

Draft

Bridging Physical & Virtual Worlds: The Military Metaverse

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HADEAN

BRIDGING PHYSICAL AND VIRTUAL WORLDS

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Introduction

The next-generation of digital technologies



The next generation of digital technologies

The world of defence and national security is experiencing the transformative effect of disruptive technology, driven by advancements in the commercial sector that continue to push boundaries at a breakneck speed.

The next generation of digital technologies encompasses a wide range of innovations aimed at improving the effectiveness and efficiency of military and security operations. Key areas of focus include AI and machine learning which are being used for data analysis, predictive analytics and decision support. This includes the development of AI-driven autonomous vehicles, unmanned aerial systems, and intelligent cybersecurity solutions used for tasks such as surveillance, logistics, and demining, reducing the risk to human personnel. AR and VR technologies also have applications in training, simulation, and mission planning, providing more immersive and effective training experiences.

These are but a few examples of emerging solutions that are pioneering novel capabilities for defence organisations and the Armed Forces. Underlying and connecting them however is a future of blended, 3D and persistent synthetic environments which can bridge the gap between physical and virtual worlds and augment all aspects of defence for battle-winning strategy, decision making and readiness. **A vision of a Military Metaverse.**



Part 1: The Emergence of a Military Metaverse in 5 Examples





The Emergence of a Military Metaverse in 5 Examples

The military helped build the Internet and they are helping to build the metaverse too. Indeed, military involvement in the metaverse can be traced back to the 1960s and here we will explore some of these military-sponsored developments that have helped contribute to the building of the metaverse and how such work continues today.

1. Networked Virtual Worlds

As computer networking and computer graphics advanced in the 1980s, visionaries such as USAF Capt Jack Thorpe saw the opportunity to develop affordable networked simulators so that hundreds of warfighters could train and experiment together in the same virtual world. Thorpe led the SIMNET (SIMulator NETworking) US DARPA-funded program which went on to develop a network of 260 simulators at 11 sites in the USA and Europe including tank and aircraft simulators and was made operational by the US Army in January 1990. Today, warfighters routinely train in large networks of simulators similar to SIMNET whether it be the British Army Combined Arms Tactical Trainer or USAF

Distributed Mission Operations network of combat flight simulators. Further, partner nations train and experiment together over large geographic distances by connecting their national simulation systems, sometimes over highly classified networks and sometimes over the Internet. Although many of the networked systems remain challenging to connect rapidly, Thorpe's bold vision of a persistent networked simulation system supporting experimentation, training, and mission preparation has been partly realised.



2. Blending the Real and Digital Worlds

In the late 1980s the concept of integrating live training into the virtual exercises was investigated by the US Navy. In its Battle Force In-Port Trainer exercises the USN together with DARPA networked over long-haul links the real amphibious assault ship U.S.S. Wasp alongside in Norfolk, Virginia, with Marine Corps SIMNET simulated helicopters, simulated Army tanks, Navy staff command centres, and the Institute for Defense Analyses. It meant that a helicopter simulator flying over simulated terrain could be viewed on the real radar screens of the Wasp from its simulated position 50 miles off the California shore, while it was physically at its Norfolk pier.

This live and virtual integration developed into the LVC or Live-Virtual-Constructive construct that the military routinely exploits today for training and experimentation. For example, in the British Army's "Synthetic Wrap" the tracked positions of combatants in the real world, for instance on Salisbury Plain, are used to

generate a simulated UAV sensor feed for an HQ without requiring an actual UAV.

3. Interoperability and Openness

Fundamental to creating a network of simulators is the need for a common protocol especially if new types of simulators are later introduced to the network. This was the case for SIMNET as it grew, and to reduce network traffic a single unified "world model" was shared across all the simulators, each of which would calculate their own status and update the world model. The approaches developed in the 1980s led to the Distributed Interactive Simulation (DIS) protocol, still in use to this day. Various international bodies have been set up to oversee and develop simulation standards, notably the Simulation Interoperability Standards Organisation (SISO) and the NATO Modelling and Simulation Group (NMSG). Beyond DIS, the High Level Architecture (HLA) has been developed and different military simulations can now be routinely linked to provide a richer distributed collective training or mission preparation experience.

4. eXtended Reality

As far back as 1961 Philco engineers developed a video-based HMD or "Headsight" with tracking so that military operatives could remotely view dangerous situations. Moving forward to 1982 and exploiting wider computer graphics advancements, the USAF developed the Visually Coupled Airborne System Simulator (VCASS) an HMD which enabled the pilot to control a plane and its weapons with gestures and voice commands. In the 1990s the US Navy ran a Virtual Environment for Submarine Shiphandling and Piloting Training (VESUB) project which demonstrated that VR-based technology could be effective for training shiphandling skills for novice and expert alike. Moving beyond research, VR-based trainers were introduced at the Parachute Training School at RAF Brize Norton in 2010 and are still in service today. As other markets such as gaming drive XR technologies, the military are now exploring the use of AR in operations through the US Army Integrated Visual Augmentation System (IVAS) program and MR is being introduced for fighter pilot training.



5. Exploiting Gaming Technologies

Generally considered as the first video game, Spacewar! was developed in 1962 by MIT graduate students on the Pentagon-funded TX-0 computer. Over the next few decades such computer technologies advancements were principally military sponsored but by the mid-1990s warfighters were realising that some video games were ripe for exploitation. In 1996 US Marines from the Marine Corps

Modeling and Simulation Management Office developed "Marine Doom". Based on id Software's Doom II, it was aimed at training riflemen who did not have access to expensive simulators. Initiated in 1999, America's Army exploited Unreal Engine 2 and was launched in 2002 as a US Army recruitment tool. Working with the US Marines and Australian Army, gaming company Bohemia Interactive released VBS in 2004 based on the Operation Flashpoint game engine and its derivative

VBS4 is in service today across the world. Tapping into the gaming generation, militaries like the RAF have established official internal Esports associations as a further demonstration of the interwoven links of video gaming and military simulation.

These are just some of the developments which illustrate how the military over many decades have explored and put into service metaverse technologies and standards. These are helping to create a military metaverse that can support the military better prepare for today, tomorrow and the future.



Part 2: How the Military Metaverse is Transforming Defence Training Programs



How the Military Metaverse is Transforming Defence Training Programs

As consumers and organisations we expect to be able to securely access and share a whole range of digital content and data 24/7 on multiple device types anywhere in the world.



Advances in cloud infrastructure and technologies and ubiquitous networking are meeting this demand and although we may not be living in metaverse-like virtual worlds just yet, our physical and digital worlds are entwined like never before.

For effective training and mission preparation, warfighters too need to be able to access and share the latest data whenever and wherever they are. This data may be about their area of operations, data about their equipment, or

data about their opponent's. The data generated in training and shared is valuable for analysis, for example tracking trends in performance, or for training new AI models. For the enterprise there are benefits in providing software and security updates across a large range of legacy and new devices such as simulators. Less expensive hardware is required if training content such as video and interactive 3D can be streamed over a network, and streaming reduces the need to keep potentially classified data on the device. These are just some of the benefits of a persistent cloud-based approach.

Cloud-based training solutions are also increasingly important for the military as the digital and physical worlds blend towards a military metaverse, and multi-domain training must respond quickly to a more uncertain world. They are a step-change from today's approach of integrating different simulation products through standard interoperability protocols. Rather, organisations can run containerized technology in the cloud, using a modern and open web architecture.

United States

The US Army Synthetic Training Environment (STE) is a training capability that will enable Army units and leaders to train realistically and effectively in a single, interconnected system combining the live, virtual, and constructive (LVC) simulations for all levels of training and mission rehearsal. It will be a transformation from the current complex federation of Army simulation capabilities that are hard to keep up to date and not flexible nor integrated sufficiently to meet current and future threats.

The STE concept envisions delivering training content from the cloud to the point of need using DoD and operational networks such as will be provided by the DoD Joint Warfighting Cloud Capability Procurement project. In doing so, all soldiers will be able to access the latest training updates and environments whether at home station or deployed. A critical component of the STE is the One World Terrain which seeks to render the entire world in 3D so soldiers can train virtually for missions located anywhere on Earth prior to a mission with the latest data streamed from both open and closed sources.

The USAF too has similar aspirations through its Joint Simulation Environment (JSE) project.

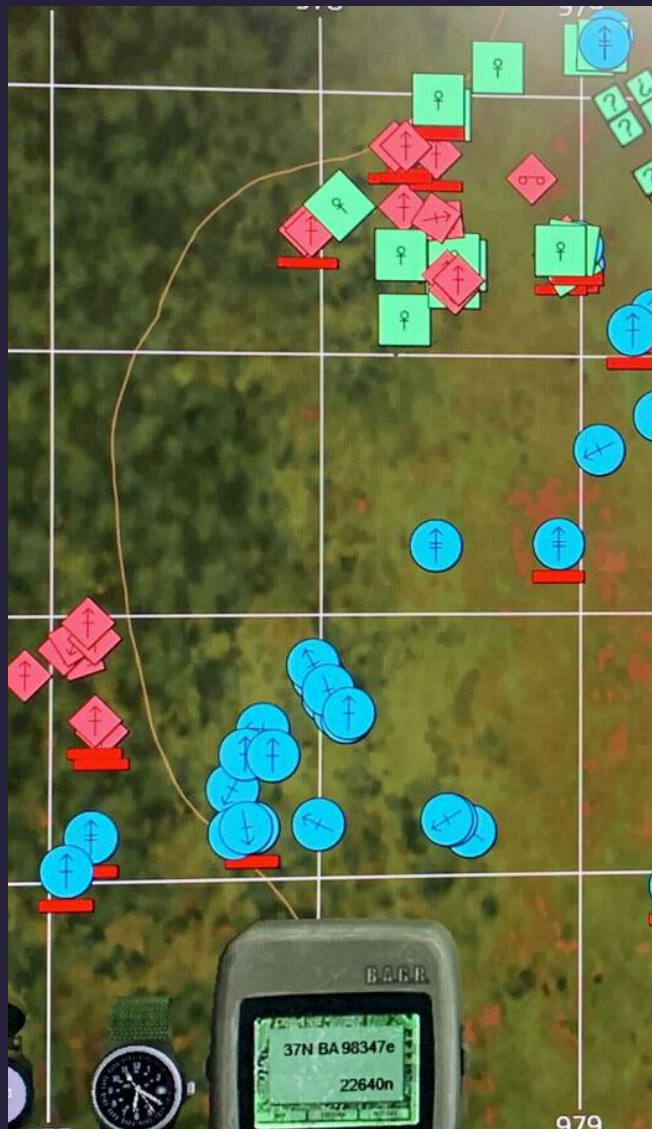
Originally designed to serve as a high-fidelity, virtual testbed to certify the capabilities of the F-35, JSE is now being used to support F-35 training as well. JSE is being developed to support other aircraft types with the ultimate goal of being a digital test and training range for the USAF. Alongside JSE, the Simulator Common Architecture Requirements and Standards (SCARS) initiative is a USAF sustainment effort to incrementally establish an open architecture infrastructure for all its simulators. The driver of SCARS is that there are 2,400 USAF training devices globally ranging from desktop trainers to full-motion simulators and they all require software and security updates. SCARS is aiming to exploit cloud technologies with local clouds to run the simulators, supported by a centralised private cloud providing the sustainment for all the sites. The transition from legacy technologies will take some time but the SCARS vision is to move to an apps store concept with a common applications library provided by the centralised cloud within the same cyber-secure private infrastructure.



NATO

With over 30 nations in the Alliance, NATO has the challenge of orchestrating and supporting the coalition training and exercising of members who will each have a range of simulation systems and tools, many of which do not interconnect nor represent the full picture of contemporary warfare. A further complication is that the nations that take part may well vary from exercise to exercise and so it is important to be able to prepare quickly and flexibly whatever the desired training outcome. For such reasons NATO has been developing a Modeling and Simulation as a Service (MSaaS) concept that supports the rapid composability of simulations from shared M&S components, data and services, all in a cloud-based environment. Building on such work, NATO has launched its Next Generation of Modelling & Simulation initiative which aims to provide a persistent and flexible M&S capability that supports not only training but other activities such as capability development and support to operations.





United Kingdom

The British Army is seeking through its Collective Training Transformation Programme (CTTP) to transform its collective training to better reflect the scale and complexity of the future multi-domain operating environment. CTTP will provide an integrated, expeditionary, and digitalised Future Collective Training System (FCTS) that can deliver training anywhere across the globe. The cloud is seen as a key enabler for this more distributed and unified approach to its array of legacy and new training systems which include instrumented live training systems and simulators. To explore cloud approaches the British Army has sponsored a number of CTTP pathfinder activities. As an example, exploiting cloud technologies, Hadean developed a persistent central simulation to aggregate data and stream training outcomes in real-time from training exercises that were using LVC simulations.

The UK Ministry of Defence (MoD) is seeking to exploit cloud technologies in support of all defence activities as set down by its Cloud Strategic Roadmap for Defence, with direct support to CTTP and other training programmes through the Defence Synthetic Environment Platform (DSEP). DSEP will be a scalable, agile capability to provide and exploit M&S data, government furnished assets, models, services and applications in support of the generation of M&S for various use cases such as training and operations. For programmes such as CTTP, DSEP will assure interoperability with federated components, compose applications from content and components, then deploy it into the training environment. A key outcome for DSEP is that it will bring M&S producers and consumers together with the potential to disrupt traditional approaches.

Part 3: Gamification of Military Training and its Impact on Force Preparedness





Gamification of Military Training and its Impact on Force Preparedness

We like to play games. Playing games is a natural and enjoyable activity for all ages, abilities and cultures. Why we play games is complex but this natural instinct can be harnessed in non-game contexts by so-called gamification.

It can be applied as a technique in many fields including in business to increase customer engagement and in education to make learning more interactive and enjoyable. Does gamification also have a role in defence and might the blending of our physical and digital worlds open our eyes to new learning opportunities in sport that can enhance both learning and force preparedness?

Why do we Play Games?

One might wonder in evolutionary terms why humans, and other animals, devote so much time to recreation and play when it could interfere with finding food or expose us to predators. As a vital part of the human experience it must have benefits for us. Although there is no definitive reason why we play games, we

likely use play as a way of improving our physical and mental abilities, helping us to learn about our world and our likes and dislikes, and enhancing our communication across different languages, cultures, and species.

What is Gamification?

Gamification aims to tap into our innate love of games. As a term it came into popular usage in the 2000s and now is mainstream across many sectors and, depending on how it is designed and implemented, can have

positive effects on learning, performance, or behaviour change. Gamification uses game elements to create engaging and rewarding experiences and has two main ingredients: game mechanics and game dynamics. Game mechanics provide a goal and sense of achievement

through points, levels, leaderboards, and badges and the like. Game dynamics are the emotional and motivational aspects of a game, such as competition, curiosity and collaboration.

Gamification is not a theoretical construct, it is used in learning and beyond and in surprising and diverse places.

- Duolingo is one of the most popular language learning apps in the world and uses points, levels, badges, and streaks to encourage users to practise daily and progress through different topics. In 2022 it reportedly had over 500 million registered users.
- Google Maps encourages users to submit reviews and photos through rewarding them as they climb the “Local Guide” ladder.
- LinkedIn uses subtle gamification techniques encouraging profile completion through a “progress strength” bar and a badge and our social curiosity is sparked by “Who’s viewed your profile”.





But what about the military? Some might argue the military has been using games for centuries with early chess being principally military pieces and board-based wargames arising in Prussia from the 1820s. The military have also exploited video games and their

technologies since the 1990s. Now, traditional military classrooms are perhaps less suited for a target population of 18-24-year-olds raised in the digital age so new learning techniques are being sought.

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- The Cyber Confident Team of the UK MoD created online games to teach cyber skills to thousands of MOD staff. One game, "SITREP", tested how well they could spot phishing emails. The team praised the games for engaging and challenging the staff.
 - In the US, gamification has been introduced to learning within Defense Acquisition. Success in the first-person shooter game depended on players' ability to correctly answer questions about federal acquisition rules and regulations.
 - Back in the UK, QinetiQ recently partnered with Gamification Nation on the xCITE project to demonstrate to the Royal Navy how gamification could better attract, train and retain millennial sailors.

Digital Sports Anyone?

As gamification grows in importance across many sectors it is also valuable to consider how we might take advantage of the role of sports in learning. It is fully accepted that physical team sports such as rugby and football are good for team building and cohesion but what about digital based sports?

Esports (or electronic sports) is an activity where students form teams and participate, train, and compete in organised video gaming competitions with online and in-person spectators. They can foster skills such as teamwork, communication, problem-solving, digital literacy, and strategic thinking and build a sense of community and belonging, benefits that are all highly valued in the military.

Reflecting this, all three services now have active esports teams. Esports are also being introduced in school curriculums, are now an intrinsic part of Formula 1 racing, and may well be part of the 2028 Olympics.

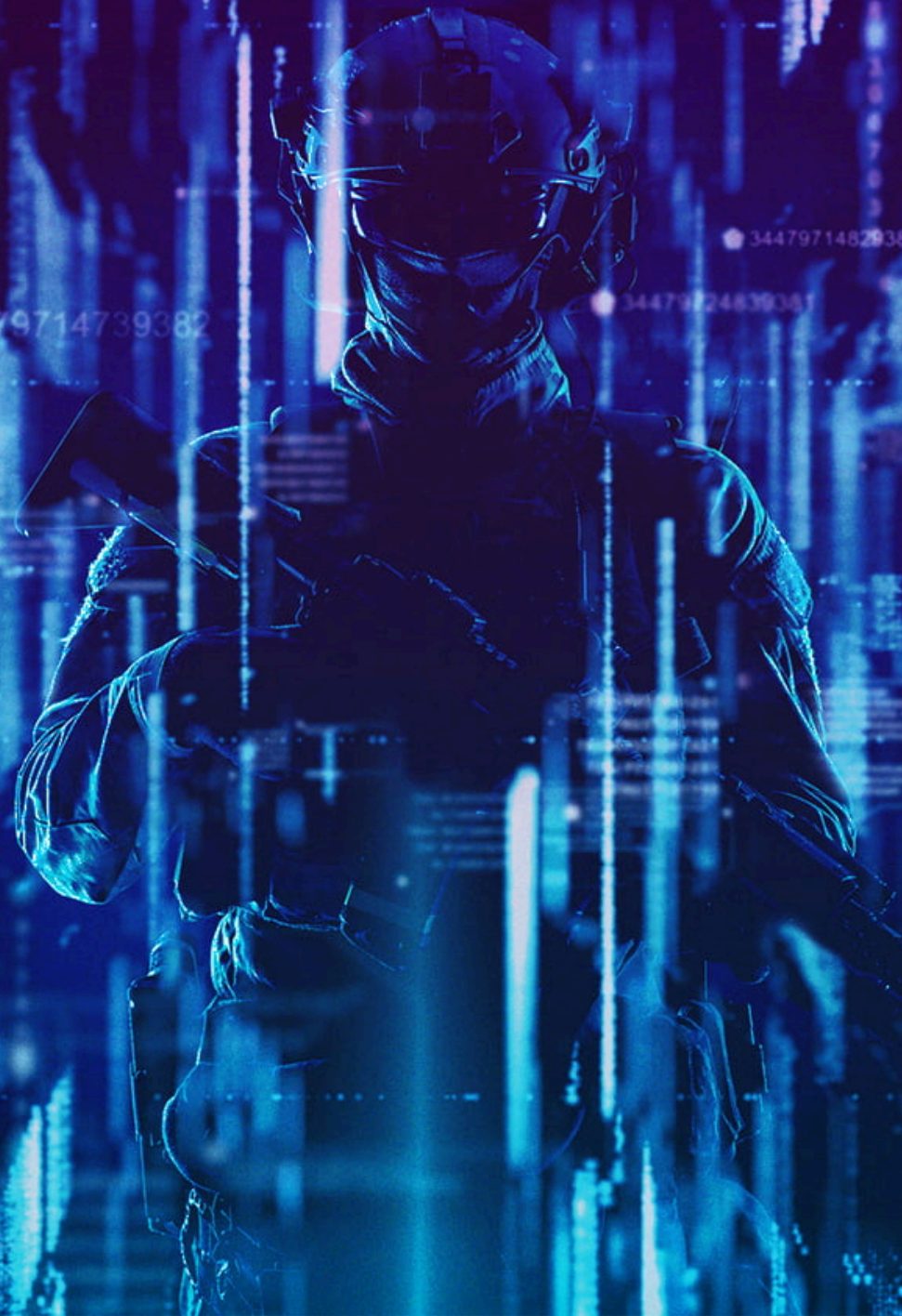
It's not all about sitting in gaming chairs either. In Virtual Taekwondo, a Korean martial art, players' bodies are transformed through real time body tracking into gaming controllers as they are able to engage in one-on-one combat with their real-life opponent's avatar from anywhere in the world. This kind of innovation together with esports could be a catalyst for thinking about how learning in defence could be delivered very differently and even impact our thinking on future military operations themselves.



Preparing the Force

As gamification and digital sports grow in scope and importance we can imagine a world where, between more formalised learning, militaries provide more “fun” learning opportunities across their digital infrastructure. From entertaining gamified learning content delivered on mobile devices through to major inter-service esports events. Some sports whilst still physical may also be played at distance in future between players across the defence estate. Such experiences may help counter skill fade and also build cohesion and understanding across defence so that it is better prepared for multi-domain missions. It is surely better to have met others before in a collective experience, even over distance, than meet for the first time in operations.

Part 4: Level Up – Recruitment and Retention in The Military Metaverse



Level Up – Recruitment and Retention in The Military Metaverse

It's Challenging

Recruiting and retaining warfighters is critical to the success of the military and an enduring challenge. A huge variety of roles must be filled and in numbers not seen in many other organisations at such scale. The military is also perhaps uniquely young on average and roles are typically short, 2-3 years in duration. Incentives such as pay must be managed within public sector constraints. The world can furthermore change very fast, and there is a constant requirement for agility and adaptiveness as operational demands change. Longer term, roles will require more digital skills with the integration and iterative development of military platforms and systems and their software, and new roles in areas such as cyber and space. Against this backdrop, does defence need a transformed digital people system that better serves both warfighters throughout their career and the wider enterprise?



Some Numbers

The UK military is not unique in the challenge of recruiting and retaining its warfighters, but a few numbers helps to frame a complex scene. The latest MOD statistics (rounded) show that there are 142,500 Regulars in the UK military and 34,000 Reserves. There is always a turnover, and in 2022 11,000 Regulars joined and 16,500 left, and correspondingly 3,500 and 5,600 Reserves.

The average age for all Regulars is 31 and 39 for the Reserves with 12% of Regulars female and 16% for the Reserves. These large numbers of warfighters fill a broad range of roles. Currently the Royal Navy lists 102 roles on its website, with 101 roles in the British Army, and 63 roles in the Royal Air Force. The military also stands out from most organisations with only 0.1% of UK businesses having greater than 500 employees.

Let's Zig-Zag

The recent UK Defence Command Paper's response to a "contested and volatile world" was to make "our first-class people" a top priority and to invest accordingly in "their overall employment offer". It recognised that as the pervasiveness of information and the pace of technological change transforms the character of warfare more skills, that change more quickly, are needed. And change is required also because aspirations and experiences are changing too.

Many warfighters have grown up in a digital era where they now expect flexible, remote and hybrid working and to be able to operate together in a digital-first world. They may also anticipate more varied careers that will focus on how their employers' goals and values align with their own. Defence is recognising these trends and that career structures and remuneration need to reflect modern aspirations such as flexible careers and roles. It is therefore promoting 'zig-zag' or 'portfolio' careers allowing the military to leave and then rejoin more easily and even change services.



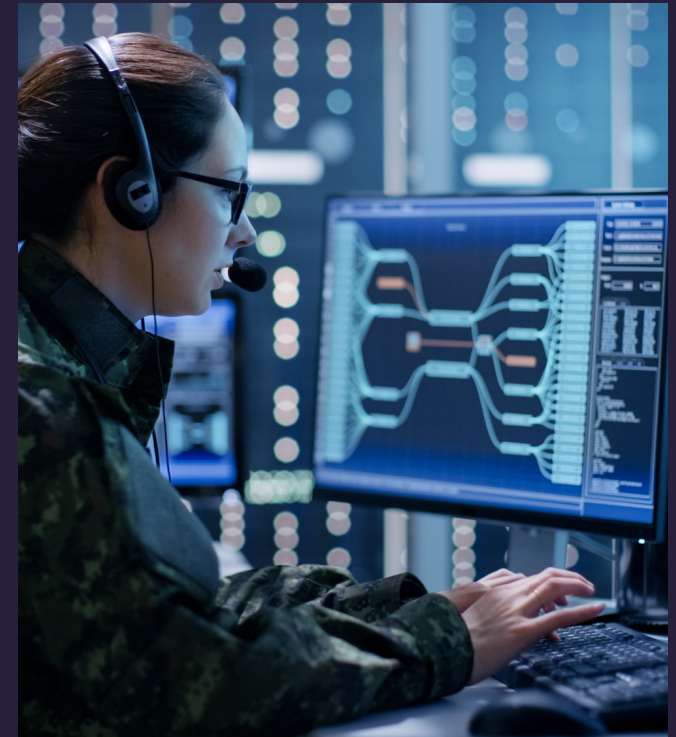
Tailored Learning

As warfighters progress through their career they have to learn and become proficient at something new and then keep their skills up to date. People learn at different rates and also might bring in previous know-how and so optimising their learning to meet their individual needs offers the prospect of getting them to front line services as soon as practicable. For these reasons defence is looking towards greater personalisation learning, or so-called adaptive learning when technology is used to achieve this. Key to such learning is data. Data-driven learning allows learners to progress based on their mastery of competencies and skills and their instructors and learning systems to provide more tailored and effective learning. Further, commanders and the wider enterprise can also monitor the readiness of units and forces more accurately. As AI techniques become more important it will be critical that such data is easily understood by machines. It will also require bringing together key data from diverse sources into what are sometimes

called 'data lakes', and so offering more insights than any single data source.

A Fractured Ecosystem

The recent Haythornthwaite Review of the incentivisation of UK Armed Forces personnel noted in its look at MOD digital people systems that “data is hard to access, technology is ageing, and... a fractured ecosystem has created the need for manual workarounds... there is no single view of data across the Armed Forces.” The Defence Command Paper has responded by stating that “as a top priority, we will look to digitalise and simplify our whole force people system”. It is clear that defence has digital people systems that will struggle to meet future demands, but that there is a will to address the problem. Nevertheless, there does not appear to be an overarching drive to integrate or converge the AFRP (Armed Forces Recruiting Programme), JPA (Joint Personnel Administration), DLMC (Defence Learning & Management Capability), and wider learning data initiatives.



“As a top priority, we will look to digitalise and simplify our whole force people system”.

Defence Command Paper, 2023

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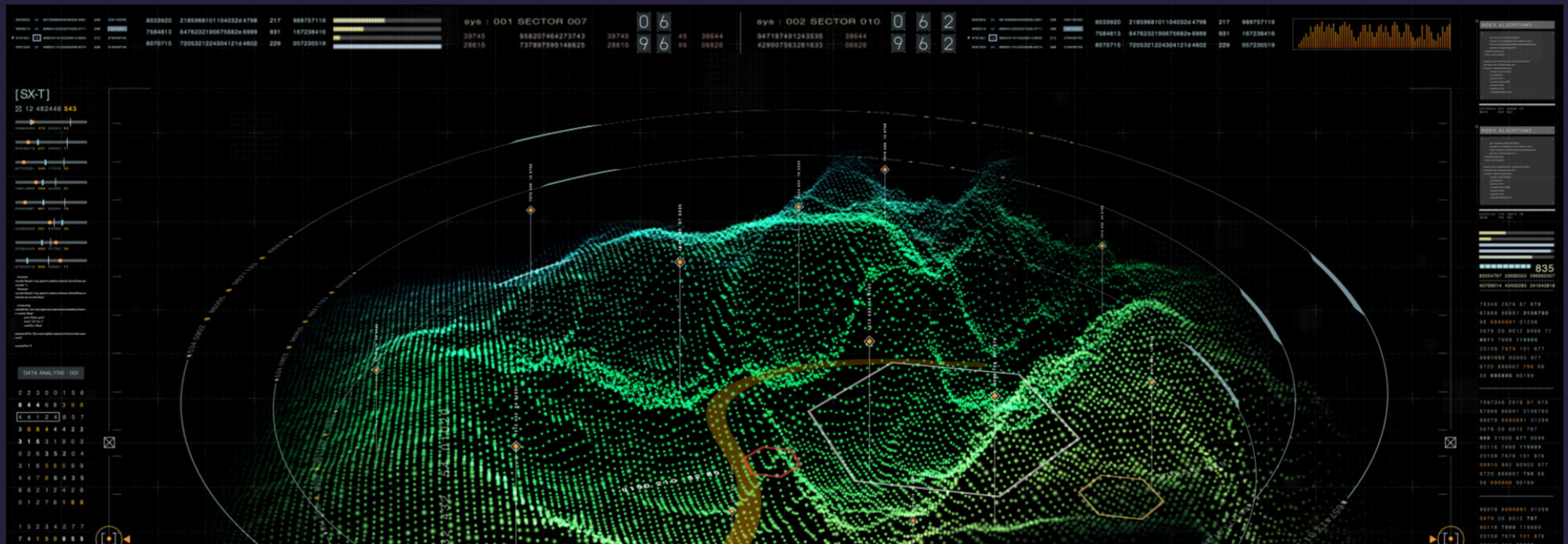
My Digital Twin Future?

Defence is not alone in having many legacy personnel systems that struggle to interact and exploit data. Indeed, they perhaps reflect the unique complexity and scale of the military. There are however, clear imperatives for defence to leave behind its “fractured ecosystem”, and fast. Is having a clear long term vision the answer? Should it be centred around the warfighter within a military

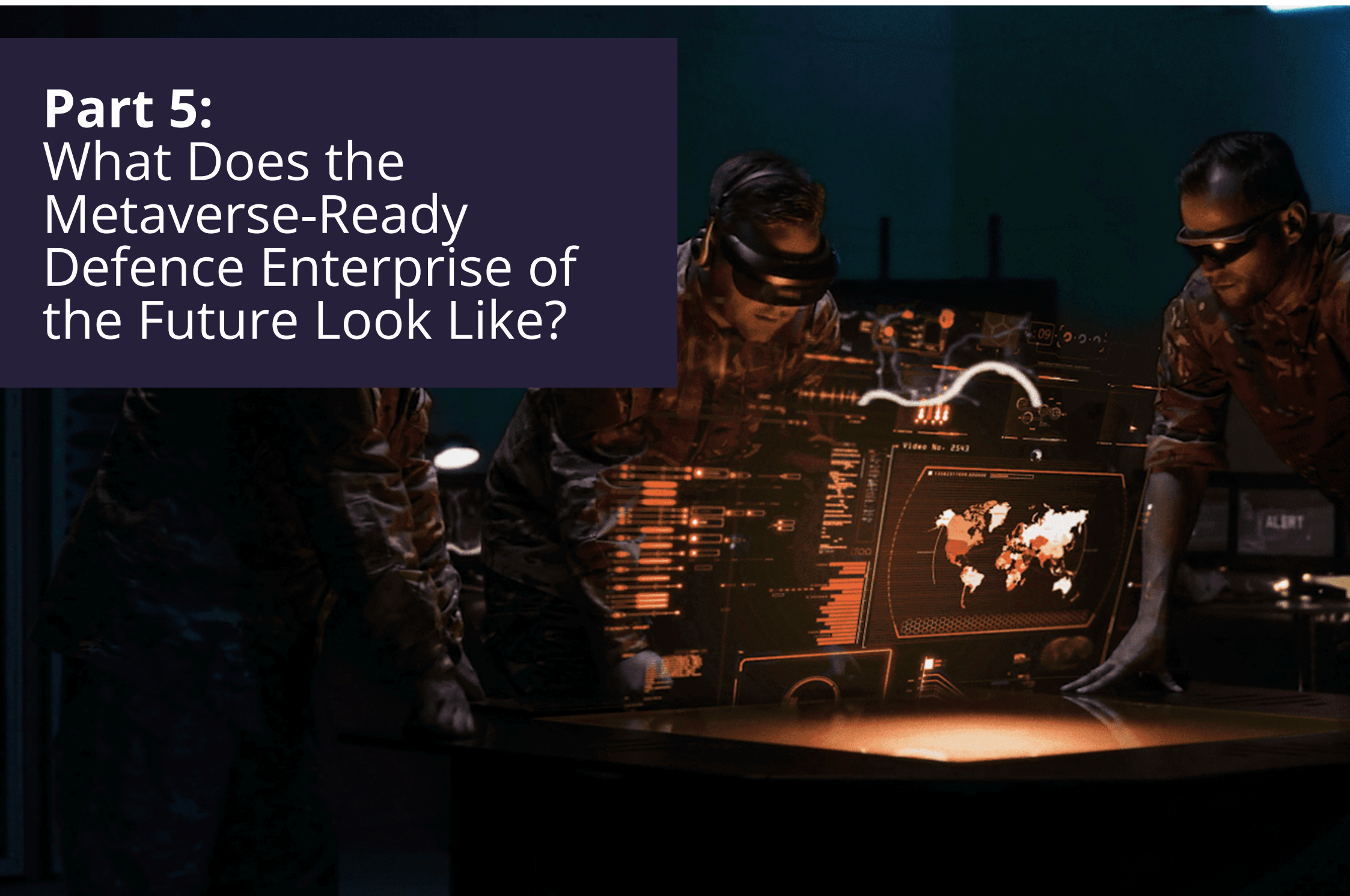
metaverse construct? A system where the warfighter has a through-career digital twin that supports them from the moment they are interested in joining the military, through recruitment and training, having an avatar that is interoperable across all training systems, helping them to counter skill fade, and support their “zig-zag” careers, in and out of the military and across the Services. A system that also provides commanders and operational planners with dashboards helping

them to identify who is ready for which role, the effectiveness of their training, and assess and control the readiness of units.

Such a convergence of digital systems has security and privacy implications and crosses many current organisational boundaries. But such a warfighter-first vision could help drive the convergence of digital platforms and data towards more integrated and effective people management systems that defence is calling for.



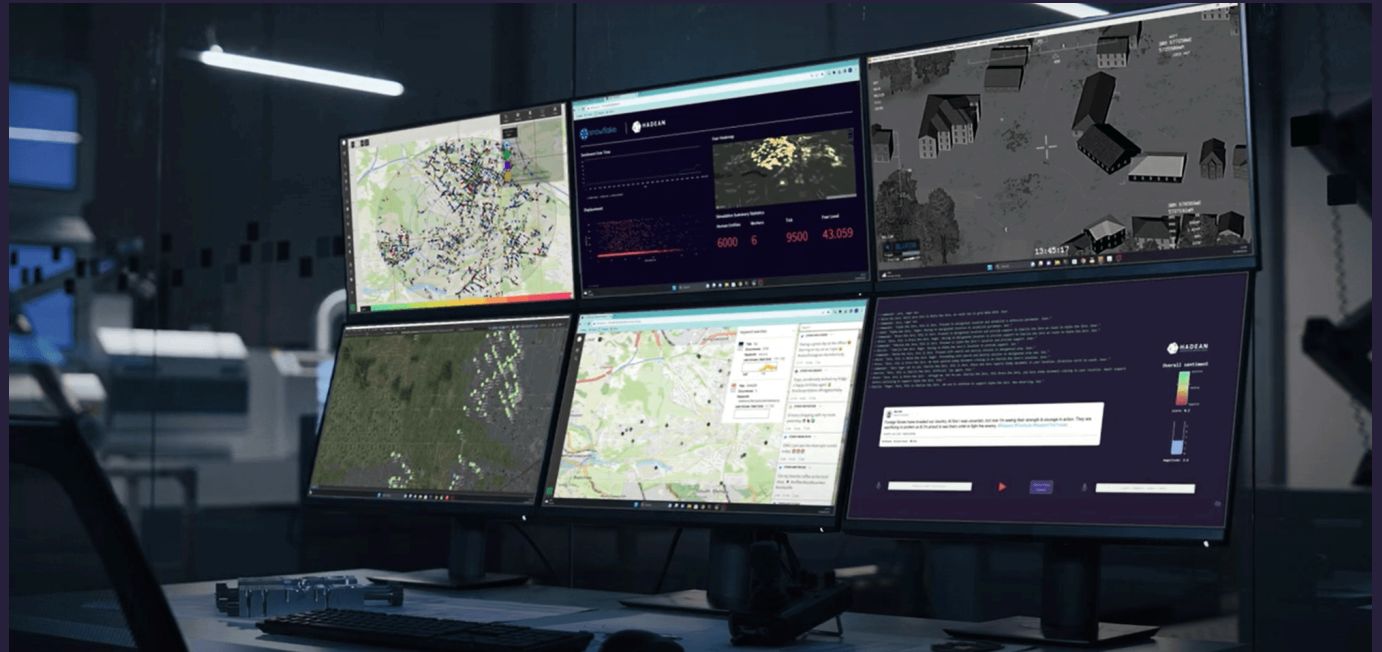
Part 5: What Does the Metaverse-Ready Defence Enterprise of the Future Look Like?



What Does the Metaverse-Ready Defence Enterprise of the Future Look Like?

The Imperative

Current conflict and history tell us that warfare is multi-domain in nature and there is no sign this will stop being the case. The complexity and breadth of the battlespace with more involvement of space and cyber domains, the massive increase of data, and the growing importance and complexity of influencing people's perceptions all point to a multi-domain future. Making the domains work better together, whether they are Cyber and electromagnetic (CEMA), Space, Air, Land, or



Sea is a strategic imperative for many nations and reflecting this, the overarching theme for DSEI 2023 was 'Achieving an Integrated Force'. This multi-domain integration (MDI) means that all aspects of defence work together to achieve a common goal. It goes beyond the military, and requires effective integration of all domains, across defence and industry partners, academia, wider government and allies.

The Challenge

Inevitably, to achieve timely and effective MDI does rely heavily on weapons, platforms and wider information systems to link and be technically interoperable. This is a very significant challenge with different system vendors and many legacy systems, but it also requires effective interoperability and understanding between people. For



individuals and teams, for example between pilots and ground forces, MDI requires mutual understanding and collaborative working so that effects can be brought to bear in a timely and effective fashion. Humans are very adaptable and warfare is inherently unpredictable but for individuals and teams being able to practise and train for a range of scenarios ahead of operations is critical. It is better such training is regularly conducted together before an actual mission, rather than for the first time facing the enemy.

A Fragmented Training Environment?

To train for multi-domain operations requires a similarly integrated training environment, otherwise training may not be representative. And because the nature of operations may not be known in advance, mission preparation requires a rapidly reconfigurable training environment, ideally networked and distributed as travelling may be too time consuming or not even practicable. Creating a sufficiently representative multi-domain training environment at pace is challenging.

The training ecosystem of people, simulators, buildings, computers and so forth from which the training environment is created is diverse and complex with many legacy systems and practices and no single supporting digital infrastructure.

A Defence Digital Platform for Training

If defence is to best prepare its people for multi-domain operations and achieve an “integrated force” it needs to build towards a vision of the future where its training ecosystem too is integrated. Wider (UK) defence is already moving towards a single “Digital Backbone”, cloud computing and valuing data as a strategic asset and its training ecosystem could too. Metaverse technologies and approaches also offer a compelling vision of how training could be more immersive and more accessible and responsive. A military metaverse that exploits the convergence of technologies such as XR, AI, computing, networking and data, and brings the physical and digital worlds together. A trend we are seeing already from



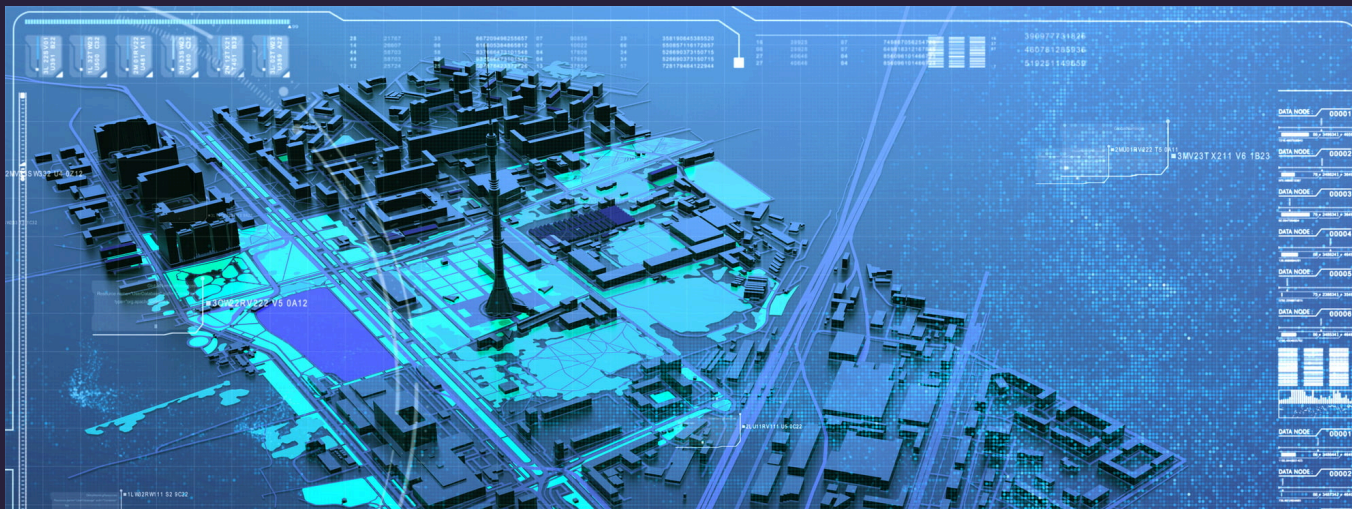
2D, to 3D digital interaction and immersion. As proto-metaverses, gaming already provides such a vision of easy-to-access immersive worlds where other players can be discovered and teamed up with. They also are increasingly served by various multimedia channels beyond the game so that whether it

is text, audio, or video players can communicate in and out of the game and watch from afar. It would seem to be just the kind of digital skills that are of value to defence as operations too are impacted by the multi-domain digital world.

Beyond Training – Integrated Defence?

A persistent network of distributed simulations built on high performance computing and networking and linked to the latest data, such as operational, geographic and equipment digital twins, would ensure that training is representative of the actual world and reach all that can benefit. Such an infrastructure could have value beyond training. Future scenarios could be run and analysed to support research and as future capabilities options are explored and decisions are made it could help to de-risk acquisition. Conducting as much activity as possible in a collaborative digital simulated

world and compressing the acquisition cycle prior to cutting any metal. Letting us see and touch the acquisition cycle. Later on, as capabilities are upgraded, the latest digital twin can automatically update the training simulators and operational systems. It goes beyond military equipment and platforms, however. The military metaverse of persistent distributed networked simulation will bring people together, connecting them in an aligned, coherent, integrated enterprise. It will harness the collective problem-solving abilities of human beings across defence, whether they are research teams, acquisition teams, manufacturing teams, support teams, training teams, or warfighting teams.



The Integrated Force: A Vision for the Future

The DSEI 2023 message for its attendees was that the future of defence lies in agility, technological advancement, and integration, served by a defence enterprise that is agile, adapting and innovating as situations demand. It will be people that make this future happen, and it will also be digital technology. Whether it is called a military metaverse or networked simulation we are seeing that interactive gaming, command and control, and ultimately future operations of information-savvy military forces are converging. At their core is the same information technology, a common digital infrastructure for all defence activities.

Thank you for reading!

Want to learn more?
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