MSG-168 Lecture Series on
Modelling and Simulation as a Service (MSaaS)

2. Overview of MSaaS Concept to Ecosystem

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ABSTRACT

This paper describes the concept of providing Modelling & Simulation as a Service (MSaaS), which has been developed from research performed by a Thales led team on behalf of the scientific branch of the UK MOD (Dstl). It describes an MSaaS ecosystem comprising M&S Resources, Registries, Repositories, process, infrastructure and tools. A key principle of MSaaS is the reuse of Modelling & Simulation (M&S) resources, which is facilitated by the use of Registries and Repositories. Different technologies are described for deploying simulations to cloud based environments; these include, virtualisation, containerisation and the use of 'Infrastructure as Code'.

The paper describes use cases that illustrate the application of MSaaS and a cloud based simulation that was implemented to investigate and demonstrate the MSaaS concept.

1.0 SIMULATION RESOURCES REUSE AND TOOLS DEMO

1.1 Introduction

Modelling & Simulation as a Service (MSaaS) offers a different approach to providing simulation capability by exploiting Service Oriented Architecture (SOA) and cloud-based infrastructures. The results presented in this paper relate to the Thales led MSaaS research performed on behalf of the scientific branch of the UK MOD (Dstl). It is also influenced by the work performed by MSG-136 [1].

The paper uses the DSEEP[1] term 'simulation environment' when referring to the executable capability, which could comprise many distributed simulations and simulators (also known as a federation).

1.2 Motivation for MSaaS Research

The use of simulation pervades all parts of defence including; Training, Mission Rehearsal, Decision Support, Concept Development and Experimentation (CD&E). Although the benefits of simulation have been exploited for training, other areas of defence are not capitalising on them due to the perceived time and cost for developing complex distributed simulations.

One of the problems in a large organisation is that, there is not a central record of all the simulation resources it owns. This can lead to parts of the organisation buying capability similar to what it already owns, which is

[1] DSEEP (Distributed Simulation Engineering and Execution Process) is an IEEE Computer Society standard sponsored by the Simulation Interoperability Standards Organization (SISO) standard.

very wasteful. A key principle of MSaaS is to have an effective 'discovery' capability to enable simulation resources to be identified and reused.

Recent advances from the Information and Communication Technology (ICT) industry such as cloud technologies can provide many advantages to the way simulations are delivered. These include the use of virtualisation and containerisation, which provide a consistent and agile way of executing simulations on generic hardware. The introduction of Service Oriented Architectures has provided a way of delivering software capability at an Enterprise level via loosely coupled re-usable services. The aim of MSaaS is to capitalise on these developments so as to provide more flexible and cost effective simulation architectures.

1.3 Simulation Trends

In the past, training systems procured by NATO and MOD were completely bespoke solutions. However, to reduce costs there has been a move for MOD to provide some elements of the simulation e.g. visual data, as Government Furnished Equipment (GFE). It is expected that this trend will continue with a higher percentage of components being reused across different training systems.

In order to promote innovation, flexibility and cost effectiveness there is a move to transition from large monolithic simulations into component architectures. This will provide opportunities for reusing these components across different simulation systems. The benefits of component architectures include;

- Reduced cost of procuring a capability as you can buy once and use many times;
- Reduced cost of maintaining a capability as only one piece of software has to undergo configuration control;
- Reduced skill requirement as only have to know about one piece of software;
- Bug fixes can be quickly propagated to wherever component is used.
- Swapping out one smaller component for another becomes easier and cost effective

The MSaaS concept provides a way of delivering software components as loosely coupled services and applications.

2.0 OVERVIEW OF MSAAS

2.1 MSaaS Definition

There is no universally accepted definition for MSaaS and different people and organisations have a different interpretation of what is meant by the term. However, it is generally accepted that MSaaS is more than just running simulations in the cloud using virtualisation and container technologies. The Thales definition of MSaaS is:

An Enterprise-level architecture that promotes modularity, loose coupling, agility and reusability of Modelling & Simulation resources from different suppliers by making them available on-demand to a large number of disparate users in order to reduce the cost and time for implementing Modelling & Simulation capability to improve operational effectiveness.

The NMSG-164 definition of MSaaS, which is derived from the Thales definition is '*M&S as a Service (MSaaS) is an enterprise-level approach for discovery, composition, execution and management of M&S services*'. A more complete understanding of MSaaS is obtained by decomposing the Thales definition into the four MSaaS principles:

- 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.

The long-term vision for MSaaS is to be able to go from a requirement for producing a simulation capability to delivering the capability with minimal human involvement.

3.0 MSAAS ENABLING TECHNOLOGIES

The development of several technologies that have recently emerged from the field of Information and Communications Technology (ICT) are timely as they are essential to implementing MSaaS.

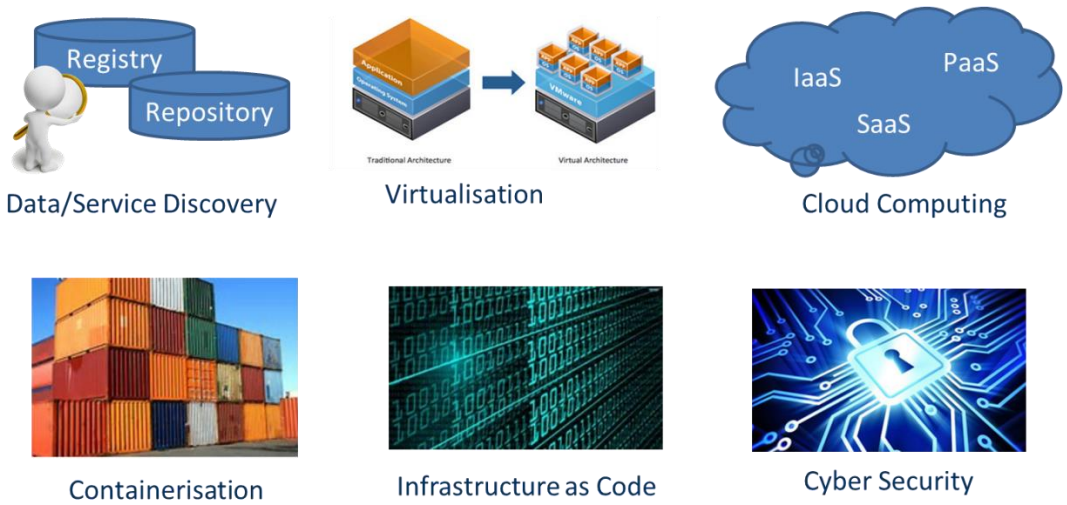

Figure 1 MSaaS Enabling Technologies

- Data/Service Discovery: provides the ability to search for or discover simulation resources that can be reused;
- Virtualisation: refers to the provision of computing resources, such as computer platforms, storage devices and network components, using virtual emulations rather than physical equipment;
- Cloud Computing: is an ICT paradigm that enables ubiquitous access to shared pools of configurable IT resources and higher-level services that can be rapidly provisioned with minimal management effort, often over the Internet;
- Containerisation: is a lightweight alternative to full machine virtualisation and involves encapsulating an application in a container with its own operating environment;
- Infrastructure as Code: uses a higher-level or descriptive language to automate the deployment of code to the infrastructure;
- Cyber Security: comprises technologies, processes and controls that are designed to protect systems,

networks and data from cyber attacks.

4.0 MSAAS ECOSYSTEM

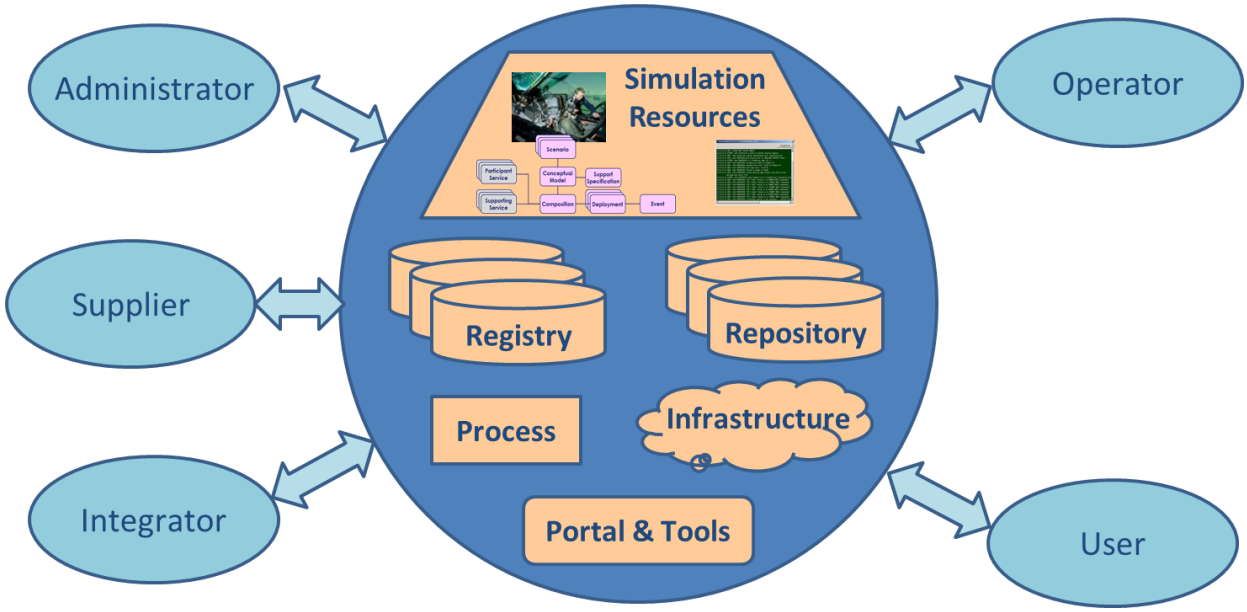

Figure 2 MSaaS Ecosystem and Stakeholders

A definition of an ecosystem is 'a complex network or interconnected system'.

Figure 2 shows the elements of the MSaaS ecosystem. They are briefly described below and a fuller explanation is provided in the following sections.

- Simulation Resources: comprises M&S Assets, M&S Services and M&S Blueprints;
- Registry: a structured, searchable database containing information about M&S Resources (analogous to an electronic, searchable catalogue);
- Repository: a store for reusable resources such as M&S Services and M&S Blueprints;
- Process: defines how services are Discovered, Composed, Deployed and Executed[2];
- Infrastructure: comprises the computing and network elements for executing the Simulation Environment;
- Portal & Tools: the Portal provides a single point of entry for accessing the toolset that supports the MSaaS process.

The MSaaS stakeholders are:

- Administrator: responsible for setting-up and operating the MSaaS ecosystem by utilising maintenance functions;
- Supplier: produces and maintains simulation resources that can be exploited by other users;
- Integrator: uses the M&S Resources for developing Simulation Environments;
- Operator: responsible for deploying and running the simulation;

[2] NATO MSG-136 has produced an overlay for the Distributed Simulation Engineering & Execution Process (DSEEP) [16]

- User: uses M&S Resources by interacting with a Simulation Environment.

4.1 M&S Resources

Modelling & Simulation (M&S) resources are highly valuable to military organisations and a fundamental principle of MSaaS is to promote the reuse of these resources across different projects.

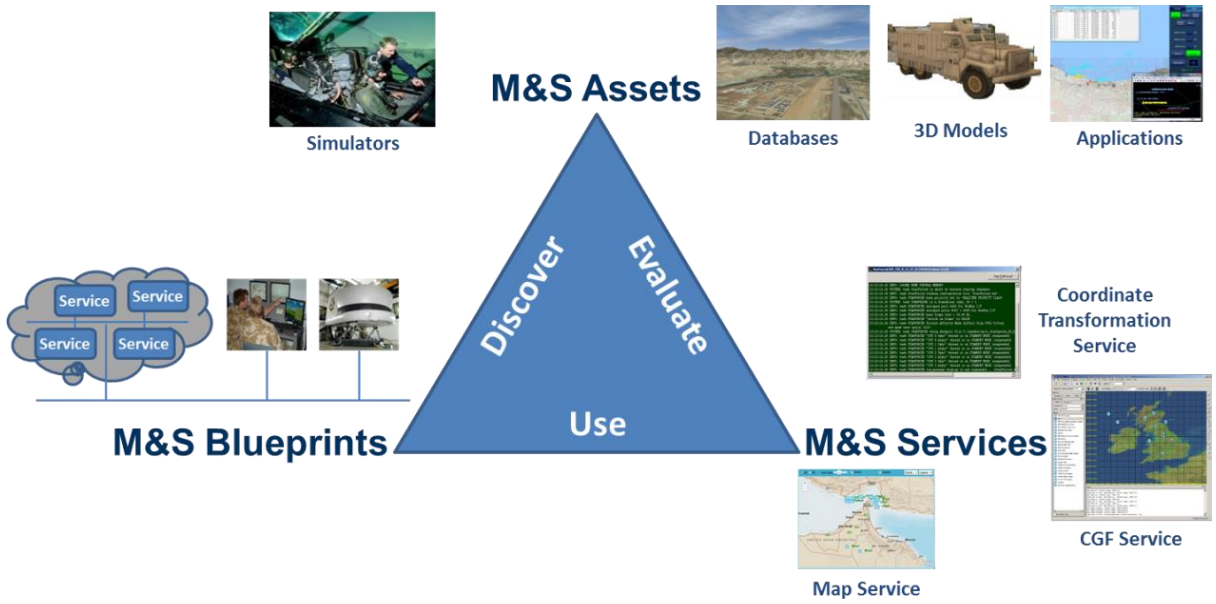

Figure 3 M&S Resources

In the context of this paper, the moniker 'M&S Resource' is used as an overarching term to represent M&S Assets, M&S Services and M&S Blueprints, which are described below.

4.1.1 M&S Assets

M&S Assets are what people currently envisage when they think about the reuse of M&S Resources. They can be physical simulators, M&S Data e.g. 3D Models, visual databases or applications.

4.1.2 M&S Services

Services represent a different way of providing functionality to Simulation Environments by providing loosely coupled services with well-defined interfaces.

M&S Services can be persistent or non-persistent. Persistent M&S Services run 24/7 and support multiple Events, whereas non-persistent M&S Services are deployed on-demand for a particular Event or Events. The M&S Services can be owned by the organisation running the Event or provided by a 3rd party. In the latter case, an appropriate licence would have to be agreed with the Resource Supplier. MSaaS does not impose any specific technology e.g. HLA or Representational State Transfer (REST), for implementing the services' interface.

4.1.3 M&S Blueprints

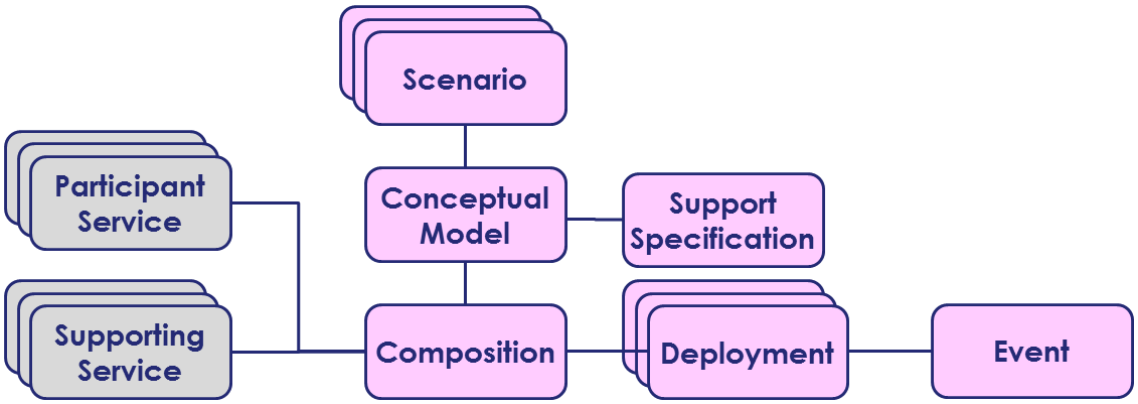

Figure 4 M&S Blueprint

The M&S Blueprint comprises a set of objects that completely describes the design and deployment of a simulation environment (those coloured pink in

Figure 4). These include;

- Conceptual Model object: defines entities participating in a simulation environment and how they can interact;
- Scenario object: defines laydown of entities and how they are tasked during the execution of the simulation environment;
- Support Specification object: defines services required by the simulation environment e.g. data logging, exercise control, that are required in addition to those specified by the Conceptual Model;
- Composition objects: describes the services used by the simulation environment;
- Deployment objects: define how the software for running the services is deployed to the infrastructure and the network properties required to integrate them;
- Event objects: provides information about a particular execution or set of executions of a simulation deployment.

By having a Blueprint comprising different simulation objects, all or parts of the design can be discovered and reused. These simulation objects can be used as is or modified, which can save a lot of time and effort. It should be noted that there is a 'one to many' relationship between some objects. For example, a Composition can have several different Deployment options associated with it for deploying on different infrastructures. The Participant Services and Supporting Services (coloured grey) are common to different Blueprints.

4.2 Registry

A Registry is analogous to a catalogue and in the context of MSaaS is used to 'Discover' M&S Resources so that they can be reused [2]. The advantage of using a Registry is that it enables more sophisticated queries to be made. This is because a Registry provides a formal definition of both the properties of registered resources and objects as well as the relationships between them. It also provides a mechanism to apply formal definition structures, such as controlled vocabularies, taxonomies and ontologies.

The use of a Registry to provide a discovery capability enables the following types of queries to be made:

- Find a Composition that has the name ‘RedFlag’?
- Find Compositions that uses the ‘Fearless Mariner scenario’?
- What Events were held between ‘May 2012 and April 2013’?
- What Scenarios are available in the bounding box (drawn on a map of the world)?
- What services represent a ‘fast jet’?
- What Compositions use the ‘weapon effects service’?
- What Events use the ‘A400 simulator at RAF Brize Norton’?

The ability to perform these types of complex searches in a Registry is enabled by it having an MSaaS Information Model.

Once an M&S Resource has been discovered, its suitability for satisfying a particular requirement can be evaluated. The evaluation is currently performed by a Simulation Integrator reviewing the metadata and other supporting information associated with the M&S Resource; however, the future vision is that it will be possible to automate the evaluation process by developing tools that exploit the power of the Registry.

In order to maximise the accessibility of information in the Registry, it is envisaged that it would be operated at the lowest level of protective marking possible. However, if required, the Registry could be configured with different levels of security access.

Typically an organisation will have a single Registry for managing its simulation resources, which can support multiple repositories. However, if Registries comply with international standards, it is possible to federate them so that information can be discovered across multiple Registries. This is useful for sharing information with other nations/organisations [3].

4.2.1 Metadata

Metadata provides descriptive information about an individual M&S Resource that allows it to be discovered and evaluated to determine if it satisfies a particular requirement.

Metadata is frequently used in many areas to discover and evaluate if a resource satisfies a requirement. Many metadata standards are available but the majority are aimed at humans interpreting the information. However, for MSaaS, the discover and evaluation functions must also be performed by a computer, which means the resource descriptions must be more rigorously defined and not ambiguous. As an example, the term tank can refer to a military vehicle, somewhere to keep fish or a place for storing water. Machine readable metadata is often coded using the Extensible Markup Language (XML).

For M&S Resources that are stored in a Repository, the metadata provides a link to enable them to be accessed. For a physical simulator, the metadata will contain contact details of who is responsible for managing it.

The biggest risk to the success of MSaaS is poor quality metadata as this inhibits the discovery process. Ideally all metadata should be produced with the minimum human involvement to ensure that the information provided is complete and consistent.

The UK research selected the ISO 19000 series as the family of standards to be used by the MSaaS research. This is because they support all the elements of Dublin Core, they are formally extensible and have an XML encoding standard to support machine interpretation.

4.2.2 Registry Information Model

The Registry Information Model (RIM) defines the relationship between the different Registry objects. It provides a framework for categorising the information to enable it to be discovered. As an example, referring to Figure 4, if say a Simulation Integrator finds a Composition they would like to reuse, the Registry knows what Deployment objects are associated with it. Similarly, it is possible for a user to traverse the RIM so that it is possible to find all Scenarios associated with a particular Composition or which Compositions use a particular Participant Service. Reference [2] describes the UK approach to information management in the MSaaS ecosystem.

4.3 Repository

A repository is required by the MSaaS ecosystem for storing M&S Resources. This can include environment data (e.g. terrain elevation and features), 3D model data, applications, and executable code in virtual machines or containers for running services. Typically an MSaaS ecosystem will have multiple Repositories, which are maintained by the Resource Supplier. This is to enable the Resource Supplier to manage who has access to the data so that they can have full control over their intellectual property. In some cases, access to M&S Resources in a Repository may only be through a 'Point of Contact' (POC) rather than it having a direct link with the Registry. This situation may arise as a result of commercial or security considerations.

Many solutions exist today for the representation and storage of M&S Resources and interchange. It is not expected that any single solution will ever meet all requirements and there is no clear single solution that stands above the rest as an easy recommendation to cover most requirements.

In addition to the metadata, an M&S Resources may also have supporting information associated with it, which also has to be stored in a Repository. As an example, a Scenario may have a video showing how the entities move over time to assist a Simulation Integrator with determining if it satisfies their requirement.

4.4 Process

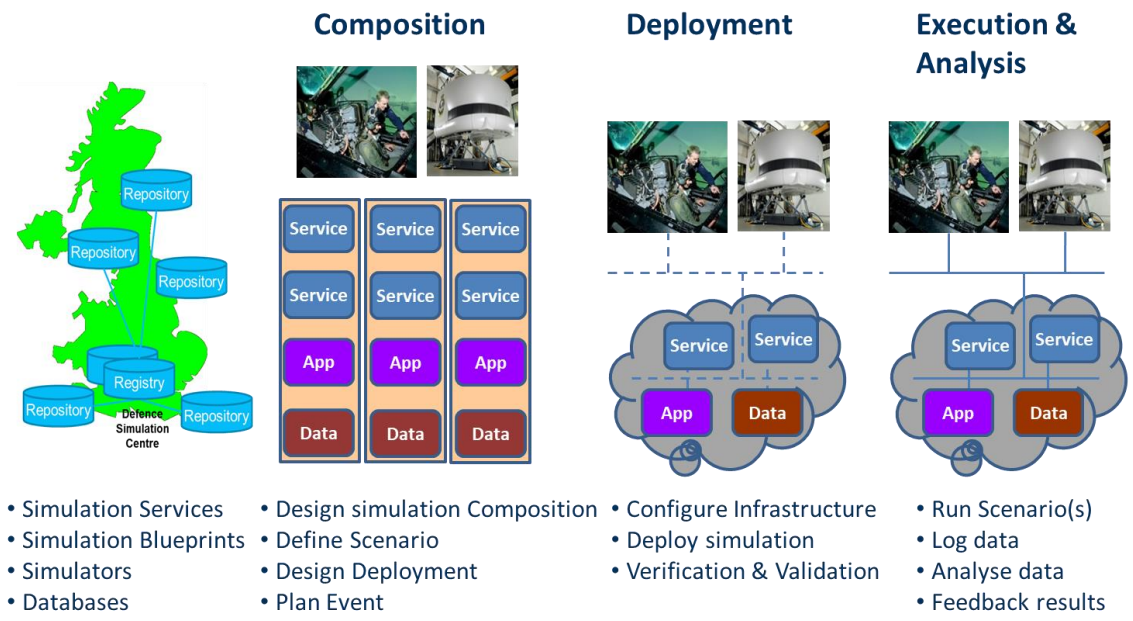

Figure 5 MSaaS Process

The UK MSaaS process comprises 5 steps as shown in
Figure 5.

- Discovery: find M&S Resources that can be reused;
- Composition: integrate sub-compositions and services;
- Deployment: deploy simulation to infrastructure and test;
- Execution: run Simulation Environment;
- Analysis: process the data collected whilst executing the Simulation Environment.

The UK process is compatible with the overlay to DSEEP produced by NATO MSaaS Modelling & Simulation Group (MSG-136) [4].

4.5 Infrastructure

Although MSaaS promotes the benefits of cloud computing for delivering simulation capability, it also allows for software to be deployed on other computing platforms. In addition to downloading software from the Repositories, MSaaS also enables physical simulators and services running 24/7 to be integrated into the simulation environment.

The UK research has been conducted on clouds supplied by 3rd party cloud providers although it is recognised that for military use, access to more secure clouds will be required. Although some 3rd party cloud providers offer clouds at higher security classifications, there is no reason why cloud services cannot be supplied internally by an organisation if security considerations demand it.

4.6 Portal & Tools

The UK research produced a suite of prototype tools to support the MSaaS process, which include:

- Horizon Portal: enables M&S Resources to be discovered;
- Composer: enables Compositions to be discovered and displayed graphically;
- Deployer: deploys simulation software to the infrastructure.

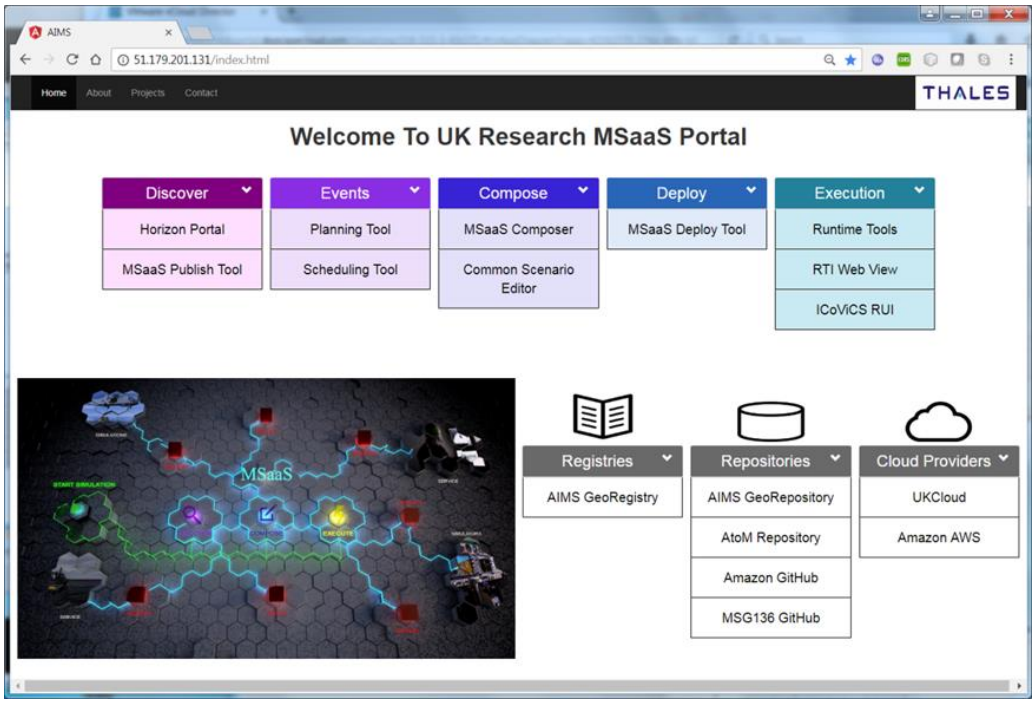

Figure 6 UK MSaaS Research Portal

The MSaaS Portal is a browser based tool that provides a single point of access to the MSaaS tool suite (Figure 6). It also provides access to tools for managing the Registry, Repositories and the services provided by 3rd party cloud providers.

5.0 USE OF MSAAS ECOSYSTEM

A fundamental principle of MSaaS is the reuse of M&S Resources. Experience from many domains has shown that it is usually more efficient to modify something rather than create it new from scratch. This approach is encouraged by the MSaaS concept. The entry point into the MSaaS ecosystem depends on how the requirements for the simulation environment are specified. These may be provided as an operational scenario or as a list of user needs. The way the MSaaS ecosystem is used will depend on the role and experience of the person using it and what they want to do.

Figure 7 Design Time Discovery

A Simulation Integrator provided with an operational scenario may initially search the Registry for Scenarios or Compositions that contain the required entities. They may also supplement the Registry queries with additional specific simulation requirements e.g. Exercise Control. The Simulation Integrator may also manually search for individual M&S Assets or M&S Services.

If the person knows of a Simulation Environment they want to rerun, they can go straight to the Deployment

for it. This can be searched for in terms of the Event name, date when the previous Event was run or the name of the person previously responsible for running the Event, etc.

The Simulation Integrator will evaluate the metadata and supporting information for the discovered Registry Objects to determine their suitability. Ideally a Composition will be discovered that completely satisfies the requirements. In this case the Simulation Integrator can use the power of the Registry's Information Model to identify Scenarios and Deployments associated with the Composition to see if they can be reused as is. If the Composition, Scenario or Deployment doesn't completely satisfy the requirements, the Simulation Integrator can modify them as required. A new Blueprint for the Event would be created that links all the objects associated with the Event and is published to the Registry/Repository so that they are available for future reuse.

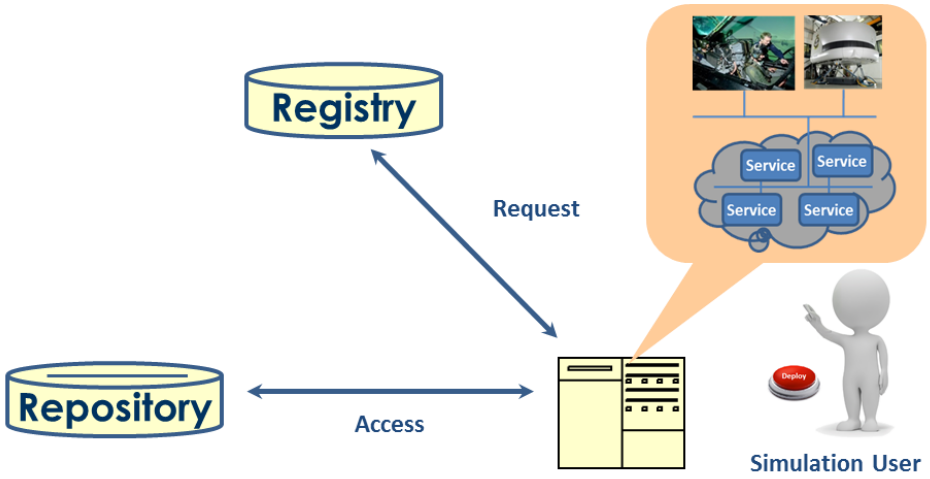

Figure 8 Runtime Discovery

During Runtime[3], the Simulation User (which for training could be an instructor or trainee) will deploy the simulation to the infrastructure. They will use the Deployment tool to search the Registry for the Deployment object for the required exercise and at a push of a button deploy the simulation to the infrastructure. Using the information specified in the Deployment object, the Deployment tool accesses the Registry to determine which Repository the services can be downloaded from or to obtain a link for those services running 24/7. For services that have to be installed, the Deployment tool creates virtual machines and containers on the infrastructure and installs the executable code. It also creates the network for connecting the services and any simulators that may be used. The deployed services can then be accessed by the Simulation User. As an example, a Simulation Operator who is a instructor will search the Registry to access the required training environment. This approach hides the complexity of the deployment process to non-technical users.

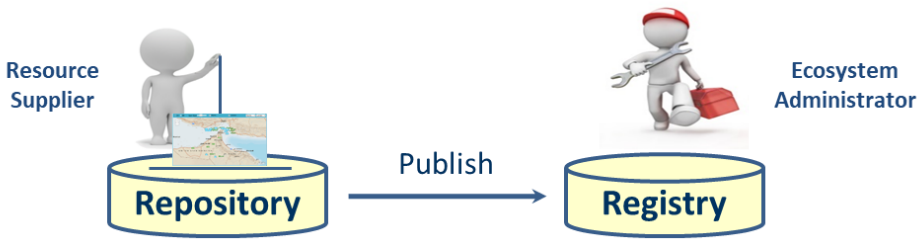

Figure 9 MSaaS Maintenance Activities

[3] Equivalent to Distributed Simulation Engineering & Execution Process (DSEEP) steps 5 and 6

The Ecosystem Administrator is responsible for performing several maintenance activities. The most important is to confirm that information about the M&S Resources to be added to the ecosystem is compliant with the required metadata standards and accurately reflects the functionality being offered by the Resource Supplier. They also need to verify that the M&S Resource performs as described.

The Ecosystem Administrator manages all aspects of the Registry including software upgrades and federating with new Registries as they become available. They also need to verify, where applicable, the authorisation and network connectivity for new Repositories that are added to the ecosystem. The Ecosystem Administrator would also be responsible for access control for the Registries and Repositories and accreditation of the MSaaS ecosystem.

6.0 MSAAS ECOSYSTEM IMPLEMENTATIONS

There are two different ways an MSaaS Ecosystem can be implemented;

- Bounded MSaaS Ecosystem;
- Unbounded MSaaS Ecosystem.

6.1 Bounded MSaaS Ecosystem

A bounded MSaaS Ecosystem is one which just supports a specific need. Examples are a simulation capability for providing collective training on a number of different simulators or for supporting the evolution of a simulation capability during the whole life cycle of a major procurement i.e. where simulation is used to evaluate different solutions, through its use as a systems integration rig, to use in a training system.

The approach is not new as it is analogous to what currently happens on training simulators e.g. A400M, where different training exercises are generated to satisfy specific training requirements e.g. air-to-air refuelling. An instructor will generate i.e. compose, the training exercise, which will require information about the scenario (tactical environment), visual database, weather, etc. Once the exercise has been fully tested, it will be stored in a library for reuse i.e. MSaaS repository. A description i.e. metadata will be generated to provide a high-level overview of the exercise e.g. training objectives, red threat, communication channels, etc. to facilitate other instructors using it. Instructors responsible for running a training session will access i.e. discover, the training exercise and download it i.e. deploy, so that it can be run on the simulator i.e. MSaaS execution.

It should be noted that most simulator manufacturers generally use a proprietary solution for providing the library capability and generating data for the composite parts of the training exercise. This inhibits the ability to reuse simulation resources e.g. scenarios, across different simulators, which is one of the deficiencies that a properly implemented MSaaS Ecosystem will overcome.

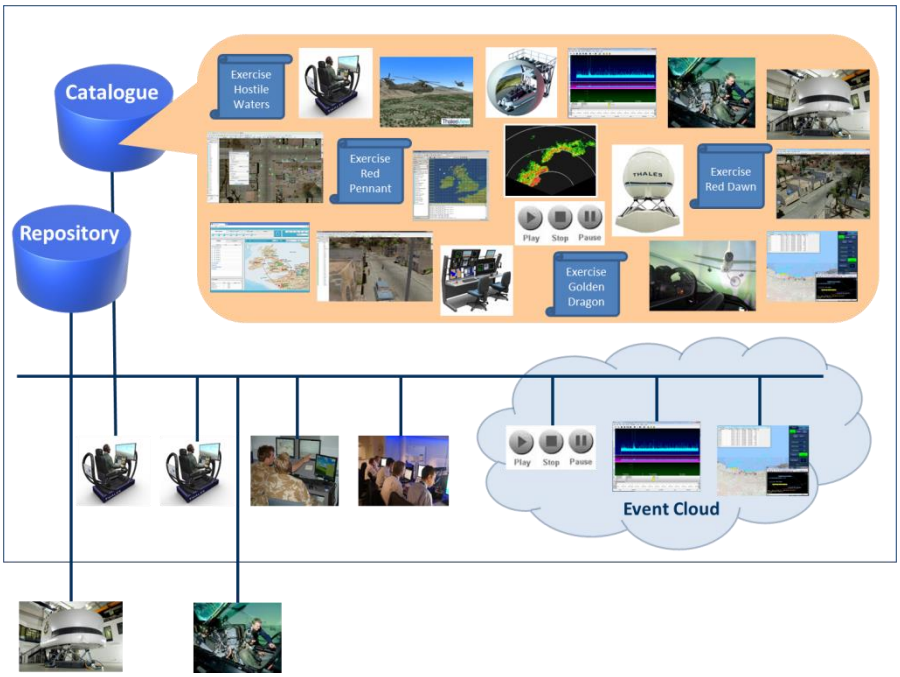

Figure 10 Bounded MSaaS Ecosystem

A characteristic of a bounded MSaaS Ecosystem is the limited number of simulators, applications and tools that are available to the Simulation Integrator and Simulation Operator/User and the number to be managed will stay relatively static. Changes to the number of available applications and tools will mainly be due to newer versions as they become available or when a new capability is required. The biggest change in the number of M&S Resources will be due to new Events being created. But even if a new Event is created and run every week, after a few years of running the MSaaS Ecosystem, the number of M&S Resources will still be in the low hundreds.

This means that a simple catalogue rather than registry capability is probably sufficient to administer the number of M&S Resources to be managed. Also, it is expected that there will be a lot of 'corporate knowledge' i.e. users will be well aware of the M&S Resources available to them, so that only a simple discovery capability will be required. In addition, less metadata will be needed to enable users to evaluate the suitability of resources as they are likely to be familiar with them. Because of the less stringent discovery requirements, a repository could potentially provide both the discovery and storage capability.

It should be noted that even with a 'bounded' MSaaS Ecosystem', Events may still use physical simulators owned by other organisations as shown in Figure 10. An example of this could be if say an F35 simulator wanted to connect to a Multi-Role Tanker Transport simulator to perform air-to-air refuelling requirement with both simulators being in the same simulation environment.

Although there may not be any connectivity to other MSaaS Ecosystems with a bounded MSaaS Ecosystem, it may still be desirable to know about M&S Resources from other MSaaS Ecosystems e.g. NATO, in order to satisfy new previously unsupported requirements. As the catalogue is likely to be air gapped, this information will have to be transferred manually. Likewise, metadata about simulators, applications, tools and Events used by a bounded MSaaS Ecosystem could be manually exported to a nationally managed registry. In this case, other parties wanting to use this capability would have to contact the MSaaS Ecosystem Administrator.

6.2 Unbounded MSaaS Ecosystem

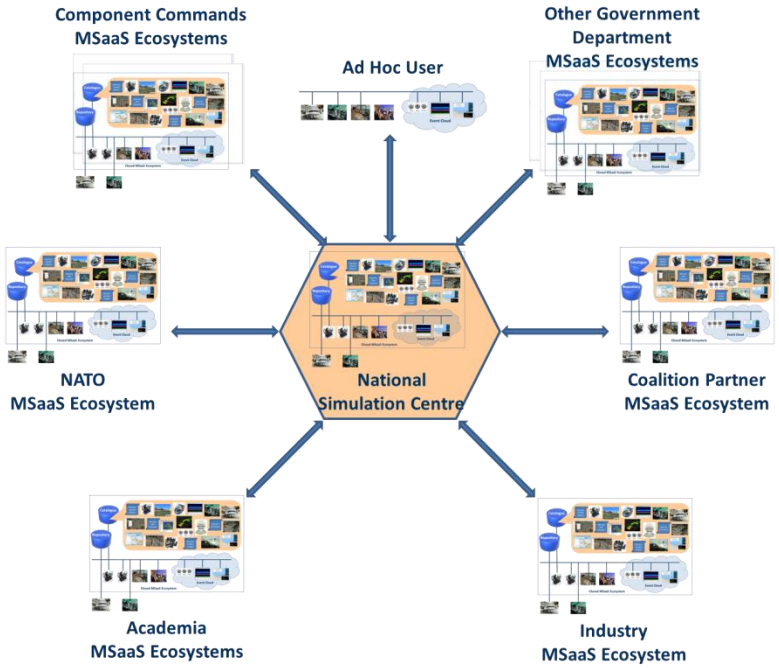

Figure 11 Potential Relationships with a National Simulation Centre

An unbounded MSaaS Ecosystem is one that will support many diverse simulation needs. Within the limits of security and commercial considerations an unbounded MSaaS Ecosystem will reach out to as many M&S Developers and M&S Users as possible.

Large Enterprises such as MOD or industrial primes with many enclaves of simulation capability are the type of organisations that will obtain the most benefit from an MSaaS Ecosystem. This is because simulation capability is often uncoordinated across large organisations, which means that capability is often duplicated. Also, there is usually no way for sharing lessons learnt and best practice.

Figure 11 shows some of the potential relationships that would need to be managed by a centrally managed simulation capability. These include MSaaS Ecosystems managed by the component commands, industry, NATO, coalition partners and ad hoc users.

Also, a national simulation centre will need to support ad hoc users who make use of simulation but do not have their own MSaaS Ecosystem for providing their simulation capability. These users can benefit from the national simulation centre's simulation knowledge and use the registry to discover simulation resources that satisfy their requirements. If these users discover simulation resources that they would like to use, they will have to contact the owners of the resource to arrange licence fees and delivery of the resource. Although the national simulation centre may facilitate negotiations, any contractual arrangement will be between the M&S Resource Supplier and M&S User.

7.0 UK MSAAS DEMONSTRATION

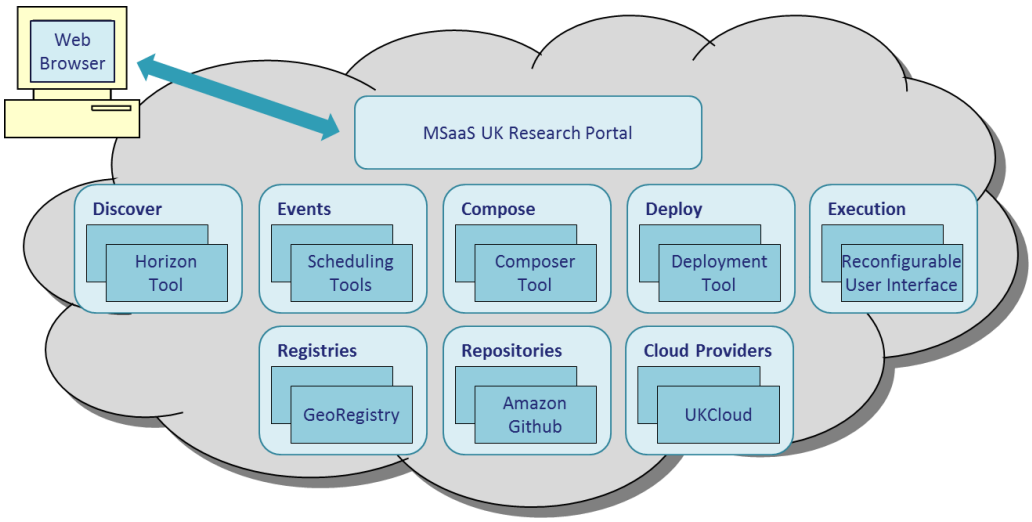

Figure 10 MSaaS Demonstration Components

The UK MSaaS demonstration comprises two parts: a demonstration of the non-runtime tools used to produce a Simulation Environment (Figure 10) and the execution of a simulation Event running in a cloud environment. All the tools are accessed through the MSaaS Portal.

The Registry function for the UK MSaaS implementation is provided by Envitia's GeoRegistry. This provides an open-standards implementation of the Open Geospatial Consortium Catalogue Services for Web Electronic Business Registry Information Model [5]. Amazon's Code Commit is used to provide the Repository function.

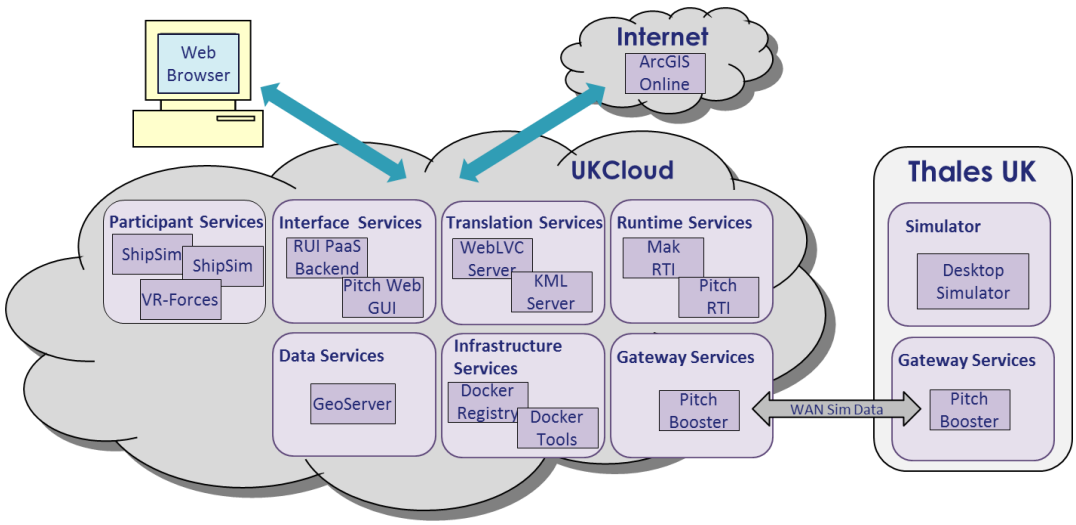

Figure 11 Demonstration Event Simulation Environment

The demonstration is deployed in the UKCloud and AWS, and uses a combination of virtual machines, Docker containers and web services. A desktop simulator has been integrated to represent a Full Mission Simulator. This is to demonstrate how multiple simulators, used for say collective training, could be

supported by a common tactical environment e.g. red force, and synthetic natural environment e.g. weather, to ensure a fair-fight. It also shows how centralised tools can be provided for supporting the exercise e.g. exercise control, data logging, After Action Review, etc.

Two ShipSim simulations have been integrated into the simulation environment, which were provided by MSG-136. This is to demonstrate the sharing of M&S Resources between nations. VR-Forces is used to generate the land and air platforms. WebLVC is used to translate the position of entities on the simulation network to JavaScript Object Notation (JSON) so they can be displayed by the Reconfigurable User Interface (RUI) in a web browser. A mobile friendly version of the RUI can be accessed by scanning a QR code. This shows the utility of MSaaS in supporting different kinds of access by users.

8.0 CONCLUSIONS

The MSaaS research has shown that it offers a strategic approach to provide coherence and modernisation of UK defence M&S systems, which will provide cost and time savings. The use of a Registry to discover M&S Resources not created locally i.e. which are not known about, can start to introduce a culture of 'Buy once, use many times'. Also, the use of M&S Blueprints means that designs for simulation environments can be used many times; resulting in time and cost savings. The UK research has demonstrated that complex simulation environments can be deployed at the push of a button, which reduces the skill level, and hence training, required.

More work is required to determine the level of granularity for decomposing simulation functionality into services in order to optimise the potential for reuse. A standard then needs to be agreed for specifying the interface for each service. The UK's vision is for the functionality and interfaces for these services to become NATO/SISO standards so that they can be provided and reused by different organisations so as to increase competition. Although different organisations may provide the same service, it is expected that 'Darwinian' principles will apply and those that provide the best functionality and price will be the most used.

The UK research has provided compelling evidence that MSaaS has potential, nevertheless there are many issues that still need to be resolved.

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