Modelling and Simulation as a Service from End User Perspective

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ABSTRACT

Modelling and Simulation as a Service (MSaaS) is a new approach being explored by NATO Science and Technology Organization (STO) Modelling & Simulation Group (MSG) Panel for a permanently available, flexible, service-based framework to provide more cost effective availability of Modelling and Simulation (M&S) products, data and processes to a large number of users on-demand. This Research Task Group is working on the development of the implementation of this framework, defining policies, stakeholders' roles, services and reference architecture and reference engineering processes. MSaaS can be defined as "enterprise-based level architecture for discovery, orchestration, deployment, delivery and management of M&S services".

The University of Defence of the Czech Republic and the NATO M&S Centre of Excellence are investigating and proposing an approach to contribute to the definition of the MSaaS from an End User perspective.
The paper proposes definition of M&S Software as a Service (MSSaaS), M&S Platform as a Service (MSPaaS) and M&S Infrastructure as a Service (MSIaaS) to introduce new roles and new business connections taking also into consideration Service Oriented Architecture (SOA) definitions and those definitions stated in NATO Modelling and Simulation Master Plan (NMSMP). In particular the authors propose a contribution to the definition of the different stakeholders' roles and their relationships, starting from those of the MSG 136 group (M&S Group 136, Modelling and Simulation as a Service) and introducing new roles regarding the End User.

In conclusion, this research and study activity proposes, in addition to the existing definitions, a taxonomy comparing roles across service models (MSSaaS, MSPaaS and MSIaaS). Furthermore, the M&S services' classification is analysed in the framework of the MSG 136 Operational Concept draft, in order to identify the services which are to be properly composed and orchestrated to satisfy the End User requirements.

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INTRODUCTION

The NATO Modelling and Simulation Group MSG-136 "Modelling and Simulation (M&S) as a Service (MSaaS)" has defined MSaaS as "the combination of service-based approaches with ideas taken from cloud computing" (NATO STO MSG 136, 2016, June 10).

MSaaS is a promising approach for realizing next generation simulation environments to support development of M&S military capabilities (NATO Allied Council, 2012). To underline the importance of M&S in NATO, the North Atlantic Council (NAC) set up the NATO Modelling and Simulation Group (NMSG) to supervise the implementation of the NATO Modelling and Simulation Master Plan (NMSMP) to maximize the effective utilization of M&S (NATO STO, 2016). According to this vision, it is essential that M&S tools are readily accessible to a large number of users as often as possible. To achieve such widespread accessibility, a new M&S framework is required where M&S tools can be accessed simultaneously and spontaneously by a large number of users for their individual purposes. This "as a Service" paradigm has to support stand-alone use as well as integration of multiple simulated and real systems into a unified simulation environment whenever the need arises.

The M&S CoE, its industrial partners and the Czech Republic University of Defense are participating in the development of the MSG-136 deliverables. In particular we are proposing contributions to the Operational Concept Document (OCD) development and supporting the Evaluation Subgroup by developing a test bed prototype to make available to the MSaaS community of Interest a first, experimental cloud-based infrastructure to execute MSaaS experimentation activities: The Open Cloud Ecosystem ApplicatioN (OCEAN) project (Biagini et all, 2016).

This paper illustrates the authors' contributions to the MSG 136 Operation Concept Document, proposing the Stakeholders roles and related M&S services' definitions. Additionally the OCEAN project and the application of the stakeholders and M&S service models to the MSaaS implemented solution, the OCEAN prototype, are discussed.

THE MSAAS STAKEOLDERS AND SERVICES PERSPECTIVE

The MSaaS Stakeholder roles that can be identified in the Allied MSaaS framework, as proposed and further implemented in the OCD, are shown in Figure 1.

MSaaS Stakeholders

MSaaS Stakeholder categories are derived from the NMSMP:

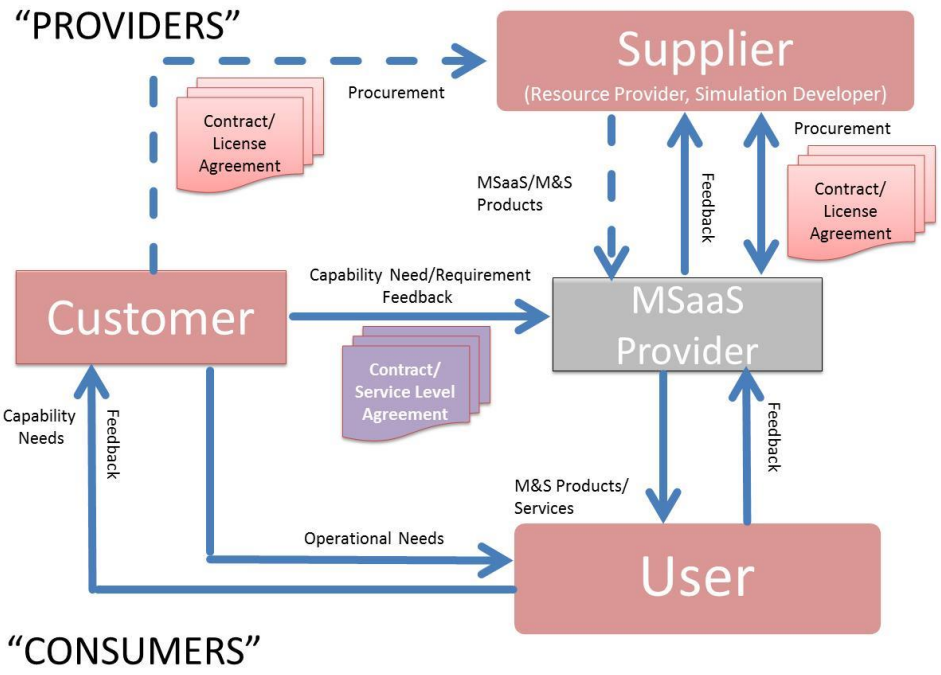

Figure 1 MSaaS Stakeholder Roles in the Allied Framework for MSaaS (NATO STO MSG 136, 2017)

Customer

The MSaaS Customer is a defense organization with an operational need (e.g. training, mission planning, acquisition), and can include a NATO Nation/HQ/Agency or group of Nations or international entities.

In order to address this need, the Customer may consider the use of MSaaS capabilities available from the Allied MSaaS Framework via a Service Level agreement (SLA). Alternatively the Customer may procure M&S products and solutions from Suppliers via a contract or license agreement, to be subsequently made available through the Allied MSaaS Framework.

Provider:

In accordance with Customer SLAs, the MSaaS Provider makes M&S products and solutions available to Users from the Allied MSaaS Framework. The MSaaS Provider needs to manage and maintain the Allied MSaaS Framework in order to meet SLAs. This will include the use of 'registry' and 'discovery' services to maintain a repository of M&S products and solutions, either already owned by defence organizations or available from Suppliers through a license agreement, purchase order, another kind of a legal contract or agreement.

The MSaaS Provider is responsible for the interoperability and composability between M&S products and solutions.

The MSaaS Provider is not responsible for developing M&S products and solutions, and does not always own them.

The MSaaS Provider is also responsible for monitoring and measuring load balancing relevant to the usage of the MSaaS capabilities, and is responsible for billing according to license agreements.

User:

The MSaaS User directly or indirectly consumes MSaaS products and solutions. There are two types of Users that need to be considered: the Operational Users and the Simulation Users.

"Operational Users" indirectly consume MSaaS products and solutions in accordance with meeting operational needs, e.g. training audience in CPX/CAX.

"Simulation Users" directly consume MSaaS products and solutions to provide simulation capabilities and applications to the Operational User, e.g. CPX/CAX operator.

What makes the difference is the direct interaction with simulations and simulators and supporting data and applications. The Operational User consumes only results of simulation, thus he is unaware of the way the M&S Services are realized and delivered to him. The Simulation User directly interacts with the simulation environment and the MSaaS Framework will require new approaches and operational procedures to satisfy the operational

community's needs, regardless of the End User's business area (e.g. training, operation planning or support to Concept Development and Experimentation).

To provide more clarification on these different roles, consider a Military Computer Assisted eXercise (CAX), like a Command Post eXercise (CPX).
In this example the Command Post (CP) at the Brigade level is the primary training audience. This audience consists of Commanders and Staff Officers who benefit from using simulated scenarios based on M&S products and solutions (e.g. to have an operational picture, obtain orders, feedback and/or receive events which they need to respond to). This audience (i.e. Operational User) is not responsible for the direct configuration of M&S products and solutions. Training centre personnel (i.e. "Simulation Users") are responsible for directly configuring the scenario aimed at training the Operational User by creating events and using models based on M&S products and solutions available from the Allied MSaaS Framework. Furthermore there could be other users of M&S products and solutions, such as a secondary training audience (e.g. 'role players') who configure and/or interact with constructive simulation tools to provide the behaviour of lower level force units, e.g. squad, platoons. In this instance these are considered to be "Simulation Users."

Supplier:
MSaaS Suppliers develop and provide M&S products and solutions to the Allied MSaaS Framework either via a product procurement or license agreement. These can include large defence contractors, small medium enterprises and academic institutions, in addition to Simulation Users.

Table 1 provides a rough stakeholder analysis

Stakeholder Type	Motivation	Interest	Power
Customer	M&S Support for core business (operational needs, training, SBA etc.); Budget (reduced cost)	Based on benefits	High (Establishes capability requirements, budget)
Provider	Business opportunity	High	Medium
Operational User	M&S Capability supporting his core business	Low – interested in result, not in means and techniques	Low
Simulation User	Flexibility, easy upgrade, maintenance…	High	Medium
Supplier	Business	Based on business opportunity – from low to high	Depends on M&S market, technology capabilities etc.

Table 1 Stakeholders Analysis

Relationships Between Stakeholders and M&S Services

The MSaaS concept requires negotiation between Customers, MSaaS Providers, Suppliers and Users regarding SLAs, licensing agreements and intellectual property.
The MSaaS Stakeholders defined above can be put into relationships with the three types of MSaaS perspectives which were identified during NATO MSG-131:

- MS Software as a service (MS-SaaS);
- MS Platform as a Service (MS-PaaS);
- MS Infrastructure as a Service (MS-IaaS).

The MSaaS Allied Framework supports all three service models which are inherited from the SOA service model, but there are slight differences. In the context of the MSaaS Allied Framework the three service models are defined as:

- **MS-SaaS**[1]: The MSaaS Simulation User consumes M&S products and solutions "as is" from the MSaaS Allied Framework without the need to manage, control or orchestrate the hardware/software infrastructure;
- **MS-PaaS**[2]:
  - The MSaaS Simulation User consumes M&S products and solutions from the MSaaS Allied Framework to compose and/or orchestrate M&S products and solutions to create a more complex simulation environment;
  - The MSaaS Provider maintains M&S products and solutions on the MSaaS Allied Framework (e.g. using a cloud infrastructure);
- **MS-IaaS**[3]: The MSaaS Supplier uses processing, storage, networks and other fundamental computing resources from the MSaaS Allied Framework to develop M&S products and solutions.

In the table below the MSaaS stakeholders are put in relation with their own role in each of the Service Model defined.

Table 2 describes possible uses of various service models of the MSaaS Ecosystem by roles.

Stakeholders		**MS-SaaS**	**MS-PaaS**	**MS-IaaS**
Customer		Not applicable		
User	Simulation User	Yes "as it is" Applications	Yes Set of collaborating applications (constructive and virtual simulations, C2SIM translation services etc.)	No
	Operational User	"Results-Oriented," reproduced by End User or C2Sim gateway	"Results Oriented," reproduced by End User or C2Sim gateway	No
Provider		Provides it to the User	Provides it to the User	Could provide it to Supplier
Supplier		Provides it to Provider (licensed Software)	Provides it to Provider (MSaaS Platform solution)	Uses the infrastructure for its own M&S applications development

Table 2 MSaaS Ecosystem by roles

[1] The capability provided to the consumer is to use the provider's applications running on a cloud infrastructure. The applications are accessible from various client devices through either a thin client interface, such as a web browser (e.g., web-based email), or a program interface. The consumer does not manage or control the underlying cloud infrastructure including network, servers, operating systems, storage, or even individual application capabilities, with the possible exception of limited user-specific application configuration settings.

[2] The capability provided to the consumer is to deploy onto the cloud infrastructure consumer-created or acquired applications created using programming languages, libraries, services, and tools supported by the provider. The consumer does not manage or control the underlying cloud infrastructure including network, servers, operating systems, or storage, but has control over the deployed applications and possibly configuration settings for the application-hosting environment.

[3] The capability provided to the consumer is to provision processing, storage, networks, and other fundamental computing resources where the consumer is able to deploy and run arbitrary software, which can include operating systems and applications. The consumer does not manage or control the underlying cloud infrastructure, but has control over operating systems, storage, and deployed applications; and possibly limited control of select networking components (e.g., host firewalls).

Resuming the CPX CAX example, the end-users operate directly the M&S tools, "as it is" from the MSaaS framework, so it is a MS-SaaS from the end-user standpoint. When the training centre personnel need to configure and compose M&S applications to build a simulated scenario with more complex features, they will be end-users who interact with the MSaaS framework as a PaaS. No end-user will use the MSaaS framework to deploy their own services or develop their own software on a provided software environment, as in the case of a PaaS in the SOA viewpoint.

THE OCEAN PROJECT

The Open SimLab initiative by the NATO M&S CoE consists of an innovative business model developed to attract industry, academia and organizations (NATO, military/government, non-government agencies) based upon the use of M&S in order to experiment on new concepts and ideas involving the integration of different systems and technologies. Under this initiative the M&S CoE, supported by Leonardo Company is developing a MSaaS cloud-based test bed prototype, the OCEAN project. The OCEAN project offers an embryonic framework made of a combination of hardware, software and services to automate the deployment of M&S tools and applications in a cloud environment.

The Platform

The proposed platform aims to offer a unique point of access through a web portal. The web portal provides a secure environment with access to the portal resources (services) granted by a user identity management system. The availability of services is managed by an M&S services management system, who facilitate the delivery, versioning, testing, consumption, termination and disposal of services

The system architecture involves the use of a hybrid cloud inside which you indiscriminately use physical machines, virtual machines and containers (Figure 2). The PaaS solution adopted is OpenStack installed inside a VMware cluster.

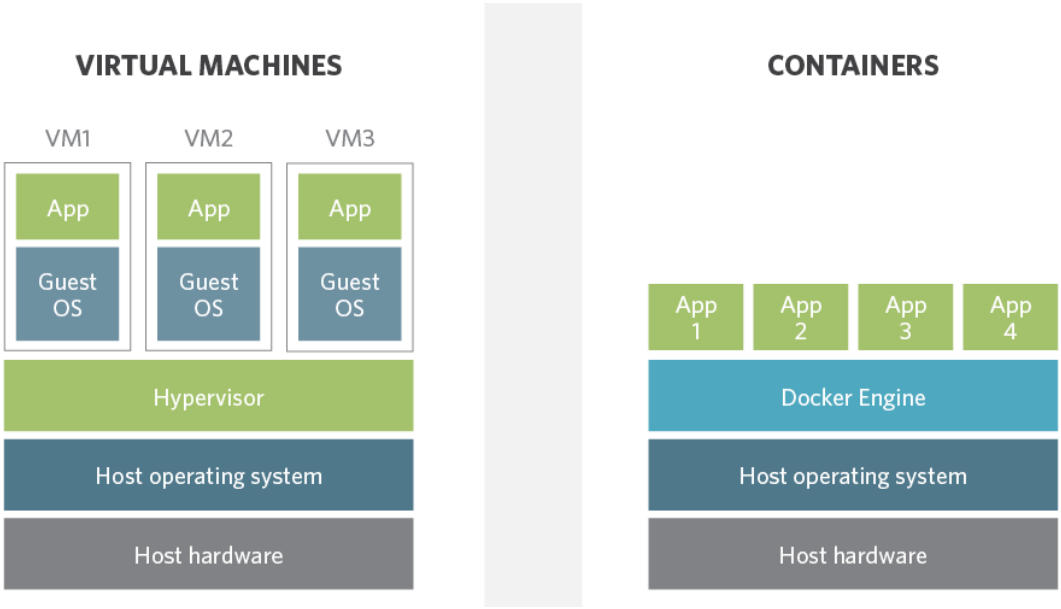

Figure 2 MSaaS System Architecture

As an open source system, OpenStack enables rapid expansion with external services. An ad hoc service has been developed (inside the OCEAN application stack) for the orchestration of these components: physical and virtual networks; physical and virtual machines; and micro applications (containers).

In this way you can go up the application stack from PaaS to SaaS - a M&S context we call MSaaS. The container management portion is relayed to the VMware Photon Platform solution and the SND (Software Defined Network) part of the virtual network (VXLAN) is implemented by VMware NSX (Figure 3).

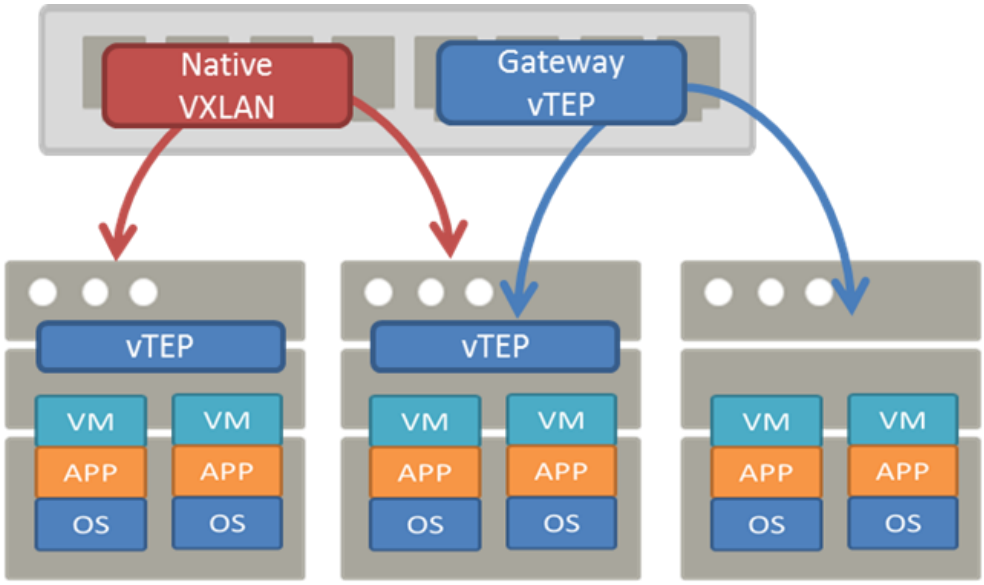

Figure 3 SND Architecture

Due to the structure of a VXLAN, tunnelled traffic can utilize traditional security options, which authenticate and encrypt the traffic. While our existing LAN infrastructure provides the perfect setting, a VLAN can be designated just for VXLAN traffic, providing security with just the servers sending the traffic. The setup ensures that all the end points are authorized on the LAN.

The service developed for MSaaS makes the management of these elements transparent to the users: by accessing a web portal in an agile and simple way, it is possible to create a segregated perimeter within which to insert asset instances (rooms, nodes, networks and software) by selecting them from a catalogue.

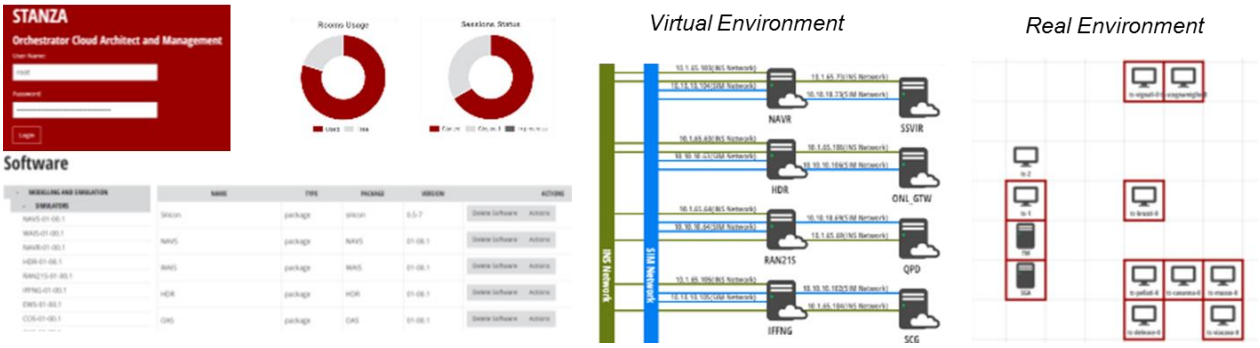

Figure 4 Example of assets networks and rooms management

After a room is created, it is possible to insert physical nodes inside it, create physical networks to connect physical nodes with virtual nodes, install software, start micro applications connected with virtual networks and so on … all from the OCEAN API. The Web Portal interface uses these APIs to perform the various operations.

OCEAN can then orchestrate all these elements by making the entire infrastructure system transparent and intuitive. A primary advantage of this MSaaS model is that a user with no knowledge of the system is able to use it without difficulty.

USE CASES

According to the experiments and the experience in which the M&S CoE is involved, it could be possible to reuse other projects run by the M&S CoE to provide already developed and well-proved use cases for MSaaS experimentation activities.

NATO M&S CoE and Leonardo are together building a use case of MSaaS based on OCEAN. The aim and complexity of this use case is to put together heterogeneous systems of services, virtual assets, real and physical systems coming both from the M&S and Command and Control (C2) worlds while also being geographically distributed. NATO M&S CoE and Leonardo deploy their assets inside OCEAN, creating an exercise in which a CGF-like (Computer Generated Force) application is stimulating at the same time two different systems: a 3D immersive training environment for communications and a ship combat system simulation.

The following is a short description of the project main components:

- Scenario Generator and Animator (SGA): a CGF application that enables preparation and execution of geo-referenced simulated representing behaviours and interactions among different simulated units and systems.
- Simulation and Validation of Communication (SVC): radio and networks simulator, implementing high fidelity models and reproducing complex data flows and transmissions.
- Equipment Simulators: simulator suite reproducing the on-board equipment for a ship, including navigation systems, radars and other sensors, to stimulate ship's combat management system.
- Combat Management System Simulation: simulation of a ship's combat management system, mainly used for integration activities and training.
- Gateway services: a suite of services able to translate DIS/HLA simulation standards into real system protocols in order to allow the simulation environment to stimulate external assets.
- MORPHEUS system: a 3D immersive system allowing the user to interact with the simulation mainly for training purposes.

All these components are deployed by OCEAN in different ways with different technologies. Real hardware platforms, virtual machine and containers, connect together in a geographically distributed environment to create an exercise room environment where the user can access and operate the different services and applications.

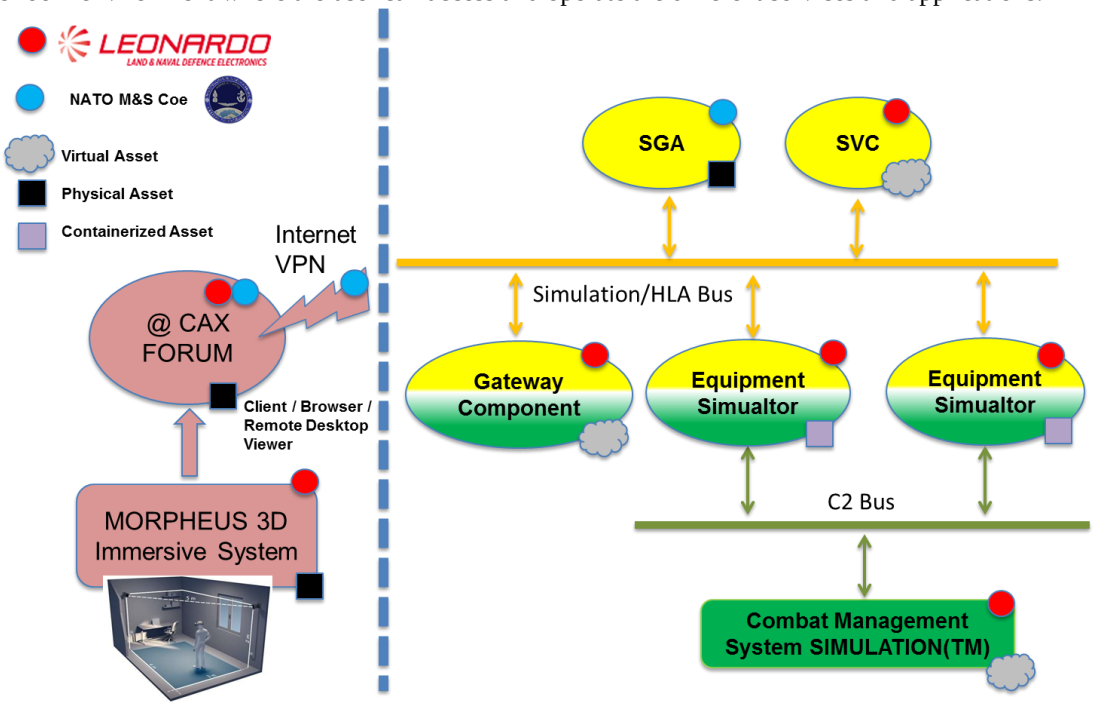

Figure 5 Example of the use case implementation at CAX FORUM 2017

CONCLUSIONS

The M&S CoE, Leonardo and other upcoming industrial and academic partners, are joining the project under the OPEN SIMLAB initiative, are designing, developing and implementing an initial MSaaS Prototype called OCEAN. The initial deployment at the M&S CoE of the OCEAN project prototype, provides an embryonic MSaaS services capability that demonstrates the value of MSaaS in relationship to the mentioned use cases.

According to the proposed Stakeholders and M&S services definitions, the OCEAN project is delivering to the NATO M&S CoE a M&S IaaS. With this in place, the M&S CoE could act as a M&S services provider to the MSaaS community of interest, while the Leonardo Company serves as the Supplier. The M&S community of interest that is consuming services could be considered the User and eventually, if they begin producing services, could act as Supplier.

WAY AHEADS

Further implementation of this capability after the development of mature M&S services, will require a dedicated M&S enclave where users (Simulation and Operational Users) will have access to these services. The M&S enclave is a new concept exploration by the M&S CoE in collaboration with the JFTC, JMSC, and other NATO and national organizations. The M&S enclave concept will require an alignment with the "M&S as a Service" paradigm and the Connected Forces Initiative (CFI), as the primary objective of the CFI (i.e., sharing and pooling of resources) is resembled in MSaaS. Similarly, it is required to align M&S and MSaaS with the NATO Consultation, Command and Control (C3) Classification Taxonomy as this is the primary tool used by NATO to chart the NATO C3 landscape. An involvement of NATO NCIA in this exploration is also desirable.

Future plans for the MSaaS include participation in Coalition Warrior Interoperability eXploration, eXperimentation, eXamination, eXercise (CWIX) 2017 and presenting a demonstration of the concept at the NATO CAX Forum 2017. The M&S CoE serves as the CWIX M&S Focus Area Lead, and during CWIX 2017 the following capabilities, are going to be experimented: A Scenario Generator and Animator (SGA) as a Service acting as both as consumer of services generating scenarios and as provider of services through a Computer Generated Forces (CGF) service to other Focus Areas like the Operational Command and the Cyber. Following the results of the CAX FORUM demonstration the M&S CoE is going to plan to experiment the OCEAN project, with new M&S service and capabilities, in CWIX 2018.

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