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The Military Metaverse: A New Frontier for Communications and Conflict

by David Burden and Andy Fawkes

The metaverse, defined as a persistent, social, immersive, 3D digital environment, is rapidly emerging as a domain with direct implications for defence. In military terms the metaverse can be broadly thought of as having two major implications. First, as a transformative platform for collaboration and information sharing in support of the full range of military activities from procurement and training to operational command and control, and analysis.

Lessons from the war in Ukraine, including the widespread use of virtual-reality headsets to pilot First Person View (FPV) drones in combat roles, demonstrate how immersive technologies are not merely enablers of support activity but are becoming integral to frontline warfare and could provide an interface for the Digital Targeting Web. The second implication is as a future domain for competition and conflict. There is a long history of both our allies and our adversaries using the metaverse for recruitment and intelligence.

With the rise of deep-fakes and digital twins the metaverse – particularly through public virtual worlds - is presenting new opportunities for grey-zone conflict. But those same public virtual worlds are also creating technologies and platforms which can democratise our use of the metaverse, enabling ground-up innovation and standards based enterprise platforms. For the Royal Corps of Signals, the metaverse offers new opportunities for communication, collaboration and information advantage, while demanding new approaches to doctrine, security, and capability development.

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Introduction

The military metaverse is not a future abstraction, it is an evolving component of the digital ecosystem. Comprising interoperable, immersive digital environments, it offers new means for procurement and planning, command and control (C2), training, mission rehearsal, command, collaboration, and situational awareness. As warfare becomes increasingly digital and data-centric, the Royal Signals' role as enablers of secure, timely communication, electronic warfare (EW) and supporting services becomes ever more vital. The metaverse provides a new layer through which Corps' capabilities can be extended.

In this article we will first establish what we mean by the metaverse and then consider the role of the metaverse as a command and control and operational enabler, and some of the enterprise considerations of the military metaverse will be highlighted. The metaverse will then be examined as a location for warfare itself. Throughout we will consider the potential role of Royal Signals in the development and use of a military metaverse.

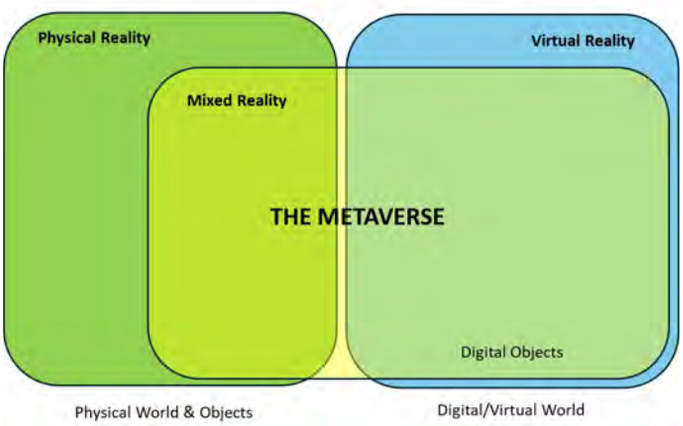


Figure 1: The Scope of the Metaverse.

A Persistent 3D Digital Layer

Our definition of the metaverse is that of one or more interactive, persistent, interconnected, 3D digital spaces, existing in virtual and physical worlds, which may be accessed through a range of technologies including Virtual Reality (VR), Mixed Reality (MR) and possibly Augmented Reality (AR), and which are populated by a large number of users, human and AI, who have agency and can interact for collaboration, work or play (Figure 1). Whilst traditionally simulation systems have been silo'd, the metaverse is about what happens as those systems become increasingly interconnected, democratised, persistent and ubiquitous.

The technology stack of a typical metaverse application is shown in Figure 2.

At the bottom of the stack is a common IT infrastructure of servers and communications links. Above this sits the simulation ecosystem, typically centred around a "game engine" which serves 3D assets and manages the interactions between users and virtual objects. Above that are the interfaces through which the user can access the 3D worlds or applications – a key consideration being that the user interface should be a user choice, not a constraint of the application. The most common interfaces are the 2D computer/tablet screen or 3D head-mounted display (HMD). At the top of the stack is the user and the user experience. This emphasises that the metaverse is about subjective experience,

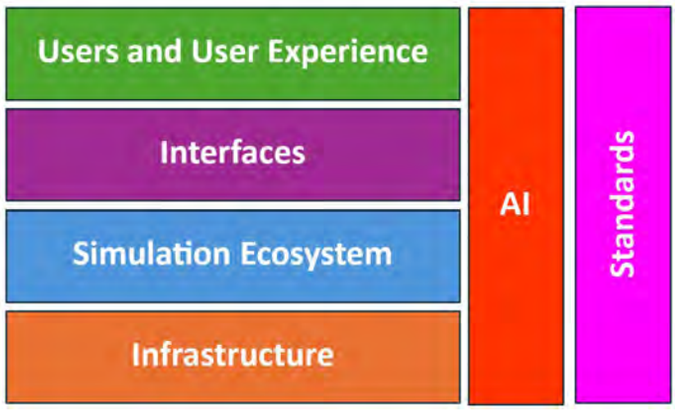


Figure 2: A Technology Stack for the Metaverse.

so every user (typically represented in world as an avatar) may respond differently to the experience created. Alongside are two cross-cutting elements – the increasing use of AI (to help to build the experience, or to control simulated entities) and a Standards, to help avoid vendor lock-in, provide commonality of user-interfaces, enforce security and enable portability between applications. It should be noted that whilst the metaverse could exist as a monolithic application a more likely scenario is that of the multiverse – where multiple smaller microverses, each with a specific focus – are integrated and networked into a larger multiverse – with transition between microverses being no harder than clicking on the link between websites (see Figure 7).

Immersive Communications and Readiness: The Potential of a Military Metaverse

The military metaverse has the potential to redefine how Defence communicates, trains, rehearses, and directs operations. NATO has already produced a Military Metaverse CONOPS 2025 (STO-MP-MSG-197, co-written by one of the authors). The military metaverse builds on the Strategic Defence Review (SDR) 2025's emphasis on the Integrated Force, a Digital Targeting Web, and adaptive training environments by offering a digital platform that goes beyond traditional voice and data networks and 2D information displays. By fusing immersive visualisation, persistent presence, and real-time data into a shared operational space, it could provide the common digital foundation for Defence. Some elements are already in use, while others are emerging or remain longer-term opportunities. But together, they illustrate how immersive technologies could become the backbone of Defence readiness and communications, with the Royal Signals at the forefront.

Immersive Command and Control

One of the most immediate possibilities is the ability for commanders and staff to enter a shared virtual operations centre regardless of their physical location. Early versions of this concept already exist in commercial collaboration platforms and military R&D. Such environments could provide secure, persistent presence, with remote participants represented as avatars, spatial audio replicating the dynamics of a real HQ, and shared access to ISR feeds and electronic warfare overlays. Mixed reality can enable users to maintain local situational awareness but augment the space with digital information and C2 assets and remote avatars. Looking further ahead, AI enabled virtual humans might act as staff "duplicates" when communications are disrupted, or as virtual watchkeepers handling routine functions. Such capabilities could allow dispersed HQs to retain the sense of working together, while remaining resilient to attack.

Figure 3: Demo of a Mixed Reality Urban Wargame - showing the user and their avatar to support remote working Figure 3: Demo of a Mixed Reality Urban Wargame - showing the user and their avatar to support remote working.

Figure 4: VR-TAK's Virtual Tactical Operations Centre.

Secure Collaboration Across Boundaries

Some collaborative immersive tools are already deployed in NATO and partner contexts, but their potential remains far greater. The military metaverse could allow joint, inter-agency, and multinational partners to better share a rich operational picture in secure digital spaces, enabling full-spectrum coalition collaboration inside a persistent shared battlespace. Personnel could interact directly with live data and synchronisation tools, making full use of the 3D nature of the environment to display multiple data layers, and supported by layered identity and access controls. Traditional liaison functions could also be extended into a virtual space, creating through telepresence a "virtual LO" visible to adjacent commands or partners. This could enable a radical rethink of the nature of deployed formation HQs.

Integrated Training and Rehearsal

Immersive training platforms such as Defence Virtual Simulation (DVS) and ICAVS(D) already show how battlecraft and planning can be rehearsed virtually. Near-term developments will expand these into adaptive environments where scenarios can be created through verbal instruction to an AI, evolve in real time, where AI-driven adversaries respond dynamically and believably, and electromagnetic warfare conditions are accurately represented. The future potential is for a virtual continuum where training, rehearsal, and operations blend seamlessly. Persistent immersive spaces could allow units to train and rehearse on the same platforms they later use for operations, providing coherence, realism, and speed of preparation.

Figure 5: By adjusting scaling soldiers can take an objective view of a target, before shrinking back to normal size for the subjective experience of a mission rehearsal.

Persistent Simulation and Operational Context

The potential of persistent digital twins is already evidenced in projects modelling urban environments and smart cities. Defence could maintain "warm start" simulations of key regions, constantly updated with intelligence and environmental data. When required, these environments could be instantly tailored to provide mission-ready digital theatres. In the longer term, persistent simulations may span whole theatres, continuously visualising terrain, infrastructure, RF communications, and EW effects. Such capabilities could support rapid "what-if" iterations, immersive debriefs, and long-term learning.

Augmented Soldier Systems

At the tactical level, the direction of metaversal development is shown by US Army's Integrated Visual Augmentation System (IVAS), fusing maps, night vision, targeting, and mission data into a single display. Even though the initial project has been problematic the follow-on project is already being defined. Similar concepts extend to see-through armoured vehicles. Immersive headsets

such as IVAS can provide each soldier with continuous access to mission data, AI-assistants, and sensor feeds – demonstrating how the metaverse concept scales from strategic HQs down to individual soldiers. However, providing bandwidth at the tactical level, with low latency and high resilience will be a significant professional and corporate challenge, with requirements possibly going beyond what currently planned systems such as Morpheus can provide.

Figure 6: The IVAS Capability Set 4 Headset, March 2021.

Tactical Immersion: Drones and Headsets

Ukraine's use of headset-controlled drones introduces a critical shift; immersive interfaces enabled by metaversal technology are now involved in direct delivery of combat effects, not just as support systems. Operators are placed within the virtual perspective of the drone, enabling faster reactions and greater precision. The support of (or at least deconfliction of) the data links required for such systems potentially adds further to the demands on the Corps.

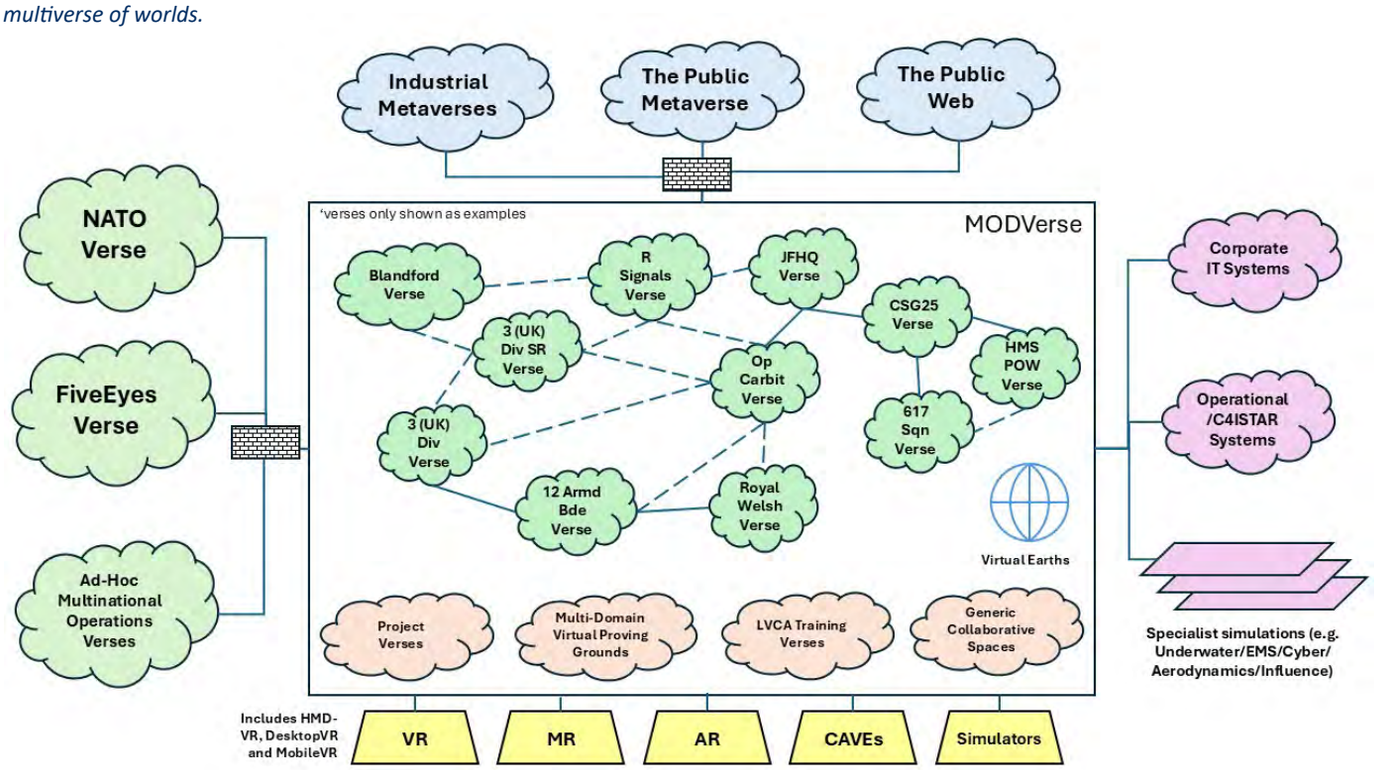
The Digital Targeting Web: The Military Metaverse Interface

SDR 2025's Digital Targeting Web (DTW) will only succeed if its vast flows of data from sensors, deciders, and effectors can be translated into a form that operators and commanders can understand and act upon at speed. The military metaverse has the potential to serve as this interface layer. By visualising sensor feeds, target nominations, strike options and even EW, cyber and influence information within a shared immersive environment, it could enable faster, more inclusive decision-making and testing of "what-if" scenarios before execution. Digital twins of platforms, weapons, and environments would allow targeting chains to be rehearsed continuously, while AI agents embedded in the metaverse can recommend prioritisation and pairing of sensors and effectors. In this way, the metaverse could provide the human–machine interface that makes the Digital Targeting Web usable, trusted, and decisive in contested multi-domain operations.

A Shared Digital Continuum

Pulling these threads together, the military metaverse can be viewed as the next evolution of the Command, Control, Communication, Intelligence, Surveillance and Reconnaissance (C3ISR) function. Its near-future trajectory is toward unifying command, training, soldier systems, and tactical execution in a shared digital continuum. The long-term potential is a persistent platform where readiness, rehearsal, and operations all take place within the same interconnected interactive environment, creating new levels of coherence and co-ordination across Defence (Figure 7). The Corps is well placed to help lead this transformation – not only by providing the underpinning communications and field computing capability, but in the longer term potentially becoming the custodians of a persistent military metaverse that unites communications, training, and operations. This is both a challenge and an opportunity to shape the environment in which UK Defence will think, learn, and fight in the decades ahead.

Figure 7: A Possible UK Military Metaverse - implemented as a multiverse of worlds.



Enterprise Considerations

Turning the military metaverse into a Defence-wide capability is as much an enterprise challenge as a technical one. The potential is clear but so is the risk of fragmented pilots that never join or scale. Some considerations stand out as helpful starting points: standards and interoperability, architecture and data, and governance, people, and process.

Standards, Interoperability, and Assurance

A useful first step is the creation of a defence military standards framework, aligned with NATO and relevant civil bodies. Such a framework as suggested in Figure 5 would help ensure portability of models and 3D content, federation of simulations, and secure access across domains and partners. Rather than reinventing, Defence might draw on existing standards such as HLA/DIS for simulation, OpenXR for XR runtimes and OpenUSD and glTF for 3D assets. Security and assurance also needs to be embedded, and conformance tiers and reference test suites could make it easier to trust and reuse models while still allowing innovation. Attention to human factors such as cognitive load, trust in AI, and ethical targeting would also be important.

Architecture and Data

The metaverse is best seen as part of a digital backbone rather than a standalone system. A hybrid cloud-and-edge design seems the most practical: cloud for aggregation, control and distribution, edge for low-latency performance. Data should be treated as a strategic asset, catalogued with provenance and metadata so it can be found and reused across Defence. The principles of "Create Once, Reach All" and "Acquire Once, Reach All" might guide investment, making sure digital twins and immersive content are available to multiple programmes.

Governance, People, and Process

Enterprise coherence might be supported by governance that is firm enough to set direction but light enough to allow experimentation. A central team could manage standards, accreditation, and shared services such as identity or catalogues, while units and agencies focus on delivery through mission-aligned teams. Agility will also be key. The commercial sector is advancing immersive and metaverse technologies rapidly, and defence risks falling behind unless procurement and development cycles become more responsive. Open systems architecture, modular design, and experimentation units embedded within units could shorten the gap between innovation and operational use.

At the same time, people and processes underpin success. A digitally fluent workforce is needed at every level: commanders with simulation literacy, specialists with model and AI skills, and Royal Signals personnel with expertise in spectrum-aware networking and immersive distribution. Embedding simulation throughout the capability lifecycle, from concept to post-operation review, would help models evolve with the force.

Resilient Enterprise Communications

The Corps is well placed to support this evolution, particularly in operating and protecting the immersive backbone. Providing resilient transport, edge access, and trusted identity services would be central contributions. By helping to run reference environments and encourage conformance, the Royal Signals could ensure that new capabilities arrive enterprise-ready.

The Metaverse as a Battlespace

The metaverse exists within the wider communications environment – and as such has vulnerabilities as well as capabilities.

Figure 8: The Metaverse as a Battlespace Stack.

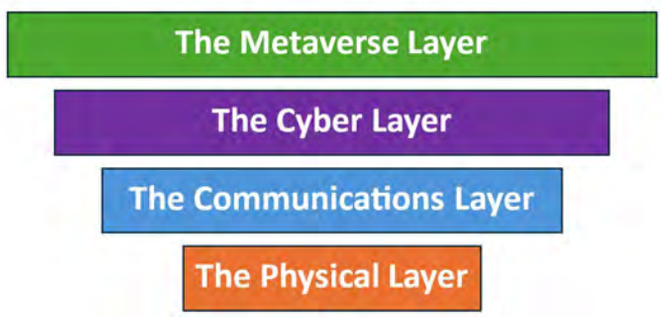


Table 1: Existing Standards which could inform a Military Metaverse.

Theme	Sub-Themes	Example Standards
3D Content	Objects, Materials, Rendering	glTF, OpenUSD, OpenPBR, MaterialX, OpenFlight, Digital Twins
3D Worlds	Geospatial, Human-Built, Biomes	CDB, CityGML, 3D Tiles, BIM, ISO 19107, OGC API - 3D GeoVolumes
Sim-Sim Interoperability	Models, Comms	HLA, DIS, DSEEP, SpaceFOM, TENA
Sim-Others Interoperability	Software, Hardware	Cyber DEM, C2-SIM, CIGI, UCATT, Link 11/16, WebLVC, OpenXR, WebXR
Networking	Performance, Wireless, Security	5G/6G, WiFi 7, ISO/IEC 27033
User Experience	Safety, UX, Performance Tracking	ISO 45001, ISO/IEC 5927:2024, ISO 25010, xAPI, Caliper Analytics
Governance	Security, VV&A, Privacy, Ethics	ISO/IEC 27001, IEEE 1012, ISO/IEC 27701, GDPR, IEEE 7000

Within the stack shown in Figure 3 exists:

• The physical layer – includes the data cables and radio masts, server farms and HMDs which enable the metaverse, but may be vulnerable to direct, physical attack;

• he communications layer – comprises the bit-streams passing over radio and cable links to connect users to servers, and servers to other servers – but which, especially in the radio case, are vulnerable to EW exploitation and attack;

• The cyber layer – where attacks are made in code against servers, applications and user devices; and

• The metaverse layer – where the metaverse is manifest to users as a collaborative, interactive 3D environment (and as code and data representing such an environment) – but is open to attack through the features of the platform.

By far the simplest way to attack any metaverse application would be through conventional physical and electronic attack against the physical and communications layers. However, this becomes problematic (as Starlink has shown) where there is also civilian use and where, increasingly, both sides are using (essentially) consumer platforms, and so such attacks can risk one's own operations. It may also be that there is more to be gained by exploiting a platform rather than denying it. This also suggests that brute-force cyber-attacks to bring down platforms might not be the best strategy, but more surreptitious attacks such as covertly monitoring (and exfiltrating) metaverse activity or enabling disinformation campaigns might be better approaches. Indeed, both sides may have to engage with each other using the tools of the metaverse itself. This may not be duelling warlocks, but autonomous scripted sensors and DDOS style attacks from artificial life forms have long been a feature of metaversal spaces.

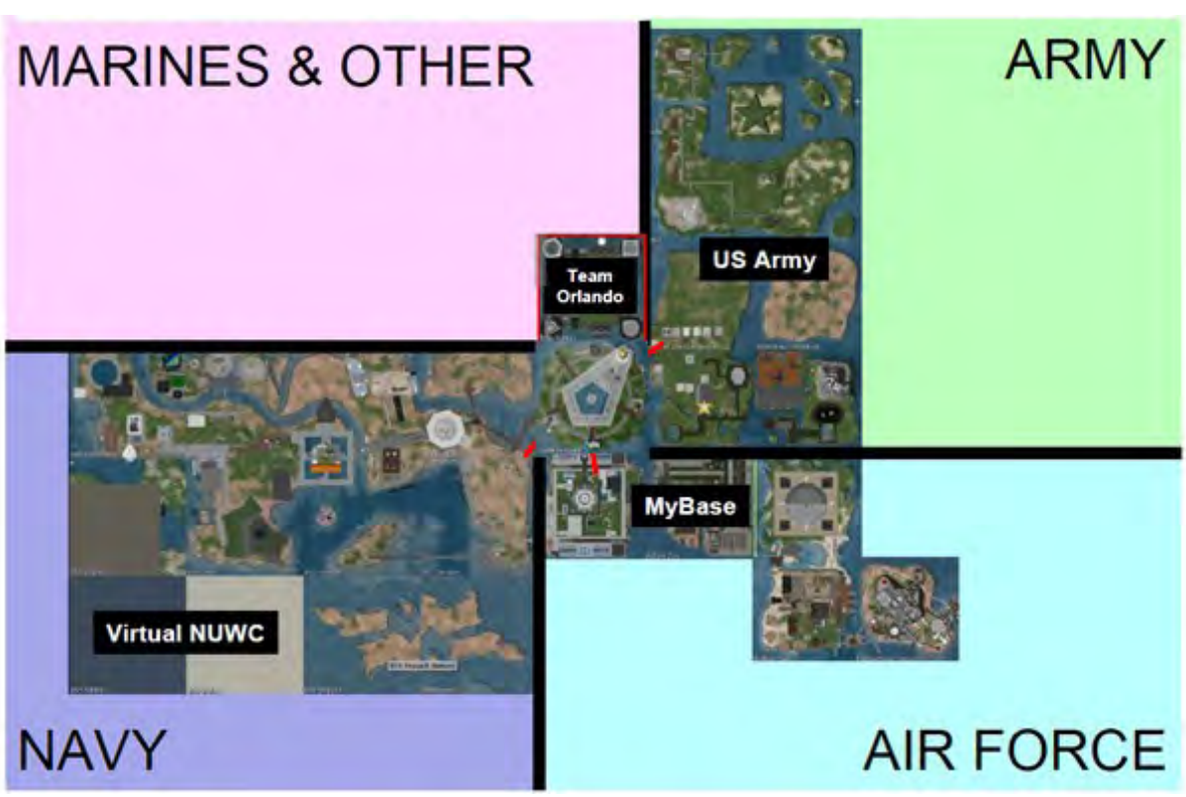
Social Virtual Worlds

If all this seems a bit far-fetched then it is useful to look at the use of the early social virtual worlds (SVW), such as Second Life. Amongst the Snowdon Papers was a report by the National Security Agency (NSA) into the use of virtual worlds. Not only did this identify their potential and actual use by hostile actors (both state and non-state) but it also considered ways in which such use could be monitored and combatted. Hostile uses included virtual recces, training, mission rehearsal, recruitment and communications. If our adversaries were using Second Life and World of Warcraft in the early 2000s, who's not to say that they are not now using Roblox, Minecraft and Fortnite?

Another interesting aspect of SVWs was that they were being actively used by western militaries and security agencies to explore the affordances of VR and the metaverse. The US military had its own part of Second Life, known as MilLands, which was used for a combination of research, recruitment, training and public outreach. This creativity and experimentation was possible due to the low barrier to entry of SVWs – almost anyone could install the software and teach themselves how to create things within a persistent, shared virtual environment. This was a democratised, bottom-up approach to the metaverse. The initiatives gave the military the skills and experience in virtual worlds to better define the next generation of simulation and virtual world projects. However, as a ground-up initiative it struggled to expand as it came up against the more corporate approach to defence IT, and the inability of most of the then current defence IT infrastructure to run 3D applications. It should be noted that though Second Life, and its open-source locally run OpenSim counterpart, are still both going strong and offer any array of features unmatched by most modern "metaverse" platforms.

One other consideration of SVWs is that there seems to be far more interest in them in eastern cultures – typified by worlds such as Fantasy Westward Journey, Phantasy Star Online 2 and

Figure 9: US Military MiLands area in Second Life.



Axie Infinity. This may suggest that even if western militaries find the idea of the metaverse "odd" and are tardy in embracing it the same may not be true for the PLA and its officers and soldiers.

A War in the Metaverse

Perhaps one of the most intriguing futures is that of a war in the Metaverse itself. In future campaigns, virtual environments may be central to strategic messaging, deception, or counter-influence operations. As use of the metaverse increases, then, as the NSA report describes, we may see more protests, recruitment and organised griefing (virtual vandalism) happening in the metaverse. Whilst fictitious environments will be left to platform owners to police, national spaces (either official or unofficial) may need their own community police forces to ensure that they do not become unwilling venues for disinformation and grey-zone conflict. This could represent a natural extension of what is happening with deep fakes and video game footage.

Many locations have invested in virtual digital twin projects (e.g. Dubai and Shanghai), and as such twins become ever more realistic it will become easier to create videos of fake news and even fake wars. Indeed, we may even reach the point where virtual militias are called up to defend a virtual homeland – just as many virtual worlds have seen battles, virtual and physical, between different factions to defend their territory (e.g. in Second Life and Eve-OnLine). It may become almost as important for a country to defend its virtual presence for prestige and informational purposes as it is to protect its physical borders.

EW, Cyber and the Metaverse?

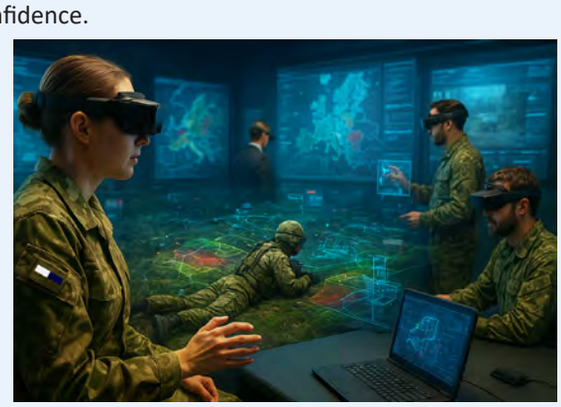
For Royal Signals there are a range of opportunities that this evolution of war in the metaverse opens up. At the communications and cyber layer activities are a natural extension of existing work in EW and cyber operations. But helping to understand, forecast and react to a war of influence or direct action in the metaverse itself is a new undertaking for the whole of the defence, security and resilience community. Just as the Corps has worked alongside the Intelligence Corps and Other Government Departments in current environments, the Corps unique combination of communications, computing and military expertise – and the reduced relevance of other Arms and Services within a virtual space – could make it the ideal military lead for such activities.

Interlude: A Glimpse into the Future Battlespace
Operation FARSIGHT – Baltic Forward, 2031

The Corps Commander and her staff are physically dispersed across Europe, yet co-located within the same immersive command space, a secure, virtual forward HQ rendered through head-mounted displays. Inside this shared operational environment, real-time data from the battlespace is streamed as interactive overlays: terrain visualisation, logistics flows, EW signatures, social media feeds and threat indicators all dynamically updating in response to unfolding events.

Close by the front line, a Light Electronic Warfare Team lies prone on a wooded ridge, observing the digital traces of enemy drone operations. Their operational picture is immersive and multi-modal: jamming vectors, signal origin triangulation, and RF propagation zones appear as colour-coded, 3D volumes surrounding them. But they are not out on their own.

With a hand gesture, the team leader summons immediate specialist support "teleporting" an EW spectrum specialist from Blandford directly into their shared virtual workspace. Though physically located 1000 miles away, the specialist appears beside them in the same battlespace, reviews the RF data, and advises a new interference pattern to disrupt the enemy's autonomous drone command net. The effect is modelled instantly, trialled virtually, then executed with confidence.



Elsewhere, a Royal Artillery drone detachment operates a swarm of loitering munitions via FPV headsets. As enemy movement is detected along a forest track, the controlling NCO requests tactical guidance. In response, a fire support officer from Brigade HQ materialises into the virtual view, a digital presence able to mark targets, authorise action, and provide reassurance. No delay. No ambiguity. Just informed, immediate direction.

In parallel, a continuously maintained simulation of an urban objective - kept current with real-time satellite and HUMINT updates, is reconfigured to reflect recent bomb damage and enemy movement. This "warm start" digital twin, modelled years earlier as part of persistent metaverse simulation efforts, enables commanders to enter the mission with a full operational picture already in place. Combat teams rehearse the updated entry plan using live data in a shared virtual workspace, cutting planning time and enhancing confidence in execution.

Back at the Corps virtual HQ, liaison officers from allied NATO partners are virtually present. Their avatars, some AI controlled, some human managed, stand alongside British planners, aided by real-time translation and cross-domain security overlays. A PSYOPS specialist, monitoring live feeds from social platforms in a 3D information space, joins the virtual environment to shape an influence campaign, designed, approved, and disseminated all within the same platform.

Throughout the operation, the metaverse is not just a mirror of the battlefield, it is part of the battlefield. It enables soldiers to receive technical, command, and psychological support from across the force, with remote personnel "arriving" into forward units' immersive spaces at the point of need. These real-time, virtual co-presences are as critical as resupply or fire support.

Conclusion: A Technological Inflection Point

Whilst Defence has for long been at the forefront of the development of metaversal technologies for simulation and modelling. However, we are now seeing a shift in leadership from defence to consumer technology companies, and the emergence of powerful metaversal COTS platforms for a wide variety of applications. The big challenge for the coming decade is not so much in the technologies themselves but in how we harness them within the Defence enterprise – deploying them in a non-silo'd integrated and secure fashion, enabled through activities such as a defence-wide metaverse framework and (open) standards. Innovation in the metaverse should also happen from the ground up, encouraging local experimentation.

The metaverse, and the improvements in AI also allow us to reconsider how the command and control of field operations are run, and what the impact on formation and unit headquarters could be. We also need to be aware of what is happening in the public metaverse space, not just in terms of technologies and approaches that the military can adopt, but also in terms of how our adversaries may be using these technologies to enhance their own militaries, and how they may now, and in the future, be using these spaces against us.

The potential emergence of the metaverse as an operational domain provides a new opportunity for Royal Signals to extend its traditional mission into new digital spaces. As seen in Ukraine, immersive control systems, remotely operated and autonomous platforms, and virtual communications are already shaping the battlefield. Royal Signals' expertise in networks, cyber, EW and information operations positions the Corps to lead the development, integration, and protection of these capabilities. The challenge now is to turn conceptual advantage into operational effect - before our adversaries do.

If you want to explore the idea of a military metaverse in more detail then the authors have recently written "The Military Metaverse", published by Routledge. In addition, you can also visit a 3D microworld that the authors have created using metaverse technologies and which is available directly in a web browser (although not over MODNet). Just point your browser to: https://framevr.io/militarymetaverse

Figure 10: The Military Metaverse micro-world.