HADEAN
BRIDGING PHYSICAL AND VIRTUAL WORLDS

Synthetic Operating Environments

The critical infrastructure
required by Digital Twins ↘

Redefining Operational Intelligence

Synthetic environments are well known in the defence industry primarily for providing **Live, Virtual & Constructive (LVC) training capabilities.**

Recent rapid developments in connectivity, scalability and AI are pushing synthetic environments into the operating domain. Leaders within defence and across industries have started to recognise and exploit the enhanced situational understanding delivered by a common operating picture infused with spatial intelligence.

These capabilities have long been the promise of digital twins. A promise that has failed to materialise over the last decade due to lack of data access and sufficient computing power required to contextualise and correlate large amounts of real-time data. A challenge that has often relied upon (often scarce) talent to model out the complexities that give digital twins predictive capabilities with persistent and scalable value.

Synthetic environments used in an operating context are unblocking these challenges through their unique capabilities and creating a new paradigm, classified in this ebook as the synthetic operating environment (SOE).

SOEs featuring the latest spatial, AI and data technology, are a modern necessity for managing high fidelity, large-scale supply chains. Their ability to connect and scale intelligence on individual assets, people and products up to strategic levels including economic markets, populations and value-chain networks is unparalleled. These SOEs offer both situational awareness (a clear view of what is happening right now) and a digital backbone to enhance organisation-wide collaboration, decision-making, efficiency, and innovation.

This ebook explores the fundamental connection between synthetic operating environments and how they present an infrastructure solution for large-scale digital twins. It highlights the critical roles of scale, interoperability, connectivity, security, and AI in creating a future proof ecosystem and strategic advantage in the modern world.

1

Scale and Interoperability: Expanding Digital Ecosystems

At the core of both synthetic environments and a digital twin infrastructure is scale. Managing large strategic networks – such as complex supply chains or value chains – requires the ability to model, simulate and process real-time data for individual entities and their complex interactions across entire interconnected systems.

Digital twins are virtual representations of real-world entities including machinery, people, products, layered up to entire facilities, each with their own operational characteristics. They also represent the behaviour, interaction, contestation and process logic that describes the systems within which these entities exist. The challenge lies in scaling our ability to execute models with hundreds, thousands, or sometimes millions of entities which function within these larger systems with our available computational resources. Fortunately, modern synthetic environments feature native capabilities to dynamically resource digital twins, providing maximum fidelity and avoiding the need for additional low resolution modelling.

The power of interoperability comes into play when these entities interact. For large systems to function, digital twins need to interact with other digital twins, regardless of the platform they are hosted within. An SOE features connectivity capabilities allowing standardised protocols and APIs to enable this kind of integration and delivering smooth interactions across a multitude of systems. Without this interoperability, digital twin ecosystems become fragmented and their effectiveness as real-time decision-making tools is rapidly diminished.

Let's Look at Global Supply Chains

A global supply chain for one of Hadean's customers (a major defence contractor) includes factories, warehouses, transportation routes, supplier resources and customer demands, all operating in a highly synchronised manner. The SOE is capable of hosting digital twins that process, combine and contextualise many data sources in order to represent the real-world logistics operations that can identify the location of individual components and the risk associated with their downstream consumption in the supply chain.

Typically, this data would be siloed in business systems (ERP, WMS, TMS, CRM and often hundreds of spreadsheets). Real-time information would be incomplete and predictive (simulated) data would often be modelled at aggregate or abstract levels losing correlation and fidelity. By removing this limitation, an SOE allows for testing changes in one part of the chain and understanding how those changes ripple through the entire system.

The result is real-time visibility of the supply chain, predicted risk from extreme weather, geopolitical incidents or other events that may disrupt asset performance or upstream supply issues. The outcome is higher resilience and more reliable end customer fulfilment.

2 Connectivity and Security: Real-Time Insights at Your Fingertips

Connectivity is the lifeblood of digital twin ecosystems, especially when managing strategic networks or supply chains. Real-time data from business systems, IoT sensors, 3rd party intelligence (e.g. weather, social media and satellites), and connected devices flows continuously into (and out of) the synthetic environment, enabling digital twins to accurately represent the real-world.

This constant stream of information provides users with unsurpassed situational understanding by having to-the-second updates of their operations. They can monitor everything from production metrics in a factory to the location and status of goods in transit.

The more connected a system is, the more vulnerable it becomes to security threats. Cybersecurity is a critical consideration for both synthetic environments and digital twins, especially when handling sensitive data across supply chains that span borders and industries. Ensuring that data is encrypted, systems are insulated with firewalls, and connected devices and users governed by access protocols and policies is crucial in maintaining operational integrity and avoiding disruptions from cyberattacks.

A very real and present cyberwarfare threat

A cyber attack such as altering the over-the-air data streams on critical assets could easily cripple a manufacturing process and cascading operation. A robust digital twin infrastructure must be designed with advanced security features and protocols that can protect, detect and trigger automated responses that remove threats before they affect operations.

3 AI as the Interface: From Data to Insights

One of the most transformative aspects of modern SOEs is the integration of artificial intelligence (AI). AI serves as an interface through which human operators can more easily engage with complex systems, translating the immense flow of data into actionable insights. By leveraging generative AI, machine learning algorithms and advanced analytics, patterns can be identified, potential issues predicted and potential solutions offered.

An AI agent can be deployed within an SOE and tasked with practical actions. An example would be to monitor and send alerts to operators or management regarding upcoming supply chain disruptions due to weather conditions or fluctuating market demands. The AI agent can also recommend alternative or optimal routes for shipping, predict maintenance needs for manufacturing equipment, or even demonstrate through a simulation how a change in one part of the supply chain could positively impact the rest of the network.

This ability to simulate multiple scenarios using AI allows businesses to test improvements and develop mitigation strategies before committing real-world action and resources. For example, we have a recently developed orbat generation capability integrated within our systems where an AI allows you to accelerate asset deployment with flexible and accurate configurations, enabling you to focus on strategic objectives rather than technical details. This capability has been pivotal in supporting NATO's multi-domain operations, where complex force structures and joint mission planning require dynamic, adaptive responses. By doing so, leaders can create feedback based planning loops in which they can avoid the daily firefight and instead focus on continuously refining their operations, strategically reducing downtime, improving resource allocation, and enhancing overall efficiency.

Reach out **here** to find out more about our training environment with NATO.
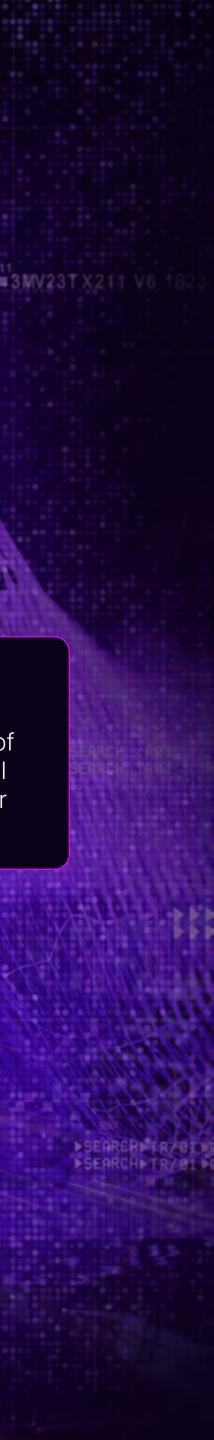
4 Building a Digital Backbone for the Future

Beyond operational improvements, an SOE provides a digital twin infrastructure backbone that supports the adoption of new technologies. As businesses and government organisations evolve, they must integrate new systems, technologies, and innovations into their existing frameworks without disrupting operations. Digital twins offer a flexible and scalable platform where new tools – such as IoT devices, 5G networks, or advanced automation (robotics and autonomous vehicles) – can be layered into existing investments.

This digital backbone is also a foundation for future AI capabilities. As artificial intelligence continues to advance, particularly in fields like natural language processing, autonomous decision-making, and AI agency, businesses need infrastructures that are ready to handle the scalable training, spatial intelligence and real-world connectivity that AI will demand. By building robust digital twins within synthetic environments today, organisations are preparing themselves to take advantage of the next wave of AI-driven innovations.

For example, new innovations in training environments enable AI to simulate complex drone swarms, refining autonomous decision-making algorithms using mission-specific data. By using these environments to train AI-driven drones to adapt in real time, organisations can ensure their future operations benefit from seamless coordination between human oversight and machine intelligence.

Why it Matters

Without the digital backbone of synthetic environments, digital twins would struggle to deliver real-time, actionable insights.

5 Synthetic Operating Environments: The Key to Unlocking Digital Twins

In conclusion, synthetic environments are the infrastructure that digital twins need to manage scale, interoperability, connectivity, security, and AI integration. They are the solution for managing large networks and supply chains and enabling users to gain valuable insights into their operations.

Situational awareness is just the beginning – by simulating complex real-world scenarios, testing improvements in risk free virtual sandboxes, and developing contingency playbooks, organisations can optimise and improve proactive decision-making.

More importantly, these digital infrastructures lay the groundwork for adoption of rapidly evolving future technologies, ensuring organisations remain agile and resilient in the face of an increasingly volatile global environment.

The future of digital twins lies in synthetic operating environments – creating not only a mirror of the real world but a powerful tool for shaping it.

Hadean provides the synthetic environments that power the next generation of digital twins, enabling you to simulate real-world scenarios, optimise decision-making, and integrate AI into your operations. Visit our **website** to find out how SOEs can help transform your digital infrastructure and keep you ahead of the game.

Hadean SOE Groundwork

Case Study

BAE SYSTEMS

Project OdySSEy – a single synthetic environment for multi-domain training and wargaming, brought together by a consortium of expert SMEs in data analytics, AR and VR.

The capability focuses on developing a large-scale synthetic training environment designed to support comprehensive multi-domain military exercises. It integrates high-fidelity artificial intelligence to simulate complex patterns of life, creating a realistic and immersive training platform for forces operating in air, land, sea, space, and cyber domains.

Hadean's Role

Framework is built to facilitate seamless training exercises across multiple domains for a cohesive and integrated training experience that mirrors real-world operations

More affordable and more frequent and diverse exercises without the logistical and financial constraints of live training

The use of advanced AI and high-quality simulations ensures that the training scenarios are as close to real-life as possible

Case Study

[dstl] The Science Inside | **Ministry of Defence**

Hadean has been awarded competitive funding by the **Defence and Security Accelerator (DASA)**, in the form of a **Defence Science and Technology Laboratory (Dstl)** contract, to research and develop a representative pattern of life simulation at scale and populate the empty digital worlds of military training.

Hadean's AI-powered spatial computing provides a scalable Pattern of Life simulation for dynamic human terrains, integrating with large-scale SSEs and LVC training for enhanced multi-domain exercises, situational awareness, and decision support.

Hadean's Role

Dynamic A3E Entities Simulation: Adapting to cues, stressors, and frictions across human and information domains.

Scalable Simulated Populations: Adjusting the number of AI civilians in simulations to meet diverse training needs.

Real-Time Social Media Sentiment Tracking: LLM-generated social media feeds to reflect population sentiment, tracking civilian responses to events in real-time.

Immediate After-Action AI Analysis: AI analysis of events for immediate after-action insights.

About Hadean

Hadean is a UK-based company that uses AI-powered spatial computing to connect physical and virtual worlds.

Hadean's spatial intelligence technology delivers massive scale synthetic environments to help governments and businesses plan, train, and make faster, better decisions.

The Hadean Platform

The Hadean platform provides out-of-the-box simulation augmentations and orchestration capabilities that are easy to develop, deploy and integrate with any system; from legacy simulators through to cutting-edge AI and LLM (Gen AI).

Visit our website for more information at hadean.com