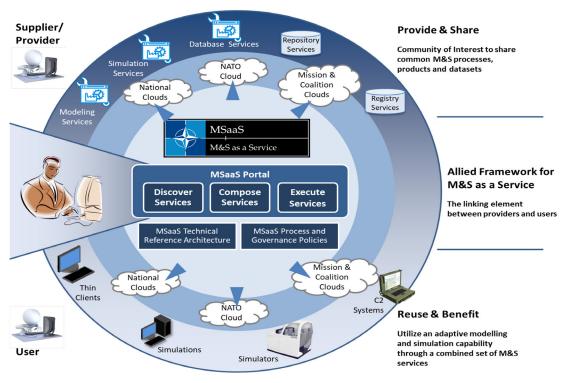The Operational Concept of the Allied Framework for M&S as a Service is presented below in Figure 3.

Figure 3: Operational Concept of the Allied Framework for MSaaS [10]

The "Allied Framework for MSaaS defines user-facing capabilities (front-end) and underlying technical infrastructure (back-end). The front-end is called the *MSaaS Portal*. The front-end provides access to a large variety of M&S capabilities from which the users are able to select the services that best suit their requirements, and track the experiences and lessons learned of other users. The users can discover, compose and execute M&S services through the front-end, which is the central access point that guides them through the process" [9].

a) *Discover*: "The Allied Framework for MSaaS provides a mechanism for users to search and discover M&S services and assets (e.g., data, services, models,

federations, and scenarios). A registry is used to catalogue available content from NATO, national, industry and academic organizations".

b) *Compose:* "The framework provides the ability to compose discovered services to perform a given simulation use case".

c) *Execute:* "The framework provides the ability to deploy the composed services automatically on a cloud-based or local computing infrastructure. The automated deployment and execution exploit the benefits of cloud computing. Once deployed and executed the M&S services can be accessed on-demand by a range of users (Live, Virtual, Constructive) directly through a simulator (e.g., a flight simulator consuming a weapon effects service), through a C2 system (e.g., embedded route planning functionality that utilizes a route planning service) or may be provided by a thin client or by a dedicated application (e.g., a decision support system utilizing various services like terrain data service, intelligence information service etc.)".

3. The employment of MSaaS as a model of "business continuity" to ensure military education and training process continuity (METPC)

The fulfilment of military education objectives and achievement of combat readiness by the armed forces are the priorities of military leadership. In order to be prepared to face and successfully accomplish every mission task, the units and subunits have to conduct joint training events in a realistic combat training environment. For NATO and partner nations, the M&S is one of the key enabling elements to support the training events of armed forces in order to meet a high level of interoperability.

Similar to a crisis situation (e.g., natural disasters in a large area, a pandemic, or any event that results in the disruption of conducting training and exercises), the ongoing and unpredictable evolution of COVID-19 pandemic situation has led to postponing or cancelling of many training events in the military field. Consequently, for the armed forces the increasing risk of not achieving the desired combat readiness level should be managed and diminished through finding other suitable training solutions. From this perspective, the understanding of *business continuity* concept can provide good insights and a viable model for building a resilient training plan that is feasible to counter the lack of armed forces training during a crisis situation. (Figure 4)

Figure 4: MSaaS as a model of "business continuity" to ensure the METPC
(This figure was compiled using https://www.smith-howard.com/event/business-continuity-resiliency-surviving-and-thriving-through-disruptions/ [11] and https://nmsg.sto.nato.int/themes/msaas [5])

To maintain the critical processes at an operational level and minimize any negative impact specific to a crisis situation, every organization has to take into account the prioritization process for building an operational resiliency program. The program should be focusing on business continuity plan (BCP) that outlines the procedures and instructions which have to be followed by an organization in order to face during an unexpected disruption in services provided. "An organization can face revenue loss and eroded customer trust if it fails to maintain business resiliency while rapidly adapting and responding to risks and opportunities" [12].

The risk management procedures have to be employed in order to have a robust analysis concerning the critical processes and critical assets of business within organization. When a business continuity plan is finished, it has to be rigorously tested to know if it is complete and will fulfil its intended purposes.

If we look further to extrapolate the business continuity model as a METPC model of armed forces, we notice that lots of common elements should be taken into account, such as: analysis phase (employing of risk management procedures), solution design, implementation, testing and acceptance, and maintenance of METPC model. Then, extrapolating every key feature of a BCP will result following elements that ensure the METPC within military field:
- Strategy (the way of planning and conducting training exercises in order to meet the training objectives of a unit);
- Organization (the level of the unit as a training audience and its suitable military education and training plan);
- Applications and data (the supporting training software, web-based applications, data repositories, etc.);
- Processes (the processes and procedures used to develop a feasible scenario, run the training exercise, and ensure the exercise management);
- Technology (the simulation systems, C2 systems, federated mission training networks and supporting technology necessary to enable continuous operations and backups for applications and data);
- Facilities (the interconnected battle labs, training centers, simtech teams, etc.).

Within military organization, it is important that every commander plans and prepares not only for events that will stop military education and training completely but for those that also have the potential to unfavourably impact military services or processes in support of training events. As for pandemic situation but also for other type of crisis situations, when the training events would not have the appropriate conditions to be conducted, the implementation and exploitation of MSaaS benefits that ensures the provision of M&S applications via the as-a-service model of cloud computing can be the core for a resilient METPC plan. In this way, through the use of cloud computing and SOA, the Allied Framework for MSaaS will provide on-hand training services in order to ensure training process continuity, support the accomplishment of training objectives, and increase the interoperability of units within NATO and partner nations.

4. Conclusions

Today, information and communication technologies play a major role in our life and they are also increasingly embedded in the military field.

The M&S has become a critical capability for NATO and its nations in terms of ensuring support to military education and training process continuity.

Achieving the M&S architecture interoperability and implementing the MSaaS concept should be a "must" for NATO and its nations. The MSaaS implementation will make use of simulation systems working in federated networks together with integrated C2 systems and will employ the state-of-the-art technology systems in order to ensure a suitable, flexible and continuous synthetic training environment.

References List

[1] *SOA - Cloud Computing,* accessed on 02.05.2021, https://www.tutorialspoint.com/soa/ soa_cloud_computing.htm

[2] *What is cloud computing?* accessed on 02.05.2021, https://azure.microsoft.com/en-us/overview/what-is-cloud-computing/#benefits

[3] *What is SOA, or service-oriented architecture?,* accessed on 02.05.2021, https://www.ibm.com/cloud/learn/soa

[4] J. E. Hannay, T. van den Berg, *The NATO MSG-136 Reference Architecture for M&S as a Service,* STO-MP-MSG-149-3, 2017, p. 1.

[5] *NATO M&S as a Service - Allied Framework for Modelling and Simulation as a Service (MSaaS),* accessed on 04.05.2021, https://nmsg.sto.nato.int/themes/msaas

[6] *Modelling and Simulation as a Service: New Concepts and Service-Oriented Architectures,* TR-MSG-131-ES, 2015, Executive Summary, p.1.

[7] *Modelling and Simulation as a Service – Volume 4: Experimentation Report,* TR-MSG-136-Part-VII, 2019, Executive Summary, p. 1.

[8] *Modelling and Simulation as a Service – Volume 1: MSaaS Technical Reference Architecture,* TR-MSG-136-Part-IV, 2019, Executive Summary, p. 1.

[9] *Modelling and Simulation as a Service – Phase 2,* NMSG Report Cards, last update 24 May 2018, p. 63.

[10] *Modelling and Simulation as a Service – Rapid Deployment of Interoperable and Credible Simulation Environments,* TR-MSG-136-Part-I, 2018, Full Report of MSG-136, pp. 2-3.

[11] *Business Continuity & Resiliency: Surviving and Thriving Through Disruptions,* accessed on 05.05.2021, https://www.smith-howard.com/event/business-continuity-resiliency-surviving-and-thriving-through-disruptions/

[12] *Adapt and respond to risks with a business continuity plan (BCP),* accessed on 10.05.2021, https://www.ibm.com/services/business-continuity/plan