‘Mind the Gap’ – Avoiding Pitfalls in Taking the MSaaS Concept from Research into Everyday Use

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ABSTRACT

Research into service based architectures for Modelling and Simulation has been recently conducted in the UK in the Architectures Interoperability and Management of Simulation (AIMS) led by the UK Defence Science and Technology Laboratory (Dstl) and partnered with an industry team. The work was internationally aligned through NATOModelling and Simulation Groups (MSG) 136 & 164 on Modelling and Simulation as a Service (MSaaS).

The MSaaS research has been successful in demonstrating the potential benefits of MSaaS in terms of improved operational benefit and providing efficiencies, however, the concept will only be adopted by industry and the wider customer community if it can be clearly shown to deliver significant benefits and value over existing methods of operation. This paper describes key outputs of the research under the AIMS programme and takes an industry centric view on the commercial and operational issues and potential disruptive effects of MSaaS. The paper discusses the new operational paradigms that need to be introduced for MSaaS to be fully exploited and become pervasive in national and international M&S programmes.

1.0 INTRODUCTION

1.1 Operational Context

With the ever changing world political environment, Simulated Training Equipment (STE) systems and modelling and simulation in general needs to be more flexible and agile to support rapidly changing requirements.

Current Defence STE is usually procured over the lifetime of a given platform (e.g. Typhoon) or to support delivery of an operationally relevant capability (e.g. Joint Fires). The lifetime of such STE is usually in the region of 10-25 years with reviews/re-competes mid-life or roughly every 5 years to maintain currency. As Defence moves into a state of contingent operations, the need to maintain currency of its STE become all the more apparent as such STE needs to be reflective of the potential constant change in operational requirements (often introducing concepts that challenge the design of the STE beyond what they were originally optimised for). This has been noted in recent years where new threats in areas such as Cyber Security or Information Operations have emerged and are not represented well in procured STE. The ability to then upgrade such STE to appropriately represent such domains is not easily achieved without large investment or re-design. This challenge is expected to be exacerbated in future years with increasing ease of access to technology by our adversaries. NATO concepts such as Global Strategic Trends and the UK Defence Concepts and Doctrine Centre (DCDC) Future Operating Environment 2035 also paint the picture of future contested and congested operating environments, rich of interconnected technology (e.g. Megacities) that will challenge the way our current Defence system operates. Therefore the need for our future STE to be more agile to representing such complex and rapidly changing environments will be a key driver in the design and development of such equipment.

Current training requirements are increasingly based on the premise of using STE for distributed collective training, with flexibility of deployment on to different platforms, rapid adaption to new mission requirements, 'go-anywhere' connectivity, and re-use of data and models being key. While distributed events are likely to become more common, the activities required to organise, generate and deploy simulation events across multiple sites are still very labour intensive. Current practices involve starting simulation components such as tactical environments, loggers and Exercise Control (EXCON) tools individually at each site. These can result in 'false starts' or delays to event execution, reducing users confidence in modelling and simulation and ensuring that Defence forces have to utilise scarce and expensive technical experts to develop, deliver and support events.

Providing a high level of agility in a traditional STE system is difficult, time consuming and costly. Introducing change in delivered systems generally requires substantial effort in time and labour in development, integration and testing. The costs involved are often not necessarily understood by the end user, leading to a widely differing expectation on pricing the change from customer and system integrator.

The work is even more challenging when the STE in question are heterogeneous in nature, or are distributed across multiple locations and connected to real equipment. This can lead to a 'fog of war' where change is too hard to be even considered and thus any new training objective is not delivered at all or delivered poorly with original equipment.

1.2 AIMS programme

Research into service based architectures for Modelling and Simulation has been carried out in the UK in the recently completed Architectures Interoperability and Management of Simulation project (AIMS) led by the UK Defence Science and Technology Laboratory (Dstl). Dstl partnered with an industry team consisting of SEA (lead contractor), Thales UK, BAE Systems and QinetiQ as key partners, along with a number of associated companies working collaboratively to achieve common goals.

While the AIMS programme researched a range of topics, this paper considers the results achieved under tasks looking at MSaaS. In terms of exploitation, the research programme was designed to provide evidence and advice to the UK Ministry of Defence acquisition policy: Joint Services Publication 939 "Defence Policy for Modelling and Simulation". JSP 939 describes the UK MODs policy for modelling and simulation and details how both governance and technical coherence is applied through concepts such as 'Defence Modelling and Simulation Coherence (DMaSC)'. DMaSC provides a defence wide coherent approach to provide improved M&S capability, reduce costs, and with less of an environmental impact. The recently published policy and guidance directive for the UK MoD demonstrates the high level commitment to a coherent approach to modelling and simulation. [1]. The AIMS and MSaaS research contributed evidence to support some of the longer term approaches that could be taken by the MOD to support implementation of this policy.

1.3 Background to MSaaS

The Service Oriented Architecture (SOA) method, consisting of dynamically deployed modular components has been proposed as a method to overcome some of the issues relating to existing simulation systems; henceforth referred to as Modelling and Simulation as a Service (MSaaS).

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 AIMS 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.

A more complete understanding of MSaaS is obtained by decomposing the AIMS 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.

1.3.1 MSaaS Ecosystem

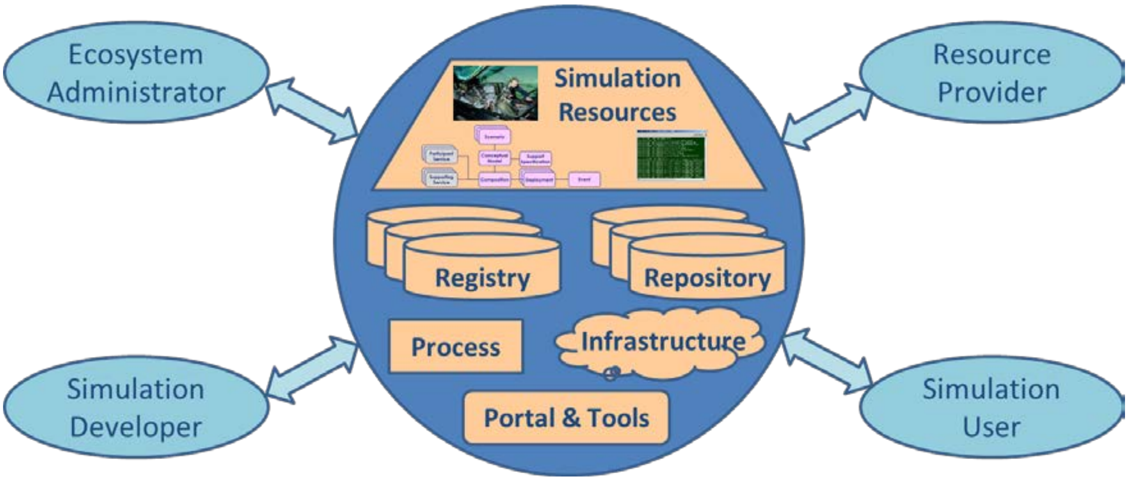

Figure 1: MSaaS Ecosystem and Stakeholders

Figure 1 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. (Assets are items like terrain datasets, services consist of capabilities like the provision of weather data,; Blueprints include information allowing the construction of a simulation system);
- 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;
- 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:
  - Ecosystem Administrator: responsible for setting-up and operating the MSaaS ecosystem by utilising maintenance functions;
  - Resource Provider: produces and maintains simulation resources that can be exploited by other users;
  - Simulation Developer: uses the M&S Resources for developing Simulation Environments;
  - Simulation User: indirectly uses M&S Resources by interacting with a Simulation Environment.

1.3.2 MSaaS Process

The AIMS MSaaS process comprises 5 steps as shown in figure 2.

- Discovery[1]: 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 AIMS process is compatible with the overlay to DSEEP produced by NATO MSaaS Modelling & Simulation Group (MSG-136) [3]

[1] From an AIMS perspective, the term 'discovery' also includes searching for M&S Resources that are known about as well as discovering those a user is unaware of.

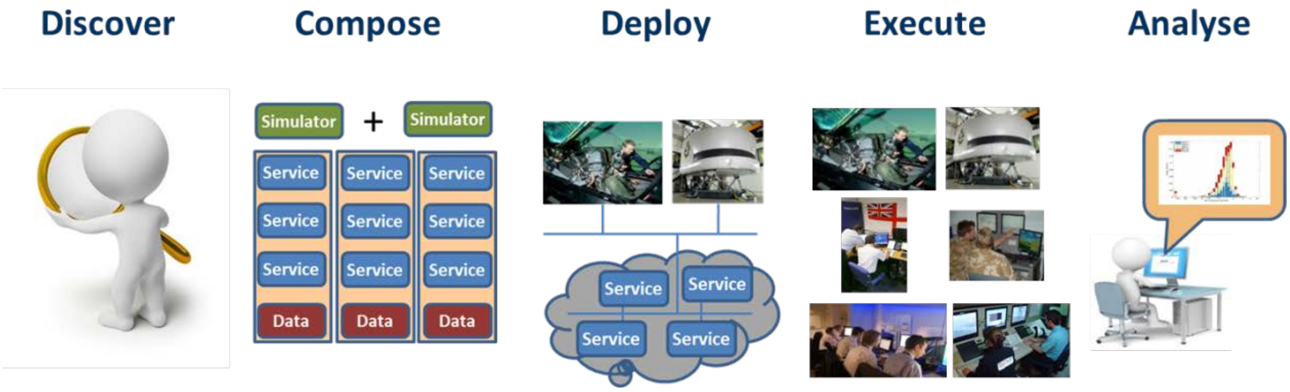

Figure 2 - MSaaS Process

1.3.3 MSaaS Service Oriented Delivery

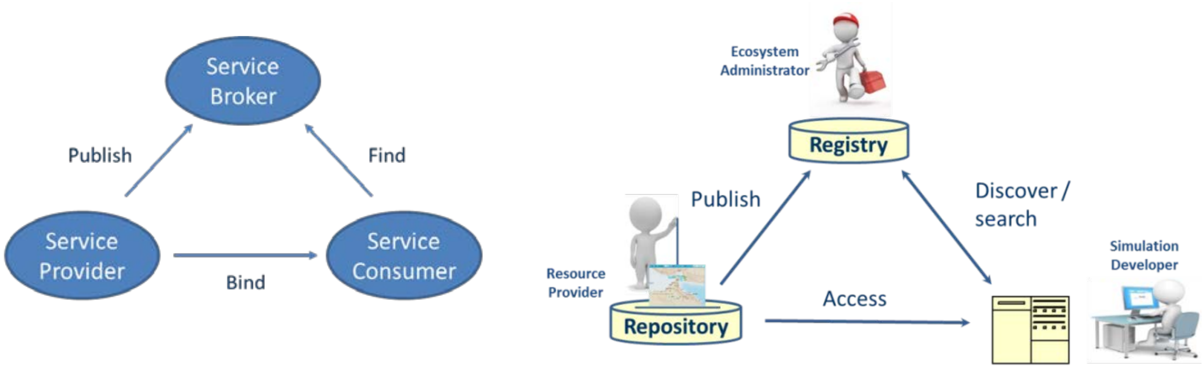

Figure 3 - MSaaS Service Oriented Delivery

The left-hand side of Figure **3** shows the traditional service oriented architecture (SOA) triangle and the right-hand side shows how it has been tailored to MSaaS. The main difference between the two approaches is that whereas SOA relates to automatic runtime discovery and binding, with MSaaS, the discovery is performed at design time (DSEEP[2] step 3) by a human or pre-runtime (DSEEP step 5) by a computer.

1.4 Driving MSaaS Exploitation

Based on the number of tracks and papers at recent conferences there is a lot of interest in MSaaS. However, the community have been here many times before with topics like virtual/augmented reality and artificial intelligence, promulgated decades ago, which have promised so much but until recently have failed to deliver. Typically expectations for new technology adoption follow a path where expectations run ahead of reality as shown in Figure 4.

[2] Distributed Simulation Engineering & Execution Process [3]

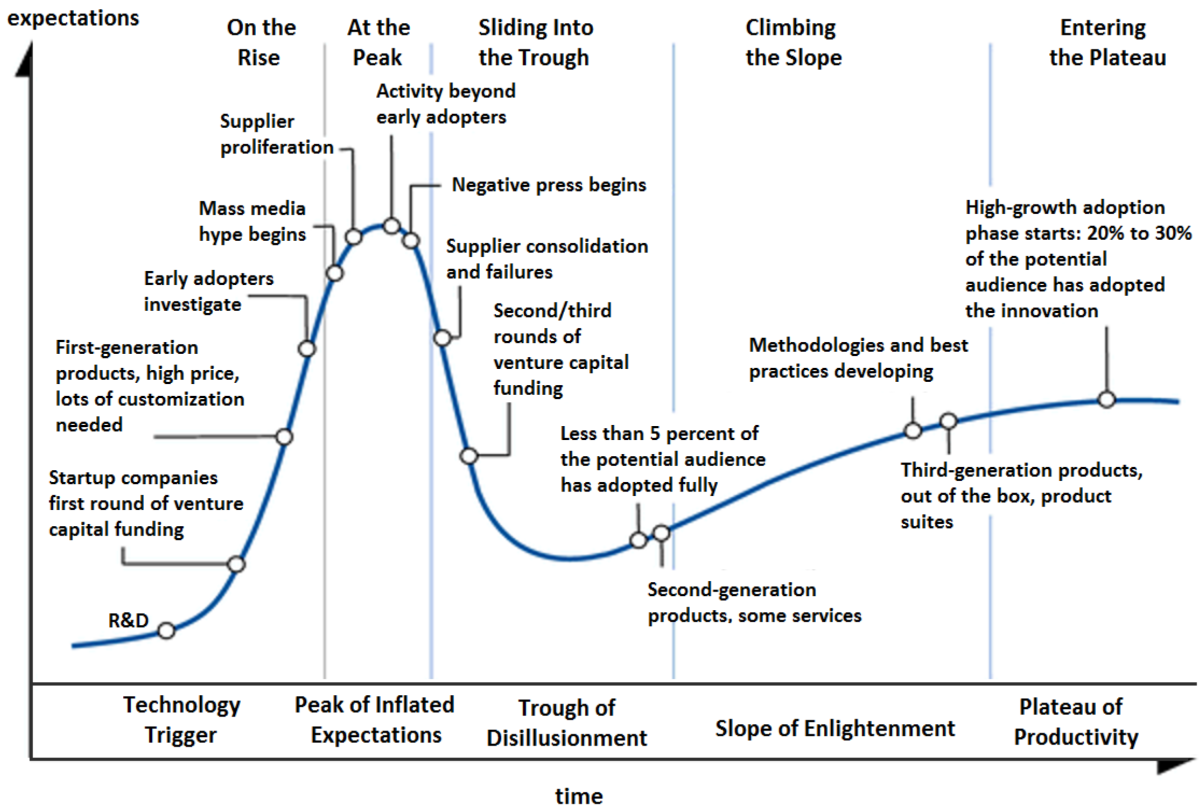

Figure 4 - Technology innovation adoption timeline (By NeedCokeNowOlga Tarkovskiy. [CC BY-SA 3.0 (https://creativecommons.org/licenses/by-sa/3.0)], from Wikimedia Commons)

On paper, MSaaS promises many features to users of simulation as described in [4] such as:

- Resolution of the long term problem of simulation interoperability through the reuse and composition of services that are already interoperable
- Technical maturity using a service based approach
- Aligned governance through a enterprise wide approach
- Improved cyber security due to the reuse of pre-tested components
- Modernisation of the procurement process to ensure defence can rapidly access the most relevant components and an opportunity for supplier to have a common way of bringing their products and services to market with a
- Composable Services that are more easily reused

The adoption of MSaaS could help the transition from large monolithic simulations into component architectures, providing opportunities for reusing these components across different simulation systems. The potential 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.

However, delivery of these benefits is not assured.

At the recent AIMS demo in the UK, these potential benefits were acknowledged but concerns were expressed over the business, security and governance issues of a successful MSaaS implementation. It is also clear that there are still substantial technical issues to be resolved.

2 TECHNICAL COLMPLEXITY AND CHALLENGES

An illustration of potential technical issues is shown by the example diagrammatic representation of potential services needed to support dynamic environmental representation (such as that being investigated through task group MSG-156) in Figure 5 Up until now it has been difficult to envisage making this kind of application work unless supplied and integrated by an individual industry partner.

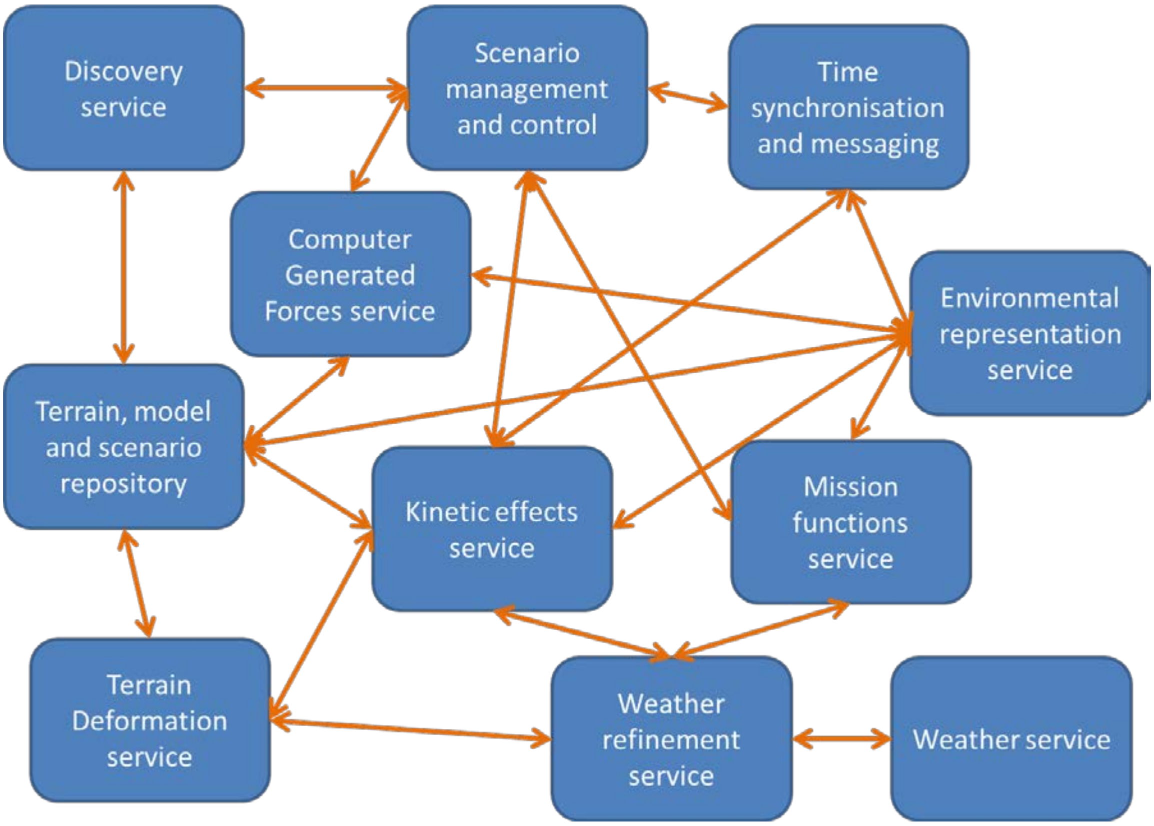

Figure 5 - Dynamic environmental representation services

It's obvious from the picture that there are a lot of linkages between services and a fair degree of complexity. Such complexity is needed to be able to represent the changing operational environment.

While not an exhaustive list, some of the issues around the area of the technical complexity and related challenges with regards to the implementation of MSaaS include:

- Service Definitions and interfaces;

- Little research has been performed into determining the appropriate granularity for providing services. There is a cross-over between having a lot of small services that cost a lot to maintain, and having fewer larger services, which will have a lower chance of being reused. Once the functionality for a service has been agreed, the interface needs to be defined.

- Cloud Latency / Quality of Service

  Associated with service definitions are issues where services are likely to be executed. Small services, such as 'coordinate transformations' may be called many times a second. If these are running in a remote cloud, the latency may impact the operation of the overall simulation. Some reliable paradigm is required to determine those services that can be run remotely and those which have to run locally. A similar consideration has to be applied to graphic intensive applications such as image generation

- Integration of heterogeneous systems;

  Although the integration of complex distributed simulations environments is becoming easier with better tool support, it is still a time consuming and error prone process. In the past, if a simulation environment had to be recreated, it would take almost as long to implement again. Whilst still challenging to perform the initial integration of heterogeneous systems (including ones which include services from different vendors), once its operation has been validated, MSaaS provides the ability to capture the design and deployment of the simulation environment so that it can be quickly recreated – but only if the service has been properly defined and documented by the vendor.

- Cyber and Security

  MSaaS encourages the geographic distribution and sharing of M&S resources. This makes the ecosystem vulnerable from cyber-attack. As a lot of work into cyber security is taking place outside the simulation domain, most MSaaS research activity has not addressed this subject directly.

Demonstrations of MSaaS technology need to be able to show that complex systems like the one shown in Figure 5 can work effectively.

3 BUSINESS COMPLEXITY AND CHALLENGES

The exploitation of MSaaS does present new business challenges to the simulation community – both suppliers and customers of M&S services and products.

One key question involves the initial investment required to set-up an MSaaS ecosystem. As one of the stated benefits of MSaaS is to be able to share simulation resources with 3rd parties, there is an issue around how a supply ecosystem works with multiple suppliers.

Business challenges therefore include the following:

1) The complexity of an initial investment appraisal on a new way of doing business

2) The apportionment of risk; balancing that borne by the customer and the supplier. The type of risks that must be included are:

   - Integration risk
   - Service delivery risk
   - Validation and verification risk

3) Defining payment models which reflect the value provided by the supplier and the risk model agreed with the customer. The model might reflect that the customer may wish to do one of the following:

- Rent tools, components and services for a period of time and do the integration
- Buy tools, components, services and integration support from a single supplier
- Buy tools, components and services from multiple suppliers and integration separately

4 POTENTIAL SOLUTIONS

The authors propose a number of potential ways in which the developer and user community might exploit MSaaS technologies in the near term. These are not exclusive and can be summarised as:

1) Exercises like technology and programme road-mapping to ensure that the implementation of MSaaS into operational systems is incremental, balanced and measured to reduce the chance of user disappointment due to inappropriate use of immature technology. Advice will need to be provided to simulation system developers so that they can understand the technical approaches available to them and the benefits/risks of using such approaches.

2) Continued research and development to reduce risk and take advantage of new technologies as they mature,

3) Promulgation and use of standards to assist international coherence where appropriate but not at a stage where innovation might be stifled,

4) Incremental experimentation and development using techniques such as Minimum Viable Product (MVP) and agile methodologies to ensure the customer and supplier community move forward together rather than the standard military product supply methodology which poses substantial risks for both parties.

4.1 AIMS Road-Mapping

As the result of experimentation and development of MSaaS; road-mapping has been used as an exercise to characterise current maturity levels of technology, systems, and implementation methods, with a focus on delivery of Modelling and Simulation as a Service (MSaaS).

The MSaaS roadmap identifies development routes for discovery, composition, execution and support over the next 10-15 years, with early implementation of technologies that are already well-developed into technology demonstrators and systems, and then evolution into an initial and then final operating capability by 2030.

Three broad phases are identified as the concept develops and matures:

- Near Term Landscape and MSaaS Research Demonstrators – MSaaS used to support research and demonstration programmes
- MSaaS Initial Operating Capability (IOC) – early adopters exploit MSaaS functions and enabling technologies
- MSaaS Final Operating Capability (FOC) – fully mature MSaaS functions and enabling technologies are available for exploitation by all capability programmes

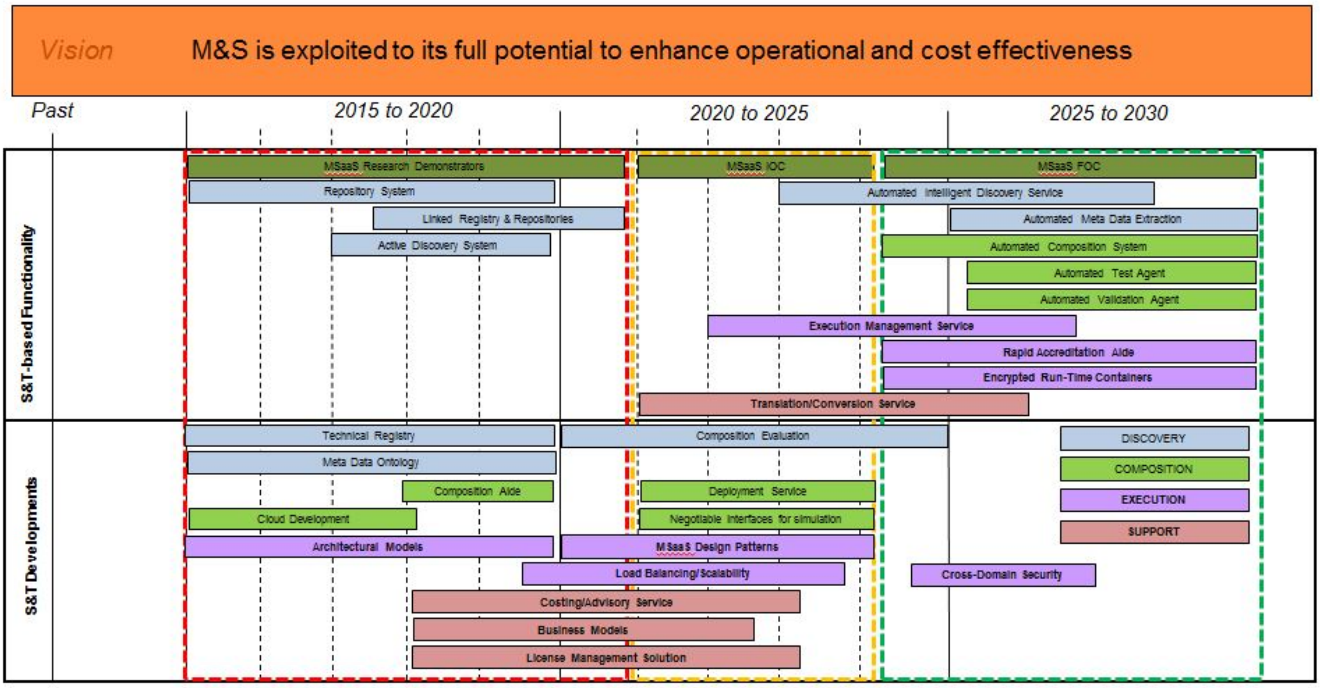

Figure 6 - MSaaS roadmap example (UK – AIMS project)

The roadmap demonstrates how MSaaS, as a complex and multi-faceted concept, will require many development activities to be progressed and integrated. It cannot be developed and rolled out as a single system, and it is therefore expected that incremental development will be carried out.

4.2 Standards

Work undertaken by the authors and others would indicate that some areas of MSaaS activity, particularly around the use of metadata to aid in the discovery process would benefit the uptake of MSaaS activities [5].

Other areas of potential standardisation include:

- Defined interfaces to enable automated composition of heterogeneous services

- The use of common industry deployment technologies (for example, Docker) – while not a standard per se, these are in wide use beyond the modelling and simulation industry.

- The use of web services using industry standard protocols to access simulations through cloud based infrastructure providers

Standardisation only will work with the involvement of customers and suppliers, so needs to be a carefully managed process. Standardisation activities do take considerable time (many years in some cases) so should be incorporated into development roadmaps to ensure that the activities are scheduled effectively.

This activity needs to be conducted by the international community, through organisations such as NATO (MSG-164) and the Simulation Interoperability Standards Organisation (SISO) with SISO being the recognised partner for standardisation activities. MSG-164 has a task to help identify areas of standardisation required for MSaaS.

The development of MSaaS standards by an international team will help to build the trust required for organisations to share their simulation resources. Also, the ability to have different MSaaS implementations is essential to prevent any one organisation dominating the MSaaS market.

4.3 Incremental development and exploitation

Typically, complex military procurements are undertaken using extensively defined requirements specifications, long and expensive bidding processes and equally expensive project phases where the requirements are analysed and solutions exhaustively tested against the requirements. While appropriate for many items, this process can take so long that it prevents the use of new technologies where experimentation and user feedback is necessary to establish nascent capability.

One solution to this problem is the introduction of a Minimum Viable Product (MVP). An MVP is defined as ‘a development technique in which a new product is developed with only those core features required to deploy the product and which are sufficient to satisfy early adopters. The final, complete set of features is only designed and developed after considering feedback from the product's initial users [6]. Gathering insights from an MVP is often less expensive than developing a product with more features, which increase costs and risk if the product fails, for example, due to incorrect assumptions. The main drawback of this development technique is that it assumes that early adopters can see the vision or promise of the final product and provide the valuable feedback needed to guide developers forward.

A key aspect of MVPs is the need to work with users to ensure there is good quality feedback to ensure the right features are implemented. This approach does need the military end user / customer to change the way that they operate and organisations are beginning to change the way they do business. An example of how this change in approach is being implemented in the UK is the jHub defence innovation organisation [7]

4.4 Application of Minimum Viable Product techniques to MSaaS

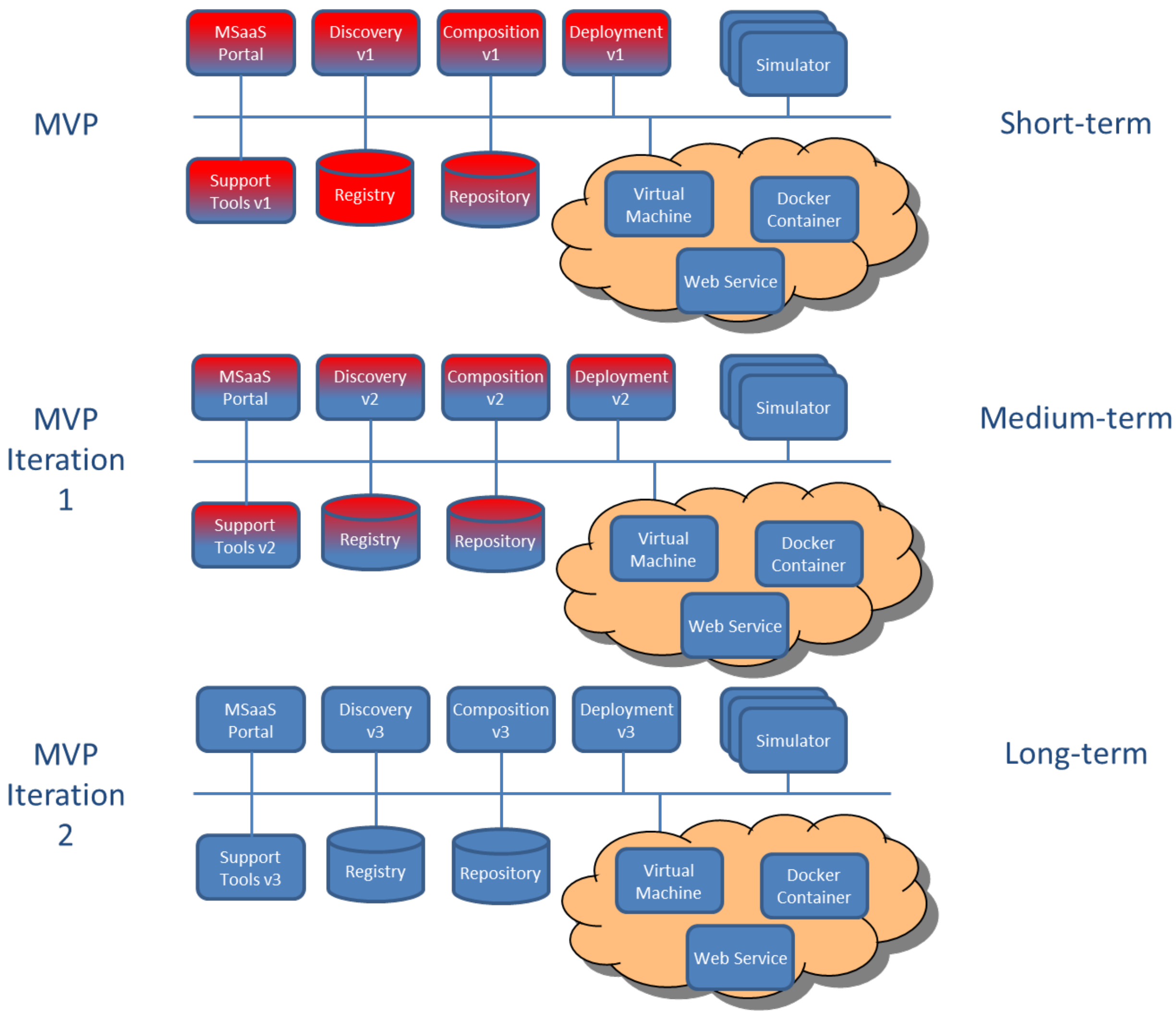

Figure 7 - MSaaS MVP iteration example

Exploitation of MSaaS could be split into 3 phases short, medium and long-term as shown in Figure 7. Programmes such as AIMS in the UK have defined the MSaaS ecosystem and already de-risked some of the technologies. The most mature part of the MSaaS process is the ability to deploy simulations in a cloud based infrastructure. AIMS has demonstrated how simulation software could be deployed as virtual machines, Docker containers and web services and integrated with a desktop simulator. Whilst the initial integration of services and simulators still requires a significant amount of engineering effort, once the deployment has been produced, the simulation can be deployed at the push of a button.

A short term MVP could comprise a framework that future MSaaS functions could be plugged into, which could be accessed by a browser based MSaaS portal. As an MVP, a simple discovery and storage capability could be provided by existing open source or COTS tools for managing simulation resources. Functionality similar to the AIMS composition tool could be provided to enable services to be discovered, selected and the topology of the integration visualised. A deployment tool could be developed that enables a library of deployments for different simulation capability to be accessed. The tool would have a limited search capability and have the ability to deploy/undeploy a simulation. This MVP would provide sufficient functionality for conveying the MSaaS vision to potential customers and for demonstrating some of the key benefits. Feedback could be obtained regarding what future functionality may be required and how the user would interact with the system. The MVP could also be used to stimulate debate as to new types of business models that may be of interest to potential customers. Also, the MVP could be used to start a dialogue with national and international organisations to encourage them to make their simulation resources available to 3rd parties (with appropriate fees and IP protection).

The medium term development of the MVP could provide a comprehensive ability to discover different types of simulation resources. However, the requirements for this MVP need to be carefully assessed to ensure that they are commensurate with the number of resources to be discovered. Customer engagement is required to determine the number of simulation assets e.g. simulators, services and blueprints likely to be managed. It is anticipated that the number of simulation assets and services will only grow slowly after the initial implementation but that the number of blueprints will grow rapidly as the way in which complex distributed simulations can be produced becomes simpler. Also, MSaaS may make the use of simulation more attractive in areas of product development and training where it is not currently used.

The AIMS research has successfully demonstrated the use of a registry for discovering simulation resources. Access to the registry would be via the MSaaS portal when performing manual searches or via an electronic interface when machine-to-machine queries are to be made (such as by the deployment tool). The principles for doing this have been demonstrated by AIMS but further work is required to define the different types of registry objects and the metadata to describe them. A suitable registry would also have to be identified and configured so that it can process the simulation metadata. The MVP could also build on AIMS use of Web Processing Services for automatically identifying compositions and services that either fully or partially satisfies a user requirement.

The long-term development of the MVP would address the difficult problem of composition. The ability to automatically integrate and configure software components has been one of the apparently insuperable problems of the simulation industry. The challenge is finding a way of determining the syntactic and semantic interoperability of the services. Once a composition has been created, the next big step is to use this information to (semi-)automatically create a suitable deployment. By this time, it is hoped that most of the benefits of MSaaS are being realised and we are moving towards the vision of transitioning from a simulation requirement to a deployed simulation system with minimal technical expertise being required.

5 CONCLUSIONS

The use of MSaaS techniques have many potential benefits for customers and suppliers if efficiently managed and incrementally applied. There are however many examples in the modelling and simulation industry where exciting technology developments have been overhyped and taken too long to be exploited into capability leading to understandable cynicism about their applicability.

This paper suggests that the MVP methodology offers a way for MSaaS technologies to be applied to leverage real customer needs in a gradualist fashion ensuring that technology push does not get ahead of the value it creates for the community which must include both customers and supplier. Coupled with proper roadmapped schedules, along with appropriate standards development to ensure international coherence, the implementation of MSaaS using MVP techniques will provide lasting benefits and promote the use of modelling and simulation beyond its current scope of use, aligning with defence needs for M&S for the next 20 years.

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