NATO Aligned UK Approach to Modelling and Simulation as a Service

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ABSTRACT

The need for modernisation of simulation technology in the United Kingdom Ministry of Defence (UK MOD) is being driven by a number of factors, including:

- *The increased importance of representing the full spectrum of effects has emphasised the importance of a more agile approach to simulation in order to rapidly represent the emerging operational environment.*
- *The increasing need for coherent simulation approaches for training, mission rehearsal, Concept Development & Experimentation and Decision Support*
- *Potential benefits for providing simulations by exploiting recent technological advances from the Information Communication and Technology (ICT) sector e.g. NATO and UK MOD ICT (Information & Communication Technology) strategies recommending "cloud first".*
- *The need to reduce Modelling and Simulation (M&S) acquisition and through-life costs; a move towards the use of common simulation services and components, which promote re-use across the UK Defence Enterprise as consistent, enduring, accessible, agile and adaptable solutions*

The UK MOD is researching the provision of Modelling and Simulation as a Service (MSaaS) as a potential Enterprise-level strategy to meet these needs and provide recommendations to de-risk the approach. This paper provides an overview of how MSaaS can be implemented to support the emerging simulation needs of UK MOD, how the UK approach is aligned with the NATO approach through participation in NATO MSG-136.

1.0 INTRODUCTION

Strategic Defence and Security Review (SDSR)

In 2010, the UK Government performed a Strategic Defence and Security Review (SDSR), which included an assessment of the use of simulation in Defence Training [1]. The review recommended "a step change in Defence exploitation of modern simulation training systems supported by an enterprise focus on driving down the barriers to acquisition and use to ensure optimal investment in simulation".

The SDSR report and supporting research at the time [2] provided key findings and recommendations on the required transformation of Defence training and simulation capability, which are summarised below:

- The current, case by case, approach to simulation system acquisition and through-life support is expensive and results in replication of near-identical capability. Moving forward it should be based on enterprise solutions to decrease diversity and maximise interoperability and collaboration.
- Simulation capability needs to be hosted on a common architecture and employed across the Defence Information Infrastructure (DII) to maximise availability to train using simulation.
- Identification of the high cost and complexity of maintaining currency through enhancing the diverse set of largely incompatible simulation systems to adequately represent the current and future operational environment (e.g. new platforms, sensors, weapons, networks, operational concepts, enemy capabilities). Simulation systems must be responsive to such rapidly changing operational requirements. The importance of this aspect has since been supported by the need to represent the full spectrum of effects.
- Simulation systems should include training scenarios that can be easily re-used or adapted to suit the training need.
- Simulation delivery approaches should enable comprehensive data capture that can be readily interrogated and presented as feedback as part of the After Action Review process.
- Simulation should be acquired through use of common simulation tools, data and systems, and Off-the-Shelf (OTS) software, where only in exceptional circumstances common components are not exploited and any additional enhancements are accessible to all other simulation capability users.

It is also worth noting that the review identified that, at the time, Defence lacked the systems and organisation to manage the delivery of simulation at an enterprise level in line with these recommendations.

Defence Training Systems and Infrastructure (DTSI) Change Programme

Following SDSR the DTSI Change Programme was initiated with a goal to deliver cost savings and increase efficiency in the Training and Education budget. The recommended reference architecture framework for DTSI was developed under the Training Transformation Capability Concept Demonstrator (TT CCD) project undertaken by Niteworks [3]. The project created a set of recommendations that future simulations systems should be developed:

- In line with a vision of future training and simulation being delivered via fully modular and distributed simulation systems.
- Via a Service Oriented Architecture (SOA) due to openness, modularity and decoupling.
- With functionality being provided by a set of loosely coupled components and services that are discoverable (either online or offline) and delivered over a network.
- As components and services (see Figure 1) that publish an open interface based on a defined message set

(the High Level Architecture (HLA) 1516-2010 Modular Federate Object Model was identified as a potential standards based message set).

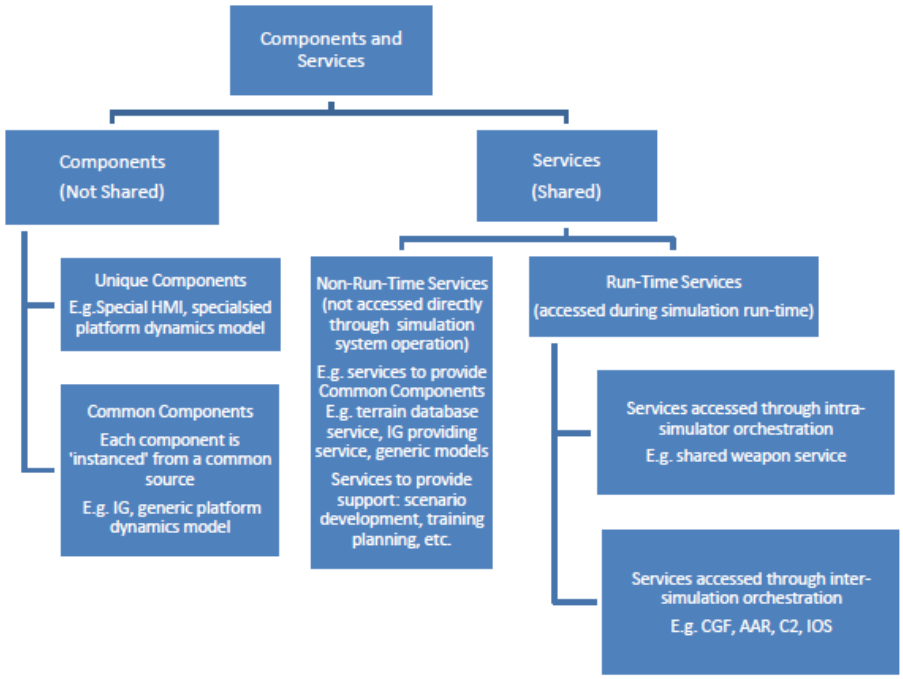

Figure 1: TT CCD Exemplar Service Taxonomy

As part of DTSI, a number of research thrusts were also identified. Those of relevance to the research discussed in this paper include:

- Research Thrust #10: focused on Simulation and Synthetic Environments framework, to improve the ability to rapidly configure cost effective simulated environments in support of analysis, experimentation, simulation, acquisition and test and evaluation, through to training and mission preparation.
- Research Thrust #10b: focused on the interoperability of Defence Live, Virtual and Constructive (LVC) simulations and C2 systems in order to maximise the flexibility for end users to exploit the optimum cost effective LVC balance.

Defence Training and Education Capability Operating Model

The DTEC Operating Model was established in 2013 to provide governance to deliver Defence Training and Education. In particular this is aimed to align the future acquisition of simulation technology more closely with the System of Systems Approach (SOSA) to capability acquisition (Joint Service Publication (JSP) 906 [4]) defined within the Acquisition System Guidance (ASG) [5]. SOSA is defined in the ASG as the "enabling way of working by which Defence will ensure that all delivered systems are procured and built" in accordance with the SOSA Vision to "enable enhanced capability through achieving commonality, reuse and the interoperability of independently procured systems". The DTEC Operating Model aims to deliver Training and Education against the DTEC vision "to train as we expect to fight and to develop our people as our strategic edge" using:

- Clearly identified Training & Education (T&E) requirements.
- Conformance to agreed standards.
- Commonality and re-use of data models and platforms.
- Consistent enduring accessible agile and adaptable solutions.
- Value for money at the Enterprise level.

Implementation activities under the DTEC enterprise model of relevance to this research are:

- Development of an experimental interim Defence Simulation Centre (iDSC) to aid centralised governance, delivery and management of simulation assets. This would help inform any potential future implementation of an actual Defence Simulation Centre (DSC).
- Development of a DTEC Catalogue of Common Products & Services.
- Development and introduction of Defence policy for the acquisition of Defence Training and Education systems against the DTEC vision and JSP 906. This policy is defined within JSP 822 (The Governance and Management of Defence Training and Education) Part 6 (The DTEC Rules) [6]. One aspect of this rule set requires the use of DTEC common products and services, enabled through the DSC, where appropriate.

2.0 UK MOD RESEARCH

Research Overview

In 2014 the MOD Chief Scientific Advisors (CSA) research programme commissioned research into the development of Live, Virtual, and Constructive (LVC) simulation capabilities. This research was in part influenced by the 2010 SDSR and subsequent recommendations from the DTSI change programme.

A vision for the research [7] was established as: "A future capability to enable the effective and efficient conduct of Joint Collective Training, Joint Mission Preparation, Joint Warfare Development; and Joint Warfare Individual Training & Education, via a networked approach with open architectures and common Live, Virtual and Constructive Simulation services that are self-synchronising to support the preparation of a cohesive Joint Force for employment in Joint/Interagency/Multinational operations"

The strategic objective of the research was: "To improve and optimise the ability to rapidly develop and configure cost-effective LVC simulations and synthetic environments in support of future joint training, concept development & experimentation, acquisition, evaluation, and mission preparation."

In order to meet the vision and strategic objectives of the research, four main research strands were established:

- Strand 1: Research strategy, coherence and coalition alignment.
- Strand 2: Architectures, Interoperability and Management of simulation systems.
- Strand 3: Representation of the Future Operating Environment through common services .
- Strand 4: Commercial and Gaming technologies.

The research is being delivered by Dstl staff and industry members through the Dstl Synthetic Environment

Tower of Excellence (SE Tower). The SE Tower was established in 2004 to grow the underpinning UK defence capability in Simulations and Synthetic Environments. It maintains a Community of Practice (COP) for UK industry to conduct research and share the lessons learned to enable the MOD supplier base to position itself strategically to meet MOD's future simulation needs. Three main commercial frameworks have been established to deliver research tasks, including: Architectures, Interoperability and Management of Simulations (AIMS) covering strand 2; Simulation Composition and Representation (SCORE) covering strand 3; and Commercial and Emerging Technology Evaluation an Exploitation (CETEE) covering strand 4.

MSaaS Research

Modelling and Simulation as a Service (MSaaS) was seen to have a lot of potential for delivering the research objectives in line with the benefits required by SDSR 2010 and the recommendations from the DTSI change programme. Therefore the technical approach to delivering research in strands 2 (AIMS) and 3 (SCORE) was aligned to delivering advice on a potential UK approach to delivering MSaaS. Research items were included in the research programme with objectives to:

1. Research and develop approaches to define and deliver the concept of MSaaS, specifically through Service Oriented Architecture and cloud-based infrastructure approaches. (AIMS)
2. Assess through use cases the architectures and interoperability approaches to meet the needs of the wider application of simulation in defence. (AIMS)
3. To develop methods for how data can be consistently captured, managed and coherently represented across simulation systems, e.g. training systems. (SCORE)
4. To evaluate and prototype methods for the provision of simulation through common content, based on using reusable modular components and services provided 'on demand'. (SCORE)
5. MSaaS Concept experimentation, evaluation and demonstration. (AIMS and SCORE)
6. Leverage and engagement in related international research activities – specifically to include participation in NATO Modelling and Simulation Group 136 (MSG-136). (AIMS and SCORE)

This paper will now draw on aspects of this research to detail the current thinking on a UK approach to delivery of MSaaS, in particularly providing a description of research against the Allied MSaaS framework described by NATO MSG-136.

3.0 NATO APPROACH TO MSAAS

The NATO Modelling and Simulation Group (NMSG) is part of the NATO Science and Technology Organisation (STO). The mission of the NMSG is to promote cooperation among Alliance bodies, NATO, and partner nations to maximise the effective utilisation of M&S. Primary mission areas include: M&S standardisation, education, and associated science and technology.

NATO MSG-136 ("Modelling and Simulation as a Service – Rapid deployment of interoperable and credible simulation environments") [8] is one of the task groups under the NMSG. This group is investigating the new concept of MSaaS with the aim of providing the technical and organisational foundations for a future permanent service-based Allied Framework for MSaaS within NATO and partner nations. NATO MSG-136 started its three-year term of work in November 2014 and finishes in December 2017. MSaaS is looking to provide a strategic approach to deliver simulation coherently across NATO.

The results of NATO MSG-136 are summarised in reference [9] but a brief summary of key relevant points from this paper are provided below:

Terminology

M&S products are highly valuable to NATO and military organisations and it is essential that M&S products, data and processes are conveniently accessible to a large number of users as often as possible. Therefore a new *M&S ecosystem* is required where M&S products 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 term service is used in the sense of a M&S service using the following definition:

An **M&S service** is a specific M&S-related capability delivered by a provider to one or more consumers according to well defined contracts including service level agreements (SLA) and interfaces.

The provided capability is implemented in a (distributed) system and/or organisation, within the following definition of MSaaS:

M&S as a Service (MSaaS) is an enterprise-level approach for discovery, composition, execution and management of M&S services.

Allied Framework for MSaaS

The Allied Framework for MSaaS is the linking element between service providers and users by providing a coherent and integrated capability with a Technical Reference Architecture, recommendations and specifications for discovery, composition, deployment and execution of services, and necessary processes and governance policies. The Allied Framework for MSaaS is the common approach of NATO and Nations towards implementing MSaaS and is defined by the following documents:

- Operational Concept Document: The Operational Concept Document (OCD) describes the intended use, key capabilities and desired effects of the Allied Framework for MSaaS from a user's perspective. [10]
- Technical Reference Architecture: The Technical Reference Architecture describes the architectural building blocks and patterns for realising MSaaS capabilities. [11]
- Governance Policies: The Governance Policies identify MSaaS stakeholders, relationships and provide guidance for implementing and maintaining the Allied Framework for MSaaS. [12]

The following sections describe how UK research has informed the potential implementation of the Allied Framework for MSaaS within a UK MSaaS ecosystem.

4.0 UK MSAAS RESEARCH APPROACH

MSaaS Guiding Principles

The operational concept described in this section aims to utilise the MSaaS framework to provide an approach to deliver:

- An on-demand fully transparent and integrated method of moving from an operational requirement to an executable simulation that can deliver that requirement;
- A semi-automated composition of simulations re-using existing capability where possible and integrating new if required;
- Deployment and execution of simulations decoupled from specific hardware and infrastructure to enable flexible and scalable use;
- Sharing of acquired capability, including hardware, software, services and infrastructure.

MSaaS Ecosystem

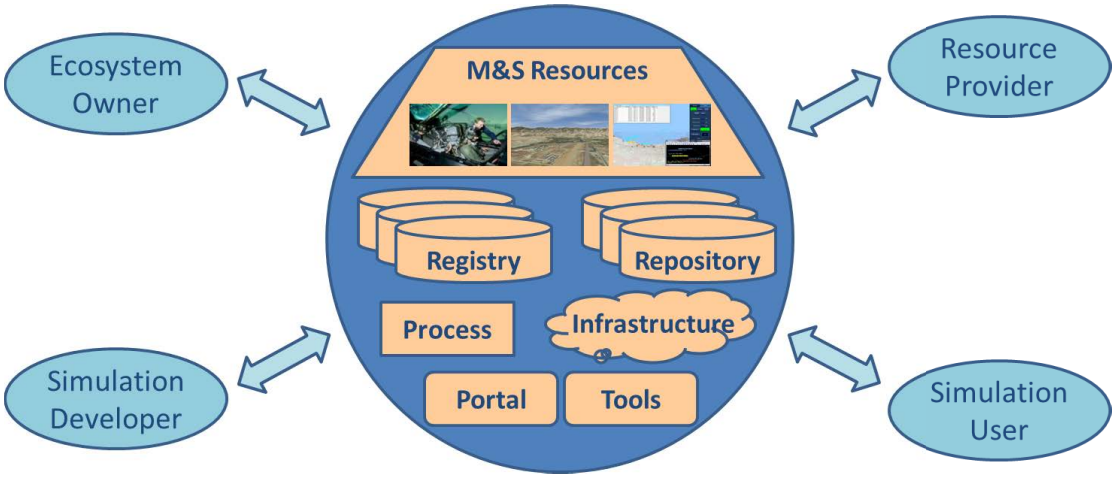

Figure 2: MSaaS Ecosystem

Figure 2 shows the Modelling & Simulation as a Service Ecosystem defined by AIMS. The stakeholders are:

- Ecosystem Owner: responsible for managing the Ecosystem by utilising maintenance functions;
- Resource Provider: produces and maintains simulation resources that can be exploited by other users;
- Simulation Developer: uses the simulation resources for developing simulation capability;
- Simulation User: Indirectly uses services by using simulation capability.

M&S Resources

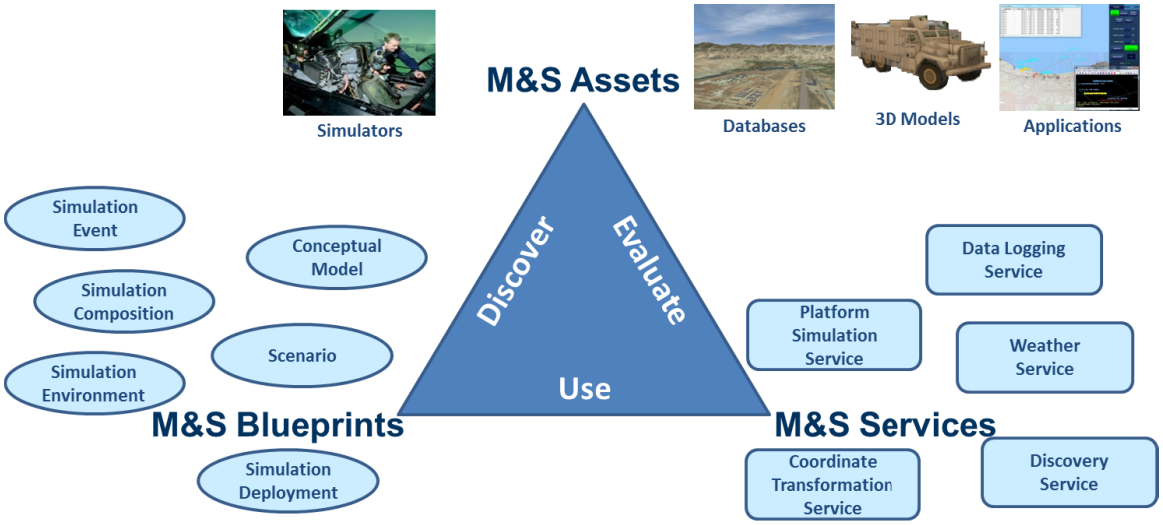

Figure 3: M&S Resources

M&S Resources can be M&S Assets, M&S Services or M&S Blueprints for which examples are provided in Figure 3. When people think of the reuse of simulation resources, they usually think of M&S Assets. M&S Services represent a different way of providing functionality to simulation environments by providing loosely coupled services with well-defined interfaces. The UK's vision is for the interfaces and functionality for these services to become NATO/SISO standards so that they can be provided and reused by different organisations.

The M&S Blueprint comprises a set of objects that completely describes the design and deployment of a simulation. By separating the design of a simulation into different component, different that parts of the design can be discovered and reused. For example, a Composition (which captures which services are to be used) can have several different Deployment options associated with it for deploying on different infrastructures.

MSaaS Portal

"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 and provides a Simulation Developer with a single point of access to the ecosystem. The MSaaS Portal can have different instantiations and provides access to the tools for Discovering, Composing, Deploying and Executing simulations and the infrastructure for running them on. "

A prototype Portal has been implemented as part of the research andit is envisaged that a full capability would be provided and centrally delivered by a future Defence Simulation Centre construct. Access to the Portal would be provided through a log on, which would then control access to tools and services appropriate to the user's role, security clearance or permissions. The Portal would be accessible on demand and accessible from anywhere on the network.

MSaaS Discovery Services

"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 organisations. This registry provides useful information on available services and assets in a manner that the user is able to assess their suitability to meet a particular requirement (i.e., user rating, requirements, simulation specific information, and verification and validation information). The registry also points to a repository (or owner) where that simulation service or asset is stored and can be obtained, including business model information (i.e. license fees, pay per use costs)."

Figure 4 shows a future vision for UK MOD providing a Discovery Service to facilitate the reuse of M&S Resources. UK research into MSaaS Discovery services [13] includes the following recommendations:

- A centralised registry is a key requirement for an effective Discovery capability. The registry should be underpinned by a Registry Information Model (RIM), and include the ability to:
    - Provide a complete and authoritative real-time catalogue of all M&S resources available within the ecosystem;
    - Provide controlled content implemented according to agreed standards to define properties of and associations between entities;
    - Provide a distillation of metadata to enable multiple approaches to be integrated within a single ecosystem.
- A centralised UK registry capability that can be accessed by MOD, coalition partners and potentially industry. It is recognised that some organisations i.e. industry, academia, may have set-up Registries for managing their own Simulation Resources. Where these organisations want to make their Simulation Resources available on a commercial basis i.e. by selling licences, they may want to federate their Registry with the centralised Registry in order to publicise their capabilities. In this case, the Discovery service accessed by the Portal will search not only the central Registry but also the Simulation Resources from these other organisations.
- The Registry would be best governed by any future Defence Simulation Centre (DSC) and would act as an electronic version of the DTEC Catalogue for managing re-use of simulation capability across Defence.
- The metadata for describing the simulation assets in the UK should become part of the UK DTEC Modelling & Simulation Standards profile. These include:
    - **ebRIM** [14] The Electronic Business Registry Information Model defined by the Open Geospatial Consortium (OGC) as the registry layer for cataloguing services.
    - **Dublin Core Metadata Initiative (DCMI)** [15] and **ISO 19115/19** [16] as metadata standards.
- The information held in the Registries would point to Repositories managed by different parts of MOD e.g. Army, Navy, Air force, Dstl, industry and academia. The Repositories would be set-up and managed by the owners of the M&S Resources, which gives them full control over managing their Intellectual Property. Access to the M&S Resources in the Repositories will be more tightly managed i.e. industry will be happy to publicise the existence of the resource but not make it freely available. Simulation Developers are likely to have direct access to Repositories owned by their organisation and will be able to download M&S Resources themselves. If a third party wanted to use the same resource,

they would initially have to contact the organisation and agree licencing terms. Once granted, they may be sent the resource or given limited access to the organisation's Repository i.e. what resources they can download and for how long.

- It is also desirable to federate Registries with UK coalition partners who have set-up their own Registries/Repositories e.g. NATO partners. Ideally, all partners would use the same metadata standards for describing the M&S Resources though it is recognised that this is not likely to be the case. However, where different terms are used to describe the same parameter, it is possible to map these terms, which enables at least some information to be shared.

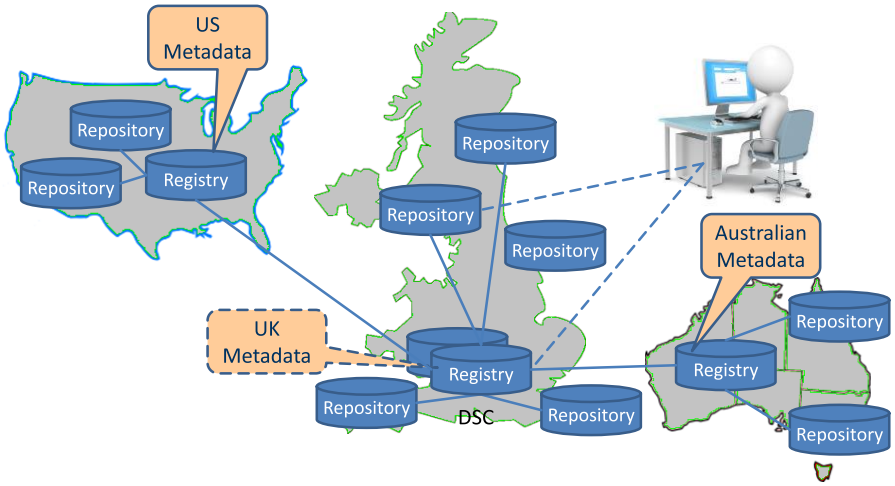

Figure 4: Discovery Service Vision

Figure 5 emphasises that where registries have been federated, it is not necessary to share all the information with every user e.g. for commercial or security reasons. Public and private areas of the Registry/Repository can be set-up to control access to the information. Even where a user can access metadata for an M&S Resource in the Registry, they may not have access to the actual resource in the Repository. This may only be granted once specific agreements have been set-up.

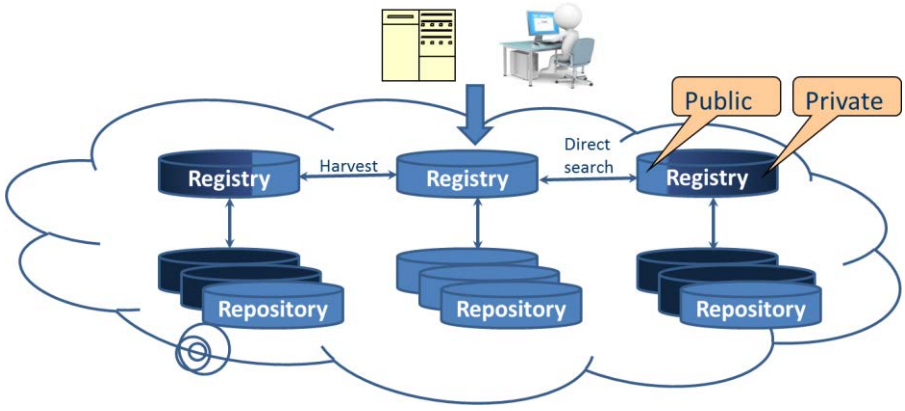

Figure 5: Secure Registry information sharing

The AIMS/SCORE research has implemented a prototype Discovery capability using a product by a company called Envitia Registry (marketed as GeoRegistry) [17]. GeoRegistry has previously been used for managing large quantities of geospatial data e.g. images, videos, and it was thought that it capabilities could be adapted for managing M&S Resources.

The GeoRegistry software has been deployed on a cloud provided as part of the AIMS MSaaS infrastructure and is available to the AIMS and SCORE project teams for research purposes. As GeoRegistry has been designed to process geospatial data, it supports the ISO19119 standard for services and ISO19115 for metadata.

Composition Services

"The Framework provides the ability to compose discovered services to perform a given simulation use case. Initially it is envisaged that simulation services will be composed through existing simulation architectures and protocols (e.g., using DIS, HLA, DDS) and can be readily executed on-demand (i.e., with no set up time). In the longer term, distributed simulation technology will evolve, enabling further automation of discovery, composition and execution than is possible today."

The goal of the AIMS research is to work towards simplifying the complexity of composing a simulation by reusing previously generated compositions. It is recognised that greater reuse can be achieved by reducing the granularity of a capability. The AIMS approach therefore breaks compositions into sub-compositions that provide some specific function e.g. exercise control. The structure of a composition and sub-composition is identical, and both can be stored in the Registry/Repository.

The sub-composition concept is to describe a group of re-usable services that have been composed and integrated and can be readily deployed on-demand, as a composition or as part of a larger composition.
A composition is a set of services which work together to provide a simulation environment for a defined event. An example composition showing the concept of grouping services into verified sub-compositions is shown in Figure 6.

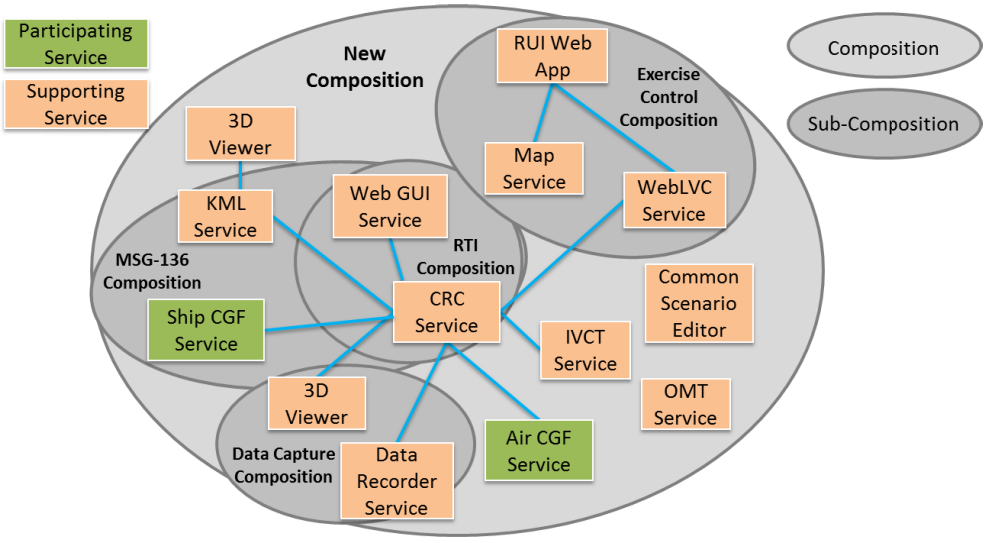

Figure 6: Sub-Composition Example

In the example above, the 'Exercise Control' composition is a group of integrated services providing the capability to control an exercise from a single Reconfigurable User Interface (RUI). Each service is described as an individual supporting service within the registry, but has been pulled together into a single sub-composition, to be used in combination with other sub-compositions to meet an Events requirement. One of the goals of the research is to produce an approach that ultimately could lead to the automatic generation of compositions from user requirements.

Research into Composition Services is still on-going, but the initial experimentation has demonstrated the potential for semi-automatically discovering sub-compositions and generating compositions that satisfy a user's requirement [18].

Initial benefits of this approach will enable a user to search and discover previously integrated simulation federations that can be automatically re-composed/re-integrated ready for deployment and execution on a given hardware solution.

MSaaS systems should be composed by fully modular and distributed simulation services via a Service Oriented Architecture (SOA). The NMSG-136 reference architecture should be used as the recommended UK MSaaS reference architecture, however, this is still at a low Technology Readiness level and needs to be further developed in any follow on activity to fully provide benefits such as automated composition.

In the MSaaS Concept, M&S services are Discovered by a Simulation Developer querying the Registry to identify those that satisfy their needs. These are captured in a Composition i.e. that specifies what services are required, and a Deployment i.e. that specifies how the services are to be deployed on hardware infrastructure. When the simulation is deployed to the infrastructure, a deployment tool will query the Registry to find out how to access the services from a URL or from a repository to be downloaded from (stored as a virtual machine, container or web service).

The main difference between MSaaS and a traditional SOA is that the binding of services is performed at the time of deployment.

Deployment and Execution Services

"The Framework provides the ability to deploy the composed services automatically on a cloud-based or local computing infrastructure. The automated deployment and execution allows to exploit the benefits of cloud computing (e.g., scalability, resilience). 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 utilises a route planning service) or may be provided by a thin client or by a dedicated application (e.g., a decision support system utilising various services like terrain data service, intelligence information service etc.). The execution services support a range of business models and are able to provide data relevant to those models (i.e., capture usage data for a pay-per-use business model)."

Research into Deployment and Execution Services is still on-going, but initial recommendations include:

- MSaaS should exploit the benefits of cloud based infrastructures It should be noted that the means of deploying simulation services on a particular cloud service provider will vary between service providers as not all cloud providers offer the same services (the AIMS research has investigated use of UK Cloud and Amazon Web Services). In particular, the following will differ between different cloud providers:

a) System resources e.g. hypervisors, operating systems, management tools, network configuration, etc.

b) The amount of control you have over the your resources

c) The way you access your resources

d) The way you deploy your resources

e) The number of Instance types supported, including graphics support

f) The types of containers supported, including Docker support

g) The cost model.

- MSaaS should exploit the benefits of IaaS, PaaS and SaaS (though AIMS has only researched IaaS and PaaS).
- Use of Infrastructure as code to enable deployments to be built once and run anywhere at any time, taking full advantage of the benefits of cloud. This reduces manual errors, promotes reuse and makes it easier to deploy on different infrastructures.
- Containerisation should be used as a method for cloud based deployment of simulation services. This is because they enable services to be deployed on any infrastructure in a consistent way and are compatible with the use of smaller loosely coupled services. The UK has proved the use of Docker for implementing MSaaS but other container technologies are available.
- Security services have not been investigated as part of this research, but should be considered for future research.
- Runtime tools are required to monitor the status of services e.g. start them if they are not already running. They should use information defined in the deployment for identifying which services are running. The AIMS research demonstrated what functionality a service requires to integrate with the Runtime tools and how a wrapper can be used with existing (legacy) services to also provide this capability.UK Defence Information Systems and Services (ISS) should provide the hardware infrastructure for deployment of simulation resources and provide access via the UK's Defence Information Infrastructure (DII).

The research team has developed a cloud based implementation of a set of services to investigate the MSaaS concept (see Figure 8).

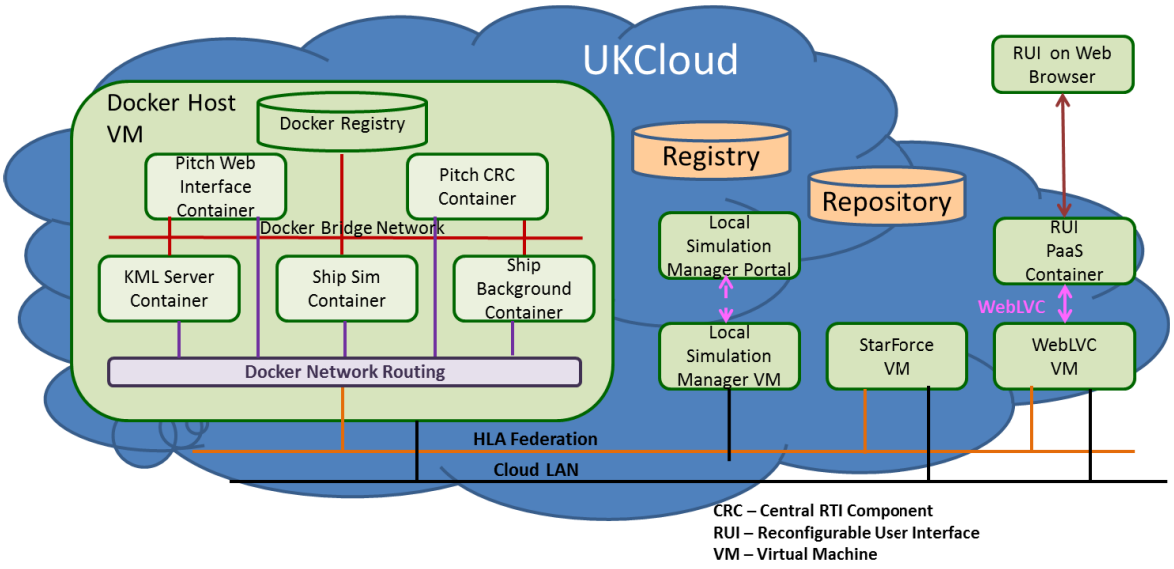

Figure 8: AIMS MSaaS Demonstration Architecture

The demonstration includes the ability for a user to Discover a simulation in the Registry and to run it on a cloud infrastructure. The composition comprises an HLA federation with services deployed in Docker containers, virtual machines and web services. The federation is controlled by a Reconfigurable User interface (RUI) run in a web browser that also displays the position of entities in the federation on a 2D map.

5.0 MSAAS BENEFITS

The UK research has identified the following potential benefits of Modelling and Simulation as a Service provides to the MOD:

- MSaaS delivers simulation whenever needed i.e. access to registries and repositories, with services potentially available 24/7.
- MSaaS brings simulation to wherever it is needed with the use of cloud computing and web services.
- MSaaS enables rapid adaptation to changing needs, by reusing previously validated simulation sub-compositions, and through provision of a modular service based approach.
- MSaaS increases capabilities by sharing and reusing resources.
    - The use of a discovery service enables previously unknown resources to be identified.
    - Previously designed simulations can be swiftly re-deployed.
    - Services can be efficiently swapped which provides resilience.
- MSaaS reduces the cost of employing simulation by:
    - Reusing simulation resources.

  - Reducing time for compositing simulations
  - Providing 'Pay as you Go' cloud computing
- MSaaS provides efficient use of hardware. Many services are accessed in a browser on local hardware, whichcan be quickly reconfigured for different exercises.
- MSaaS enables multiple simulations to be run simultaneously.
- MSaaS provides resilience by enabling services to be mirrored in a different cloud.

6.0 CHALLENGES / ISSUES

Although the research has been largely positive in demonstrating a technical approach to the delivery of MSaaS, the research has identified a number of challenges/risks associated with the implementation of MSaaS in the UK MOD.

Whilst there are significant advantages with running simulations in the cloud by exploiting virtualisation and container technologies, the biggest impact for MSaaS is if it is implemented at the Enterprise level. However, it is realised that up front investment will be required for setting-up and maintaining Registries/Repositories and developing the required toolset. The concept of reusing simulation resources is not new and there have been various previous initiatives using catalogues and repositories that have failed. Experience has shown that after the initial flurry of interest, these initiatives have withered as the people who originally promoted them move on. For MSaaS to be successful it needs to be championed at an Executive level through Defence simulation policy and strategy to ensure investment for the long-term. Concepts such as the Defence Simulation Centre should be supported to provide enablers for MSaaS. Although there will be some short-term gains e.g. use of cloud technologies, many of the financial benefits of MSaaS will only be realised once a culture of reuse in procurements is adopted.

The major risk for MSaaS is that by making the ecosystem available to a large number of users as possible through cloud based approaches, it makes it vulnerable to cyber-attacks. However, the same solutions can be employed as used for protecting an organisations normal IT infrastructure.

A limitation to the use of cloud computing is latency when the cloud is not physically located close to the point of use. This particularly affects services that are accessed synchronously at high rates. For these cases, it may be necessary for the service to be downloaded to the local hardware. There is currently an issue with running services with a high graphic content in the cloud but graphic card vendors are beginning to address these issues. For conventional simulation traffic e.g. that transmitted using HLA, having the service in a cloud is no different to running a conventional distributed simulation, which industry has a lot of experience with. By having all the common elements of a distributed simulation running in one place e.g. tactical environment, weapons effects, weather, this may actually reduce network traffic and improve performance. It should be noted that AIMS has not conducted much research into the effects of latency and further investigation required.

7.0 CONCLUSIONS

MSaaS offers a strategic approach to provide coherence and modernisation of UK defence M&S systems, which will provide cost and time savings.

NATO MSG 136 has defined the Operational Concept, Reference Architecture and Governance approach to the

delivery of MSaaS. UK research has been used to inform the NATO approach.

The use of a Registry provides an effective way to publicise information about M&S Resources, for humans to discover and evaluate them and for machines to automatically find and download them.

The use of sub-compositions provides a viable approach to expediting the generation of simulations.

Cloud based infrastructures provide many benefits for deploying simulations, e.g. efficient use of resources, different business models.

The use of container technologies provides an efficient way for storing and deploying services.

The ability to deploy simulation services on Cloud based hardware solutions can be effectively achieved through the use of Infrastructure as Code.

8.0 RECOMMENDATIONS

Any future UK approach to the delivery of MSaaS should be aligned with the NATO Allied Framework for MSaaS defined within the Operational Concept, Reference Architecture and Governance document outputs of NATO MSG-136.

The UK MOD authority for Joint Training and Simulation should either establish a Concept of Employment (CONEMP) for MSaaS, or inform the CONEMPS of related capability development projects based on the recommendations of this research.

The Discovery Service approach described in this research should be considered as an approach to the delivery of future Catalogue service for Defence Modelling and Simulation.

The architecture for future simulations should to be more component based so that they can capitalise on the benefits provided by MSaaS.

Future research to mature the capability should be sought for the following areas:

- Ability to track the Usage history, Verification and Validation (V&V) status of simulation services within a Discovery service approach.
- Automated composition and verification of simulations.
- Simulation architectures to fully exploit the benefits of MSaaS and cloud based deployments.
- Security of cloud based simulation deployment and execution.

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