Opportunities for Military M&S to Capitalise on GamingTechnologies and Competences

Mr Andrew John Fawkes
Vedette Consulting
UNITED KINGDOM

andy.fawkes@vedetteconsulting.com

Mr Matthew Hemsley
Vedette Consulting
UNITED KINGDOM

matthew.hemsley@vedetteconsulting.com

Mr Douglas Henry
Dstl
UNITED KINGDOM

djhenry@dstl.gov.uk

Mr Brian Wardman
Dstl
UNITED KINGDOM

bwardman@dstl.gov.uk

ABSTRACT

The $175bn video games ecosystem is vast and constantly evolving, serving 2.8bn gamers across the world, and includes technologies and ways of working of direct relevance to current and future military modelling and simulation (M&S). A study was commissioned under the UK Defence Science and Technology Laboratory's (Dstl) research programme to analyse the gaming ecosystem to understand where emerging or extant approaches could provide significant benefit for military training and wider M&S. Emphasis was placed on the development of Modelling and Simulation as a Service (MSaaS) and the potential for a "step change" in the cost effectiveness of training for more complex multi-domain operations. A heatmap of gaming and military M&S capabilities was first generated to highlight areas of most relevance to the military. Working with Dstl subject matter experts, 20 key opportunities were then identified for military M&S to modernise through capitalising on technologies and competences from within the gaming sector. They were a mix of quick wins and longer-term opportunities across technology, people, and process. Key among these, were the growing potential of game engine technology; the value of community in gaming and game development; and the role of widespread network access as an enabler for M&S discovery, sharing and innovation.

1.0 INTRODUCTION

1.1 Research Background

This study was commissioned to support the Mastering Architectures and Artificial Intelligence for Training and Education Efficiency (MAAITEE) research programme which sits itself within Dstl's Transforming Training, Education and Preparation (TTEP) project. Success for MAAITEE includes enabling a step change in MOD's training and education thereby creating better prepared, more effective Armed Forces.

1.2 Research Objective

This academic study analysed the current day gaming ecosystem to understand where emerging or extant approaches could provide benefit for defence training and education. It also sought to identify technology and approaches that can steer the future direction of Modelling and Simulation as a Service (MSaaS) and to provide targets for more in-depth research to solve real world challenges around reuse and scalability as

training simulations become more complex and data intensive.

2.0 THE GAMING ECOSYSTEM

2.2 The Gaming Ecosystem

Most are familiar with the concept of natural or biotic ecosystem. Organisms compete for or exchange resources (energy, shelter etc). Participants in ecosystems evolve continually and, when the change leads to more effective competition for limited resources, this results in the predominance of 'successful' genetic variations. The idea of a business ecosystem applies the concept of a biotic ecosystem to the interconnection and interaction of actors in an economy or part of an economy. The boundaries of any business ecosystem are blurred. Lines can be drawn in different ways to exclude or include loosely associated participants or to centre on different innovations or foci. The same is true of 'The Gaming Ecosystem'. However, for the purposes of this study 'the Gaming Ecosystem' has been taken as the interconnected web of buyers, suppliers, researchers, and enabling service providers which centre on delivering gaming experiences in the private sector market.

Serving 2.8Bn gamers across the world, the $175bn global video games market is large, growing, dynamic, and highly competitive. Figure 1[1] illustrates how the gaming industry continues to grow and the trends in gaming hardware. Consoles, Personal Computers (PCs) and in particular mobile now dominate with VR and cloud gaming as recent entrants. The Gaming Ecosystem can be considered even larger in scale than the market value indicates. Many elements have low or zero quantifiable '£ value', such as community generated content, support, and training and others feature as 'enablers' such as people, process, and business culture.

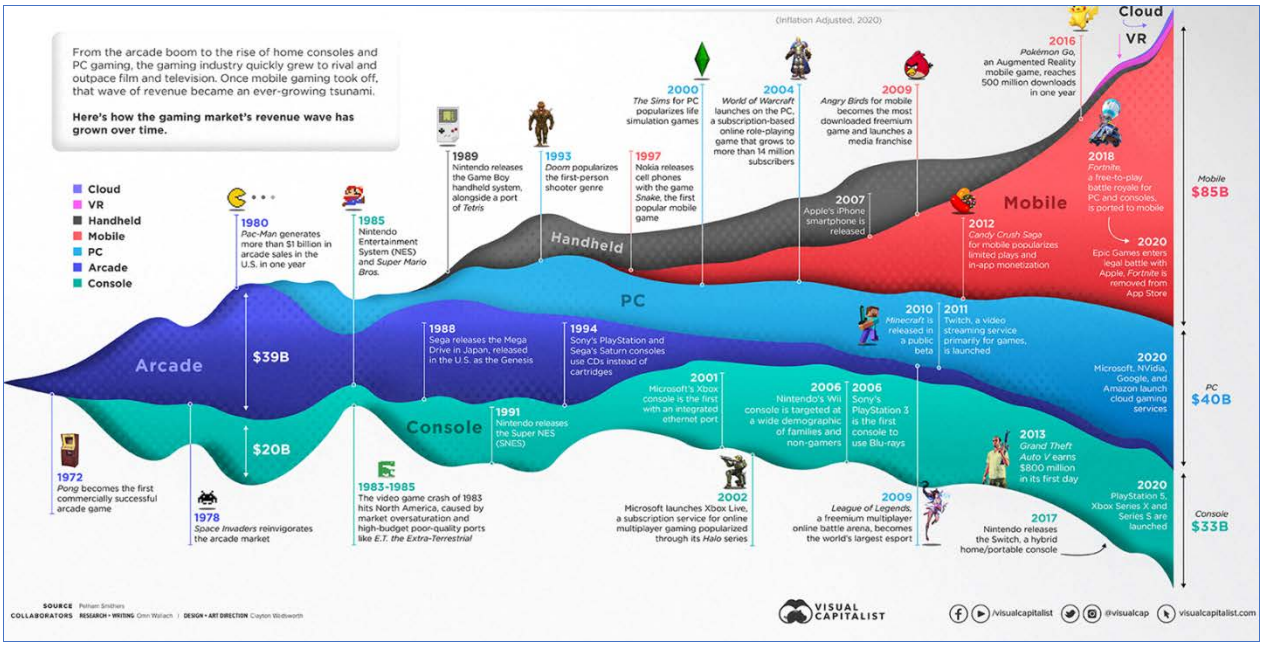


Figure 1: 50 Years of Gaming History, by Revenue Stream (1970-2020)

2.2 Why is Defence Interested in the Gaming Ecosystem?

Business ecosystems are generally considered efficient at evolving new capabilities centred on emergent

ideas or innovations within a market. It is hard for the public sector to match the pace at which these new innovations and capabilities evolve and subsequently to incorporate them into long term public investment programmes. As defence continues to invest in the training and analytical value of simulation, there is significant benefit in monitoring the development of the Gaming Ecosystem as the nearest comparable business ecosystem for defence M&S. It provides the opportunity for defence to harvest emerging ideas, influence direction, and

incentivise private sector innovation in a way that could be brought into defence spending programmes. It builds on the long heritage the military already has of exploiting finished products and Research and Development (R&D) associated with the gaming technology sector.

3.0 STUDY APPROACH AND ANALYSIS

3.1 Evidence Gathering

This study was conducted primarily as a literature review. This included review of open-source material, grey literature, and a review of Government Furnished Information (GFI). This work was supplemented by:

- Informal discussion with members of the gaming industry (including Epic Games, VRAI, and SimCentric)
- Participation in a flagship industry conference including vIITSEC (December 2020) and GamesBeat (January 2021)
- Regular discussive sessions with Dstl and NSC technical partners
- Engagement with other current Dstl programmes

3.2 Heatmapping

3.2.1 Defining the Heatmap Axes

At the outset of the study, it was clear that both the gaming and defence Modelling and Simulation (M&S) ecosystems were large and complex and that in order to progress the study it would be necessary to map the two to help identify "hotspots" of interest to defence. The heatmapping exercise had three elements:

1. Defining the 'Gaming Ecosystem' (the x-axis of the heatmap)
2. Defining the 'Defence M&S Requirements' (the y-axis of the heatmap)
3. Reviewing each element (typically a company) within the Gaming Ecosystem against each defence M&S Requirement (leading to a 'heat score' for each cell of the heatmap. These elements are discussed in detail below.

3.2.2 Defining the Gaming Ecosystem

Multiple interpretations are possible when bounding 'The Gaming Ecosystem'. This study decided on a broad, inclusive, and recent interpretation for the development of the Gaming Ecosystem Heatmap. A broad approach ensured that elements of the gaming ecosystem which might have unexpected features of interest to defence were not excluded early based only on assumptions. This study considered 7 pre-existing definitions of Gaming Ecosystems as candidates for the heatmap. These were:

1. Konvoy Ventures 'investment' ecosystem[2]
2. Newzoo Gametech Ecosystem Map[3]
3. Maps in video games – range of applications[4]
4. Hacker Noon - The Gaming Ecosystem Explained[5]
5. The Benefits of Playing Video Games[6]
6. Genbby Ecosystem[7]

7. Virtual Reality Sector Overview[8]

None of the candidates were perfectly aligned to the needs of this study, but it was determined that the Konvoy Ventures 'investment' games and Esports ecosystem gave the most comprehensive and recent (September 2020) starting point due to its range of categories and granularity of subcategories (Figure 2).

Figure 2: Konvoy Ventures video gaming & Esports Ecosystem (2020)

The study team modified the Konvoy Ventures ecosystem realigning sections on Major Games to point at game genres rather than specific titles. The categories and subcategories of the modified Konvoy ecosystem then formed the basis of the Gaming Ecosystem x-axis of the heatmap. The Gaming Ecosystem is highly dynamic which meant that companies were added and subtracted during the study and groupings, products, and organisations emerge and decline on short timescales, and at reading – the gaming ecosystem will look different to the that used for this paper.

3.2.3 Defining the Defence M&S Ecosystem

A defence M&S y-axis was required for the heatmap. This had to feature key MSaaS attributes and be broad enough to match the full spectrum of the Gaming Ecosystem. During the study the authors became aware of Dstl-funded work[9] on the MOD's learning ecosystems. Although not exactly equivalent, it modelled the complexity of the systems, interconnections and organisations within MOD M&S. This research noted that learning "technology in itself will not be exploited unless the operational, cultural, financial, contractual and organisation aspects are also considered". This work provided a catalyst to think about the defence M&S axis not just in terms of technology but to include softer issues too such as people and process.

The well-established people, process, technology framework[10] was used to structure the defence M&S y-axis. The MSaaS key attributes of "Discover", "Compose", and "Execute" were also expanded to include additional areas of technological interest that were relevant to both gaming and wider defence M&S. The following Table 1 lists the defence M&S attributes selected for the y-axis.

Table 1: Heatmap Defence M&S Ecosystem Attributes

	Defence M&S Attribute	Note
Technology	Discover	Discover M&S services (MSaaS)
	Compose	Compose M&S Services (MSaaS)
	Execute	Execute M&S Services (MSaaS)
	Cloud & Online Services	Infrastructure to enable MSaaS
	Share & Reuse	Ease of M&S sharing and reuse across defence
	Data & Analytics	Improved insights from training
People	Community	Capabilities to bring people together
	Culture	Willingness to share and reuse
	Education	Ability to exploit M&S effectively
Process	Process	Cost effective M&S development and usage
	Governance	Strategy, policies and co-ordination

3.2.4 Heatmap Scoring

Each cell of the heatmap was assigned a score. This score was an aggregate score for that x-axis subcategory against the defence M&S Requirement (on the y-axis). The cell score was based on an individual assessment of each constituent element within a subcategory. As an example, for game development, the relationship between element, subcategory, and category can be seen below in Table 2.

Table 2: Relationship between Category, Sub-category, and elements - using the Game Development Category as an example

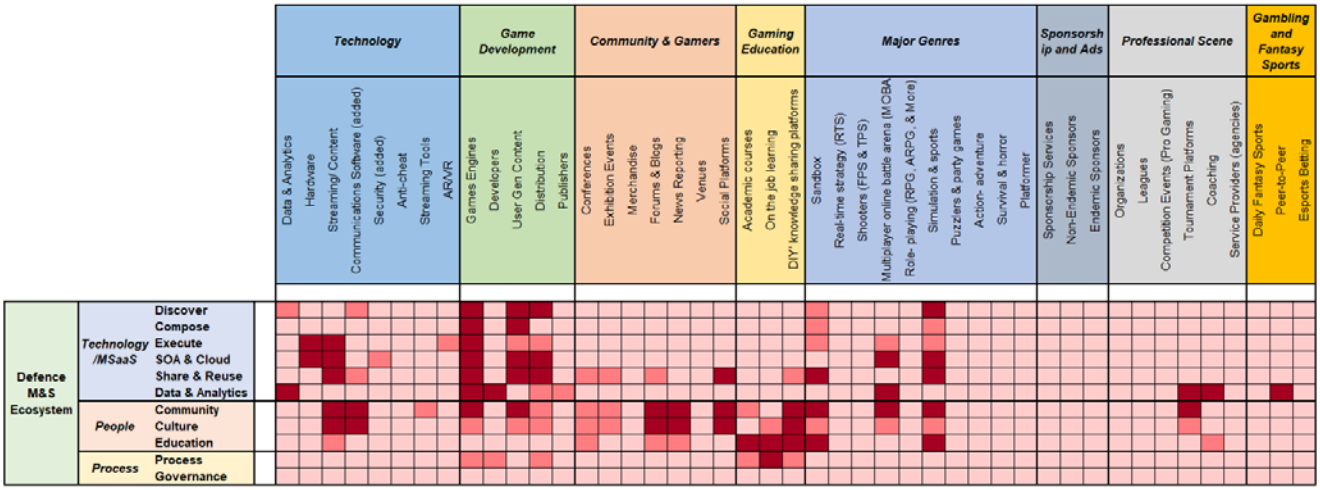
Category:	Game Development				
Sub-categories:	Games Engines	Games development	User Generated Content	Distribution	Publishers
Elements:	Unity Unreal Engine CryEngine Amazon Lumberyard AppGameKit Frostbite GameMaker Nvidia GameWorks Solar 2D (formerly Corona) Havok Buildbox Cocos2Dx GODOT Cocos2d Etc.	Capcom Activision Blizzard Valve EA Games Ubisoft Epic Games Nintendo Riot Games Bluehole/Krafton Bethesda Softworks Respawn Tencent Etc.	Minecraft Dota 2 Roblox StarCraft Garry's Mod Super Mario Maker Super Smash Bros Brawl Counter-Strike: Global Offensive Hiberworld Etc.	Epic Games Store Apple EA Games Origin Valve Steam Nintendo eShop Google Play Sony PlayStation Store Xbox Games Store Microsoft Store Blizzard Battle.net Ubisoft Connect gog.com Etc.	Capcom EA Games Kongregate Activision Blizzard SEGA Bandai Namco Ubisoft Nintendo Sony Square Enix Xbox Game Studios Bethesda

To arrive at an aggregated subcategory score, the study team individually researched and scored the circa 400 constituent elements of the Gaming Ecosystem. The scores of each individual element fed a subcategory score against each of the defence M&S requirements. An element or cell of the heatmap could have one of three scores, outlined below in Table 3.

Table 3: Key of Heatmap scores and associated meaning

3	Technology/concept worthy of investigation now
2	Relevant but mature/exploited Commercial Off The Shelf (COTS) concept
1	Not currently relevant

This scoring was necessarily qualitative. The research team were able to draw upon extensive experience in defence M&S, the private gaming sector, and wider research to make assessments which were reasonable and deemed credible enough to provide indicative scores for the heatmap. The results of the heatmapping



exercise are shown below in Figure 3.

Figure 3: The Gaming Ecosystem and Defence M&S Heatmap

4.0 FINDINGS

4.1 Hotspots and Targeted Investigations

The heatmapping exercise identified 54 hotspots. These were points where a subcategory of the Gaming Ecosystem was deemed to have significant potential for a specific area of defence M&S. For example, the subcategory of 'coaching technology' in the category of 'professional Gaming Scene' scored highly against the defence M&S requirement of Data & Analytics. Some of the most striking hotspots are discussed in more detail below. Four hotspots (Game Engines, Cloud Gaming, Data & Analytics, and Community) were taken forward for more detailed analysis as Targeted Investigations and are covered separately in Section 5.

4.2 Hotspots (Excluding Targeted Investigations)

4.2.1 Distribution and User Generated Content

Companies involved in distribution scored highly against several of the defence M&S technology-specific requirements. Many games developers and publishers provide online catalogues and content delivery &

update. They are incentivised to make these platforms as user friendly as possible for gamers due to the ease of switching and decreasing tolerance for technical friction. MSaaS places heavy emphasis on the M&S user and meeting their need to "Discover", "Compose" and "Execute" services. Games and content distribution

platforms appear to align strongly with MSaaS in this regard. Even if the services themselves cannot be used directly they provide a good blueprint for the design of any MSaaS user portal and its user experience. Companies involved in hosting and providing tools to support user generated content (e.g. Minecraft[11], Roblox[12]) also scored well against defence M&S needs. They provide a model for how defence users might be equipped to compose, execute, and share M&S services without extensive training. In essence, empowering the military to create their own training content and to speak to the gaming experience of today's children, the next generation to join the military.

4.2.2 Artificial Intelligence

AI did not have a subcategory in the gaming ecosystem. Whilst prevalent amongst business and defence, in the gaming ecosystem it impacts 'behind the scenes' across the breadth of the gaming ecosystem. For many companies it is inextricably linked to their products, in game engines and/or in analytics. Nevertheless, there are several usages and developments that are of interest to defence M&S.

There are well publicised examples of video games being used to train AI algorithms, for example Google DeepMind's AlphaStar was trained successfully to play StarCraft, a Real-Time Strategy (RTS) game[13]. Algorithms developed in this way might lead to improved AI in the games themselves and perhaps help create "digital twins" of exemplar humans such as pilots who trainees could train with and against. AI is being used in games design and development for example in AI-generated storylines[14] and human and natural terrain databases[15]. Such examples point to a future where MSaaS simulations might be partially generated and managed using AI that takes the desired training outcomes from say an instructor and automates the composing, running and analytics of the simulation.

4.2.3 Process and Game Development

Gaming can be high stakes for organisations and relies on a number of processes and techniques to maximise the chance of successful delivery. Two commonly used aspects are the game development pipeline and the game design document. A game development pipeline is the process of building a game from concept to completion with development typically divided into 4 stages: concept, pre-production, production and post-production[16]. A Game Design Document (GDD) is primarily used to organise efforts within a development team[17]. The document is created by the development team through collaboration between their designers, artists and programmers and is used as a guiding vision throughout the game development process. In the time available for this study, it was not possible to investigate games processes in depth. Given the pressure of the games industry to design, test and deliver, future research could investigate what processes may usefully be transferred to defence software development.

Another interesting feature of the gaming ecosystem is that there is no clear governance as such. Although the major companies will of course have a significant influence on direction of the industry and the standards that are used the ecosystem's overall interoperability is principally driven by market forces supported by industry and Internet standards. This raises the interesting possibility that with the right incentives and interventions a defence M&S ecosystem might work as effectively from a user point of view with little or no governance.

4.2.4 Education in Gaming

The gaming industry relies on highly skilled people with a broad range of skills including programming, hardware, AI, art, and project management. The study did not investigated this hotspot in depth, but it is clearly fundamental to the success and growth of the gaming industry. There are many routes into the field,

especially due to its multi-discipline nature and the increasingly low technical barriers to entry. The evidence seen would suggest that many in the industry are self-taught, which is possible due to the volume and quality of training material that is available online.

M&S practitioners often say that defence does have difficulty in training and educating Suitably Qualified and Experienced Personnel (SQEP) in M&S. Defence jobs can be attractive due to their relative job security and steady income but whether defence can make itself more attractive to games industry professionals was beyond the scope of the study. Nevertheless, M&S education is extremely important to the success of MSaaS and further research could be valuable.

4.2.5 Simulation Games

The study considered all the major games genres. Perhaps not surprising, the simulation game genre had the largest number of games of interest. The latest Microsoft Flight Simulator (2020)[18] has parallels to the vision of MSaaS. It simulates the entire Earth's surface using textures and data from Bing Maps (providing over two petabytes of world map data taken from the cloud on demand). This includes Earth's 3D features generated by Microsoft Azure's AI. It also uses the Azure cloud to render visuals, enhance visual fidelity, and simulate real-world data and effects (such as real time weather), as well as calculating physics. Another example from this genre is the modern combat simulation series ARMA, which is a single and multi-player game and although it is not licenced for training is used by the military for recreation.

4.2.6 Professional Sports/Esports

Esports (also known as electronic sports, e-sports, or eSports) is a form of sport competition in gaming. Professional players, individually or as teams, participate multiplayer game competitions. Although organised competitions have long been a part of video game culture, these were largely between amateurs. However, by the late 2000s, participation by professional gamers and spectatorship in these events through live streaming saw a large surge in popularity. Since then, the increasing availability of online streaming media platforms, particularly YouTube and Twitch, have become central to the growth and promotion of Esports competitions that is currently valued at $1bn[19] in total. Esports are driving technological developments in data capture and analytics providing insights to players, spectators, organisers, marketeers, and business developers. Esports are already being embraced by the military for recreation and mental wellbeing[20]. How Esports are driving data and analytics is also of significant relevance to defence training, perhaps in the same way that professional sports and military training can intersect.

5.0 TARGETED INVESTIGATIONS

5.1 Games Engines

5.1.1 Background & Overview

There is naturally considerable focus on gaming hardware, whether it be the latest console or graphics card. However, many of the advances in gaming have arisen from advances in game engines, which are usually the software behind game development and a key part of the gaming ecosystem. The term game engine started to appear in the early 1990s when designers saw the economies of developing a series of games on a common software platform, separating the more technical aspects such as 3D image generation from the design and content. Early examples of game engines that later licensed to other companies were id Software's Doom (1993) and then the Quake Engine (1996) and Epic Games Unreal Engine (1998)[21].

Although without a formal definition, today a game engine is generally considered reusable software-development environment for the purpose of building video games and interactive simulations[22]. They have core functionalities such a 2D/3D graphics rendering, physics, sound, animation, artificial intelligence, and

networking. They may also have capabilities including data capture and analytics, multiplayer and matchmaking, and commonly have content libraries. Some game engines allow games designers to deploy their games and content across a wide range of hardware including desktops, consoles, mobiles, and VR both locally and in the cloud. By providing a focus for technology development for all software, hardware, and

business stakeholders they have contributed to the rapid development of the industry, with each generation of knowledge built on the last.

As personnel build up their expertise in a particular game engine, they can transfer their knowledge across projects and companies. This advantage for employees and employers alike is reinforced by the extensive advice and training available online and user communities. Further, game engines enable games designers to focus on design, with technology development the focus of the game engine builder. This lowers the technology skill requirement for games design, making the endeavour more accessible and blurring the line of responsibilities between art, design, and game development.

Like software in general, game engines can be in-house proprietary, licensable proprietary, or open source, each with their advantages and disadvantages. Around 175 game engines are listed in Wikipedia[23] but many of these are niche and/or no longer available. Our gaming ecosystem analysis considered 15 game engines with Unity Technologies' Unity and Epic Games' Unreal currently the most dominant and widely used.

Games engines have been exploited by non-gaming industries for many years but typically without the direct involvement of the game engine (after software licensing). However, in recognition of the potential growth of the interactive 3D simulation market, companies such as Epic Games[24] and Unity are moving toward providing enterprise services offerings such as support and training.

5.1.2 Potential Benefits to Defence

Game engines have not gone unnoticed by the military and as early as 1996 "Marine Doom" was created by serving personnel from the US Marines Modelling and Simulation Office. Designed for 4-person fire-team training it aimed at filling a gap in simulation and training capabilities that at that time was more focused on expensive platform simulators. Conceived in 1999 and still available, America's Army was the first game to feature Unreal Engine 2 and was launched in 2002 as a US Army recruitment tool[25]. Today, game engines are routinely used across defence, providing a cost-effective route to the defence simulation market for both large companies and SMEs. Use cases are diverse, from training and operations through to R&D and manufacture. Game engines' ever-increasing functionality, vibrant online user communities, accessible and searchable content libraries, and the shift to professional services will very likely mean that they will play a bigger role in defence in the future. Whether they replace the existing set of bespoke defence simulation software or augment them in a larger simulation ecosystem remains to be seen. Either way, increasing competition is likely a good thing for the military customer as simulation becomes more cost effective over time.

In the context of MSaaS, game engines could contribute to many of the key features of a successful MSaaS setup. Designed to be user friendly and accessible and with rich and searchable content libraries, game engines could support rapid simulation discovery and composability for some use cases. They could be deployable on local and cloud infrastructures. Together with the wider ecosystems that game engines integrate with there will be significant relevance to MSaaS. Tools such as multi-player, data and analytics, AI, streaming, geospatial, and CAD/CAM data import are examples. Although proprietary, many game engines give visibility of their source code to customers that can give improved confidence to both customers and industry in critical use cases.

5.1.3 Exploitability Challenges and Risks

Although defence has exploited licensable game engines for many years, it may well be difficult for them to

replace existing long term bespoke simulation software. Defence customers may not see the direct benefits of shared content and expertise for example, and some contractors may be content to keep their own software and data to make competition more difficult and achieve vendor lock in. Further, bespoke simulation software can still have significant advantages where consumers have very specific military requirements.

5.2 Cloud Gaming and Online Services

5.2.1 Background & Overview

Cloud gaming is a category of online gaming where the game is run on remote servers (the "cloud") and the game is streamed directly to a user's device[26]. It places less reliance on local processing and can make access to games more frictionless for the end user. Subject to all network requirements being met, cloud & online services improve deployability by supporting greater diversity of hardware devices, including those underpowered and unable to run the service/game locally. Cloud gaming is an expanding part of the gaming ecosystem and forecast by Newzoo to be worth $4.8 billion by 2023[27]. It is not a new concept. Through the 2000s a number of companies experimented with cloud gaming, but internet infrastructure could not reliably meet the requirements (e.g. bandwidth and latency).

Today, technology giants (e.g. Amazon, Google, Microsoft) as well as gaming-specific companies (e.g. Nvidia, Sony Interactive Entertainment) are delivering standalone cloud gaming services. Benefits of taking this approach include being able to enter the growing gaming market without investing in proprietary console development, reaching a wider customer base through ease of use and accessibility across hardware platforms, monetising catalogues of older less technologically demanding games, and monetising and marketing their wider cloud infrastructure. Growth in cloud gaming is being underpinned by wider improvements to Internet infrastructure (for example the continuing emergence of 5G) including the proliferation of local data centres and general standards of connectivity in the civilian world.

Presently most cloud gaming services carry out the required graphical calculations in the cloud and then stream the resulting video in real time to the gamer. This poses scaling challenges to companies, which must set aside adequate cloud graphics processing to manage peaks and troughs in the number of concurrent gamers across the globe. Further, a reliable, low latency, high bandwidth internet connection is essential to support real time single and multi-player games and, although there are 'tricks' such as extrapolation to counter latency, companies need to invest in data centres located across the world. Despite these issues, cloud gaming is eminently technically achievable and is reaching a wide range of customers. This is perhaps exemplified by Google Stadia which, putting aside its commercial issues[28], can deliver AAA gaming in 4K resolution to a Chrome browser. Smaller companies are addressing some of the cloud gaming challenges. Intel-backed[29] Polystream's technology promotes scalability by computing the game in the cloud but sending the graphics commands to the local graphics card rather than the video.

Today many of the gaming backend services are hosted in the cloud. Steam[30] provides a marketplace for games, installation and automatic updating of user game libraries, community features such as friends lists and groups, cloud storage of game saves and player achievements, and social tools such as in-game voice and text chat. Conceptually, a "MSaaS Platform" based on Steam capabilities would have powerful utility for the defence M&S user (trainee, trainer, or analyst) including ease of use, M&S discovery, M&S composability, software distribution, update management, user-generated content support, and community tools. Less visible than player facing services like Steam are services such as PlayFab. Acquired by Microsoft in 2018[31], PlayFab enables developers to build and operate games and capture and analyse gaming data from users. This data supports continual improvement of gaming experiences and hence better engagement, retention, and monetisation of players.

5.2.2 Potential Benefits to Defence

The study recognised that a wholescale change to "cloud simulation" in defence, mirroring the trend in the gaming world, is unlikely to be achievable in the near term. The number of different legacy systems, diversity of M&S capabilities, required infrastructure, and security considerations present some significant practical challenges. However, cloud gaming and wider online services provide a powerful model for how a defence MSaaS could be designed, particularly regarding the: user-centric focus and ease of use, discoverability and

composability of content, library content management, community and knowledge sharing tools. A cloud-based model offers the enterprise potential to reduce local hardware requirements, enhance security through use of centralised data storage & processing, enhance training data capture and analytics, and improve content and version management. Learning from the approach of companies in this space could drive enterprise-wide, cost-effective, agile, and accessible M&S capabilities in support of training, operations and analysis.

5.2.3 Exploitability Challenges and Risks

Even over the short period of the research there were significant changes in cloud gaming. The area is still maturing both technically and commercially. For example, Nvidia rolled out in-browser streaming for Ge Force Now in January 2021[32] and Google shut down Stadia Games and Entertainment[33] to become purely a publishing platform for third-party developers in February 2021. As companies change hands, reprioritise their business, or cease to exist, there are many questions about commercial viability in the near term of current cloud gaming services and risks that they will cease to be supported in the long term.

As compared to a simulator with its own local processing, cloud simulation has an inherent risk that, even with a capable network, connectivity to the servers might be lost. The M&S user may have low tolerance to simulation systems going offline during a potential network outage. Building in an acceptable level of redundancy/resilience into a cloud deployment offers mitigation but comes at additional cost, potentially undermining the cost-effectiveness of a cloud choice.

5.3 Data & Analytics

5.3.1 Background & Overview

In broad terms, data and analytics extract insights from data to inform and assist decision making. The explosion of 'data science' facilitated by the Internet and the rise of AI and other analytical techniques is driving the discipline forward. At a consumer or individual level, there have been major steps forward in sensors and connectivity. As a result, consumer consumption of analytics is now common, ranging from health to home power usage.

Data and analytics are also having significant impact in the gaming world. 'Big data' has arrived, with organisations using gaming data to better understand gamers' behaviours and needs. Where early this century gamers and their games were mostly disconnected from the games companies, now developers and analysts typically have continuous online access to gaming data. By collecting data on consumers, the games industry can now evolve or create business models and develop titles that will be played and maximally monetised (e.g. micro-transactions) over long periods of time.

The volume, variety and velocity of gaming data is significant. In December 2020 Epic Games' Fortnite had 350m accounts, achieved a record 15.3m concurrent players, and had a further 3.4m viewing on YouTube Gaming and Twitch[34]. In 2019 it was reported[35] that Fortnite generates two petabytes of data per month from data capture and analytics tools built on Amazon's cloud services. Key Performance Indicators (KPIs) such as the length of time players are engaging with the game are being tracked and used to guide changes to the game.

Just as data and analytics are helping athletes and F1 teams to improve their performance, the $1bn[36] eSports sector is also following suit helping to analyse performance and develop new strategies. The digital nature of gaming means they can be recorded, re-watched, analysed, and fed into databases so they can be referenced and compared. With universal online connectivity, professional gamers do not need to physically attend events to watch rival players and can guide their own training through access to match footage and data analysis. Gaming sessions can also be analysed. For example, StreamHatchet[37] provides live dashboards of viewer counts, comparison between streaming sessions, information about the audience reached, and team analytics

with historical data to analyse past trends and performance across all genres, games, events, and channels. Data analytics are heavily employed by broadcasting platforms. Twitch and YouTube use analytics to recommend content based on previous viewing information. The betting industry has made moves into Esports and is leveraging data and analytics tools to look for gaming (cheating) and betting anomalies in tournaments to enhance betting security. They are also exploiting data to establish live odds and design new, more addictive gambling products.

5.3.2 Potential Benefits to Defence

Military and intelligence organisations are heavily reliant on data feeds to function. Defence already recognises the potential of AI and advanced analytics technologies to deliver insights for operational decision makers in ever more complex and dynamic operational scenarios. In the simulation and training world however, there has traditionally been more emphasis on qualitative assessment of training design and performance. This is especially true at an enterprise-wide level but there are signs that this is changing. If defence could mirror the technology and approaches already being used in the gaming sector it could look to new ways of capturing and analysing trainee performance, provide enhanced real-time analytical tools for instructors, and inform enterprise-wide decision making on trends, usage and effectiveness of simulation and training investments across defence.

5.3.3 Exploitability Challenges and Risks

Defence does not currently have widespread access to cloud data and analytics tools that gamers and gaming companies rely on. Where defence does make use of cloud data capture and analysis it is typically siloed and disconnected. Further, trainee data is likely stored in pockets with inadequate metadata and without common Master Data and Data Interoperability standards. Ultimately this means the data generated is not easily transferrable, widely viewed, or analysed on an enterprise-wide basis.

5.4 Community

5.4.1 Background & Overview

Since the earliest days of computer games there has been a social element to networked gaming. One example is the chat function in the MUD or Multi-User Dungeon games that originated in the 1970s. Technology now allows millions around the world to enjoy gaming as a shared activity. Gamers come together to play, share, watch, comment, and learn. As online capabilities and connectedness improved, this became easier and more frictionless. Today, ever larger and more vibrant communities exist across many game genres. Community focused platforms such as Discord and Twitch have seen significant growth and are being used outside recreational gaming e.g. for business communication. In addition, gamers are using virtual spaces for other forms of entertainment such as concerts[38] and film festivals[39] inside gaming environments. In 2015 the Entertainment Software Association (ESA) reported[40] that 54% of frequent gamers feel their hobby helps them connect with friends, and 45% use gaming as a way to spend time with their family. The Covid-19 pandemic is likely to have accelerated this trend although data has not yet had

time to fully emerge regarding the long term.

Roblox is an online game platform and game creation system which has grown significantly during the pandemic with Roblox claiming[41] three-quarters of American 9- to 12-year-olds play its games and during the lockdowns, birthday parties and classes have been held on the platform. These children, playing games like Roblox and Minecraft, are the generation who will join the military later this decade. They quite reasonably might expect to socialise and interact in similar ways in uniform as they have whilst growing up.

Some games are becoming social spaces on a much bigger scale. As well as being multi-player games Fortnite, Minecraft, and Roblox now also hosts live events. In April 2020 over 12.3m concurrent players watched a

Travis Scott concert[42] and on 20 February 2021 Fortnite's "Party Royale" (non-combat) platform hosted a film festival with 12 films. Spectating games is also becoming very significant. Amazon's Twitch is the world's leading live streaming platform for gamers. In 2020 alone 18.3bn hours were watched with 87,500 average concurrent live channels[43]. The growth of spectating over Twitch and the influence of the pandemic can be seen in Figure 4 below.

Figure 4: Twitch hours watched per month (as of 23 Feb 2021)

Motivations for spectating are varied but include learning how to play a game or simply enjoying the gamer commentary and personality and streaming communities have grown organically within the gaming ecosystem as services like Twitch and YouTube have become more capable and widespread.

Perhaps one of the most visible signs of the growth in online gaming communities is the rise of Discord, a platform for group communications. Originally built for gamers, its origins lay in improving voice communications for online games. The platform is divided into servers, each of which has its own members, topics, rules, and channels and allows users to voice- and video-chat, as well as livestream games and other programs from their computers. Since 2015, Discord has grown to 140 million monthly active users in December 2020[44] with over 6.7 million active servers (or communities) in July 2020. The success of Discord[45] has been put down to its community focus as opposed to the principally individual focus of other social platforms such as Instagram.

5.4.2 Potential Benefits to Defence

As gaming has become increasingly online, there has been a significant growth in the communities around gaming, for gamers, spectators, and developers. Games technology is becoming a platform for other uses such as concerts and business. Of interest and relevance to defence are both the technologies and the culture surrounding gaming communities. Such developments are not going unnoticed by the military and eSports

clubs have been set up for recreation and to "increase mental resilience[46]".

5.4.3 Exploitability Challenges and Risks

The military are in some spaces already working on community for defence M&S. Conducting this at an enterprise-wide scale present a number of challenges. In terms of technology, it is not clear whether defence IT managers would be willing or able to host Discord, Twitch or similar software tools to improve communications and sharing. In any endeavour as large as defence M&S there are always cultural challenges. Although the military appear ready to embrace community gaming there are many disconnected initiatives reflecting different cultures across defence, and perhaps some organisational debt in IT and Security policy. The creation of a vibrant and connected community creating and sharing defence M&S content seems a long way away.

6.0 DISCUSSION AND OPPORTUNITIES

6.1 Discussion

This study undertook to review the full breadth of the private sector gaming ecosystem and to seek out opportunities for defence M&S in the short and longer term. It was targeted at opportunities which might contribute to the MAAITEE goal of a “step change” in training and education in defence. With knowledge of both the gaming and the defence simulation and training domains it has been possible to identify the intersection points (‘hotspots’) between the two domains and suggest opportunities for exploitation and further investigation. Although ultimately subjective, this work has taken a structured and auditable approach and based its assessment on the study team’s experience in defence M&S and the private gaming sector. The military have looked to the gaming domain for many years and there are many past and current examples of how the military are exploiting gaming technology. It was the opinion of the study that it remains a valuable endeavour and that the private gaming sector will continue to generate new opportunities for defence to learn from to exploit.

Within the resources of this study, it was not feasible to create a gaming ecosystem from scratch and so a number of existing ecosystems were reviewed as starting points. The “Konvoy Ventures” game ecosystem was selected to structure the x-axis of the heatmap as it was judged to be the most up to date and comprehensive. It was striking how challenging it is to create such an ecosystem. The gaming sector is highly dynamic and ever-changing. In the space of months whole new areas can take on greater importance or fade as companies enter or withdraw from sections of the ecosystem. The people, process, technology framework used for the defence M&S attributes (heatmap y-axis) mapped well against the gaming ecosystem and can easily be expanded to accommodate new trends or areas of interest. Critically, it is captures areas of importance that are less technological such as communities and culture – essential aspects of both the defence M&S and gaming ecosystems.

A common theme emerged during the course of the study. The Gaming Ecosystem is practically universally connected online. Over the Internet, whether it be console, PC or mobile, games are discovered, downloaded, and updated and players play and connect with each other. Game developers and publishers too have persistent Internet access to game and player data together with software and content. This enhances games development through easy access to libraries and knowledge and online monitoring and updating, enhances player experience through ease of discovery and access to communities, and provides a catalyst for new activities such as spectating and new business models through enhanced data and analytics.

Another area of note was the significant number of MOD/military organisations who are already exploiting gaming technology and approaches, from game engines through to Esports. However, there appears to be limited coordination or organised knowledge or data sharing. In comparison with the gaming ecosystem, the defence M&S ecosystem seems unconnected in terms of physical networks and in people and culture,

leading to missed opportunities to reuse and share M&S content and knowledge. Defence organisations could look to learn from this "softer side" from an organisational and cultural perspective.

6.2 Opportunities

6.2.1 Heatmapping

The heatmapping approach trialled a way of uncovering opportunities for defence M&S to learn from private sector gaming. By looking at the gaming ecosystem as groupings of capability and scoring these groups against a defence M&S ecosystem, this work was able to generate a rich set of targets for further research and exploitation and display them in a highly visual manner. This method can be reused and might provide a valuable approach for future horizon scanning work.

6.2.2 Coordination of Defence Game Engine Use

Games engines are already being used in defence. They are becoming ever more capable and versatile and are supported by their own ecosystems, communities, and professional services. They have large user bases that generate open source training and knowledge. Defence could see major cost and quality benefit by taking a coordinated approach to procuring and deploying game engines, sharing best practice on their use, and ensuring the content generated can be used elsewhere in defence.

6.2.3 Leveraging Cloud Gaming Approaches

Cloud gaming is a technological reality now and aligns with many core MSaaS characteristics. Despite the many advantages relating to removing local hardware limitations, central management of content, data, and services, and cost effectiveness 'defence cloud simulation' and MSaaS will only be fully realised if defence can define the appropriate network infrastructure requirement and provides the funding to deliver a cloud-ready network. Through a cloud-based testbed defence could explore leveraging instances of best-in-class cloud services such as Steam, Playfab, or Unity, and investigate emerging cloud offerings.

6.2.4 Data and Analytics

Data and analytics is a well-established focus across M&S and defence. However, there are many emerging technologies in unexpected parts of the gaming ecosystem that could drive new opportunities for defence M&S and defence wide individual and collective training. Examples include, live player performance analytics in pro gaming, computer vision (video to data) technologies in Esports streaming, and the use of AI to create digital twins of 'ideal humans'.

6.2.5 Communities

Communities connect gamers, spectators, and developers across the ecosystem. These communities act as force multipliers, sharing knowledge, providing user-generated content, and experimenting with the technology of choice. Defence already has bottom-up initiatives such as "Fight Club" and it could reap further community benefit with top-down support and technologies to enable M&S communities to mirror the dynamics found in the gaming ecosystem.

7.0 REFERENCES

[1] 50 Years of Gaming History, by Revenue Stream (1970-2020) (https://www.visualcapitalist.com/50-years-gaming-history-revenue-stream)
[2] Industry Landscape: Video Gaming & Esports Sep 20 (https://medium.com/konvoy/industry-landscape-video-gaming-esports-1e5ad89d0f88)

[3] Newzoo Gametech Ecosystem Map 2020 (https://newzoo.com/insights/infographics/gametech-ecosystem-map-technology-game-creation-supply-chain)
[4] Maps in video games – range of applications (https://images.app.goo.gl/HTCDY7kFDzsf62x48)
[5] Hacker Noon - The Gaming Ecosystem Explained (https://hackernoon.com/the-gaming-ecosystem-explained-nk1d32ts)
[6] The Benefits of Playing Video Games (https://doubleplus.gg/2014/01/31/the-benefits-of-playing-video-games)
[7] Genbby Ecosystem (https://www.linkedin.com/pulse/genbby-gain-maximum-profit-from-your-hobby-ryza-aditya-s)
[8] Virtual Reality Sector Overview (https://www.venturescanner.com/2018/07/23/virtual-reality-sector-overview-q1-2018/)
[9] A Future Vision for the Defence Learning Ecosystem (vIITSEC 2020) Dstl/LiMETOOLS
[10] People, Process, Technology: The PPT Framework, Explained (https://www.plutora.com/blog/people-process-technology-ppt-framework-explained)
[11] Minecraft (https://en.wikipedia.org/wiki/Minecraft)
[12] Roblox (https://en.wikipedia.org/wiki/Roblox)
[13] Google DeepMind AlphaStar (https://en.wikipedia.org/wiki/AlphaStar_(software))
[14] Latitude (https://techcrunch.com/2021/02/04/latitude-seed-funding/)
[15] Game Rant - Interview: Microsoft's Head of Cloud Gaming James Gwertzman (https://gamerant.com/microsoft-head-cloud-gaming-xbox-james-gwertzman-interview/)
[16] The Game Production Pipeline: Concept to Completion (https://www.ign.com/articles/2006/03/16/the-game-production-pipeline-concept-to-completion)
[17] Game Design Document (https://en.wikipedia.org/wiki/Game_design_document)
[18] Microsoft Flight Simulator 2020 (https://en.wikipedia.org/wiki/Microsoft_Flight_Simulator_(2020_video_game))
[19] eSports market revenue worldwide from 2018 to 2023 (https://www.statista.com/statistics/490522/global-esports-market-revenue)
[20] British Army Esports (https://www.twitch.tv/britisharmyesports)
[21] Kinephanos - Game Engines and Game History - https://www.kinephanos.ca/2014/game-engines-and-game-history/
[22] Games Engines (https://en.wikipedia.org/wiki/Game_engine)
[23] List of Game Engines (https://en.wikipedia.org/wiki/List_of_game_engines)
[24] Unreal Training & Simulation (https://www.unrealengine.com/en-US/industry/training-simulation)
[25] America's Army (https://en.wikipedia.org/wiki/America's_Army)
[26] Cloud Gaming (https://en.wikipedia.org/wiki/Cloud_gaming)
[27] Newzoo (https://newzoo.com/insights/articles/global-cloud-gaming-market-report-consumer-engagement-spending-revenues-2020-2023)
[28] GamesIndustry.Biz - Stadia's issues were clear from the start | This Week in Business (https://www.gamesindustry.biz/articles/2021-02-05-stadias-issues-were-clear-from-the-start-this-week-in-business)
[29] https://www.gamesindustry.biz/articles/2019-04-01-polystream-secures-usd12m-in-series-a-funding.
[30] Steam (https://en.wikipedia.org/wiki/Steam_(service))
[31] PlayFab (https://blog.playfab.com/blog/playfab-joins-microsoft)
[32] Nvidia (https://www.nvidia.com/pt-br/geforce/release-notes/GFN/2_0_27/Rich/gfn-v2_0_27-rich-release-highlights/)
[33] Google (https://blog.google/products/stadia/focusing-on-stadias-future-as-a-platform-and-winding-down-sge/)
[34] Twitter – Fortnite (https://twitter.com/FortniteGame/status/1333954074371383296)
[35] Forbes - Fortnite: How Artificial Intelligence and Analytics Make It More Fun (https://www.forbes.com/sites/bernardmarr/2019/06/10/fortnite-how-artificial-intelligence-and-analytics-make-it-more-fun)
[36] Statista - eSports market revenue worldwide from 2018 to 2023 – (https://www.statista.com/statistics/490522/global-esports-market-revenue/)
[37] StreamHatchet (https://www.streamhatchet.com/)
[38] CBR - Could Fortnite Be the Future of Music Concerts? - https://www.cbr.com/fortnite-future-music-concerts-bts/
[39] Epic Games - Gather for the Short Nite Film Festival (https://www.epicgames.com/fortnite/en-US/news/gather-for-the-short-nite-film-festival-watch-film-shorts-in-fortnites-party-royale)
[40] TechCrunch - The History of Gaming: An Evolving Community (https://techcrunch.com/2015/10/31/the-history-of-gaming-an-evolving-community/)
[41] The Economist - Gamers are logging millions of hours a day on Roblox (https://www-economist-com.libproxy.ncl.ac.uk/graphic-detail/2020/08/21/gamers-are-logging-millions-of-hours-a-day-on-roblox
[42] Twitter – Fortnite (https://twitter.com/FortniteGame/status/1253524351376330752))

[43] Twitch Statistics & Charts · TwitchTracker (https://twitchtracker.com/statistics)
[44] TechCrunch - Discord confirms raising $100M at a valuation of $7B (https://techcrunch.com/2020/12/17/filing-discord-is-raising-up-to-140m-at-a-valuation-of-up-to-7b/)
[45] YoYoFuMedia - The Rise of Discord: How Discord Has Become Popular Outside of Gaming - https://yoyofumedia.com/blog/rise-of-discord
[46] RAF News (https://issuu.com/rafnews/docs/raf-news-13-nov-2020)