



HADEAN



Synthetic Training and Decision Support
FOR FUTURE WARFARE

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Executive Summary

This eBook explores the rapidly changing world of defence and the significance of distributed simulations in synthetic training and decision making. With new threats on the rise and the landscape of battle changing, modern militaries require digitalisation to become greater prepared. However, cloud-native solutions can achieve the scale and complexity of multi-domain operations that occur in one common operating picture. Accessible at the point of need with situational awareness and decision support, these simulations offer the strongest digital backbone that is required for militaries in 2021 and beyond.



New Threats and the Future of Warfare

“Traditional warfare has changed. The threats are no longer only conventional. No longer only overt. Our adversaries are striking from the shadows. They are pursuing new tactics to divide and destabilise. Exploiting new technologies to exacerbate the uncertainties of an uncertain world, and undermine our way of life.”

Ben Wallace, UK Defence Secretary

Change is an inevitability. And nowhere is this truism felt more keenly than in the world of defence, where a constant technological race against a backdrop of shifting political tension is leading to a spike in expenditure and igniting a rapid period of digitalisation. The main drivers of this transformation are:

- The rise of new military powers and tensions
- The adoption of commercial technologies driving innovation in training and operations
- The need for globally coordinated responses to international threats
- The increasing complexity of battlespaces

Despite the economic impact of Covid-19, global defence spending is at its highest level for over a decade, and is continuing to rise across Europe, North America and Asia as governments invest in best-in class technologies to safeguard national security. The emergence of new technologies is drastically changing the landscape of modern warfare.

The convergence of this technology is allowing for the creation of highly realistic synthetic environments. As battlespaces become ever more complex these simulations must grow accordingly, recreating the world with millions of entities and variables.

New platforms provide a holistic service, where ‘entire picture’ simulations can be accessed from different locations and viewed in different ways. Virtual and augmented reality plays a key role in this as their supporting technologies become more advanced. Providing multi-echelon viewpoints, from the soldiers on the ground up to the commanding base, will allow training and real missions to be carried out with more clarity and control.

Game Engines

The latest generation of gaming engines provide high-fidelity and realistic simulations of any conceivable operational scenario

Distributed Cloud Platforms

Distributed networks provide powerful single coherent systems to improve decision-making and operational effectiveness

VR/AR

Virtual and augmented reality provide a level of immersiveness in training, bringing it to the point of need.

Artificial Intelligence

AI behaviour is becoming ever more realistic and representative of real life scenarios, playing a key role in informing our decisions



Digitalisation in Defence

Adopting and scaling digital technologies is key to victory in air, land, sea and space – and now cyberspace. The UK's Ministry of Defence is making a concerted effort to form what it terms a 'digital backbone', which has been at the heart of an overhaul of the UK's defence strategy. The division set up to lead this change, Defense Digital, has the key target of forming a common, secure platform that connects every division and relevant party in a way that will greatly enhance decision making.



Defence organisations everywhere are recognising the need for investment in order to counter new technological threats. The Stockholm International Peace Research Institute (SIPRI), recently recorded the largest annual increase in global military expenditure in a decade, reaching \$1,981 billion in 2020.

SIPRI described that this huge increase has primarily been driven by the heightened interest in new technologies, as organisations seek to digitalise their services.

Outside of NATO the need for digitalisation is already afoot - founded in 2015 China's 'Strategic Support Force' was set up to cover space, cyber and general electronic warfare. As American analysts John Costello and Joe McReynolds put it, "the SSF's structure is first and foremost intended to create synergies between disparate information warfare capabilities in order to execute specific types of strategic missions... The PLA views cyber, electronic, and psychological warfare as interconnected subcomponents of information warfare writ large."

Overhauls in defence infrastructure are of course not done easily, and there is increasing concern that NATO is beginning to lag behind. According to a recent report published by the NATO Cooperative Cyber Defence Centre of Excellence, currently NATO cyber defence policy is not as up to date compared to a number of other nations such as China and Russia. It described that "NATO will need to bridge the gap between the national cyber operations strategies of various Allies and its own policy on cyber defence. Recognising cyberspace as a domain of warfare would be an important step in the right direction. This will impel the Allies to define not only terms and definitions but also to establish common ambitions, procedures and doctrine."



CROSS DOMAIN TRANSFORMATION



Land

Information gathered at the ground level, such as sensing and mapping enemy movement contributes to a common operational picture, providing strategic insight and more informed decision making. Moreover, utilising new devices, including wearable technology, and streamlining communication from the ground provides a more effective and data driven approach to combat. Moving to this idea of 'soldiers as sensors' will also significantly change training procedures. Training scenarios will have to integrate and include usage of the various new technologies, as well as provide the common picture that multi-domain operations involve. Soldiers are no longer training for simply physical encounters, but also for cyber encounters and the use of remotely controlled equipment.



Sea

Greater sophistication of sensor technology is spearheaded by the emergence of unmanned surface vessels (USVs). These autonomous vehicles represent a valuable opportunity in terms of reducing risk in activities such as minesweeping. USVs also circumnavigate the high labour cost associated with surveying and mapping the ocean, which is key to creating large and accurate synthetic training environments.



Air

The Air Force is often considered pioneering in its use of simulation technologies, thanks to its role in training, recruitment and more recently with meeting sustainability objectives. Training without the use of actual aircrafts eliminates the risk to machinery and personnel, as well as greatly reducing expenditure. In recent years simulations has played a huge role in allowing students to progress through training courses, by allowing for modular training rather than simply fixed hours. This helps graduate students faster and provides flexibility in helping them to meet their goals. Moreover, organisations such as the RAF are under pressure to meet sustainability goals and synthetic training can help reduce carbon footprint by pulling planes out of the sky and into the classroom.



Space

In 2019, the US Space Force gained its independence as one of key eight U.S uniformed services. They join a number of other nations such as France, Russia, Japan and China in forming space divisions in their militaries. It undoubtedly comes at such a relevant time for space exploration as well: with SpaceX continuing their push for colonising Mars, NASA's Artemis program that intends to put people on the Moon once again and of course the latest hugely successful Mars rover missions from both the NASA's 'Perseverance' and China's 'Zhurong'. While on the one hand space conflict might seem academic, the fierce competition accelerated technological innovation during the first space race and recent developments suggest that it is set to play a key role in intelligence, surveillance and reconnaissance.





Cyber

Information warfare poses a constant threat to national security. To put the scale of this new sphere into perspective, back in 2012 IBM concluded that over 90% of the information recorded in the world had been made in just the last two years. Defence organisations must find a way to incorporate this interpreted data within the military domains, where it can inform and optimise the planning and procedure of missions. Even this domain is being 'digitalised' or at least simulated. But rather than simulating, for instance, citizen behaviour we are simulation computers, networks, datacentres and so on. Benefits range from risk analysis without infecting computers with real malware, through to actually modifying messages to enemy units.



The background of the slide is a dark, monochromatic image of soldiers in a desert environment. The soldiers are wearing full combat gear, including helmets, vests, and carrying rifles. They are in various positions, some crouching and others standing, suggesting a tactical movement or engagement. The overall tone is serious and military-oriented.

Representing Modern Battlefields

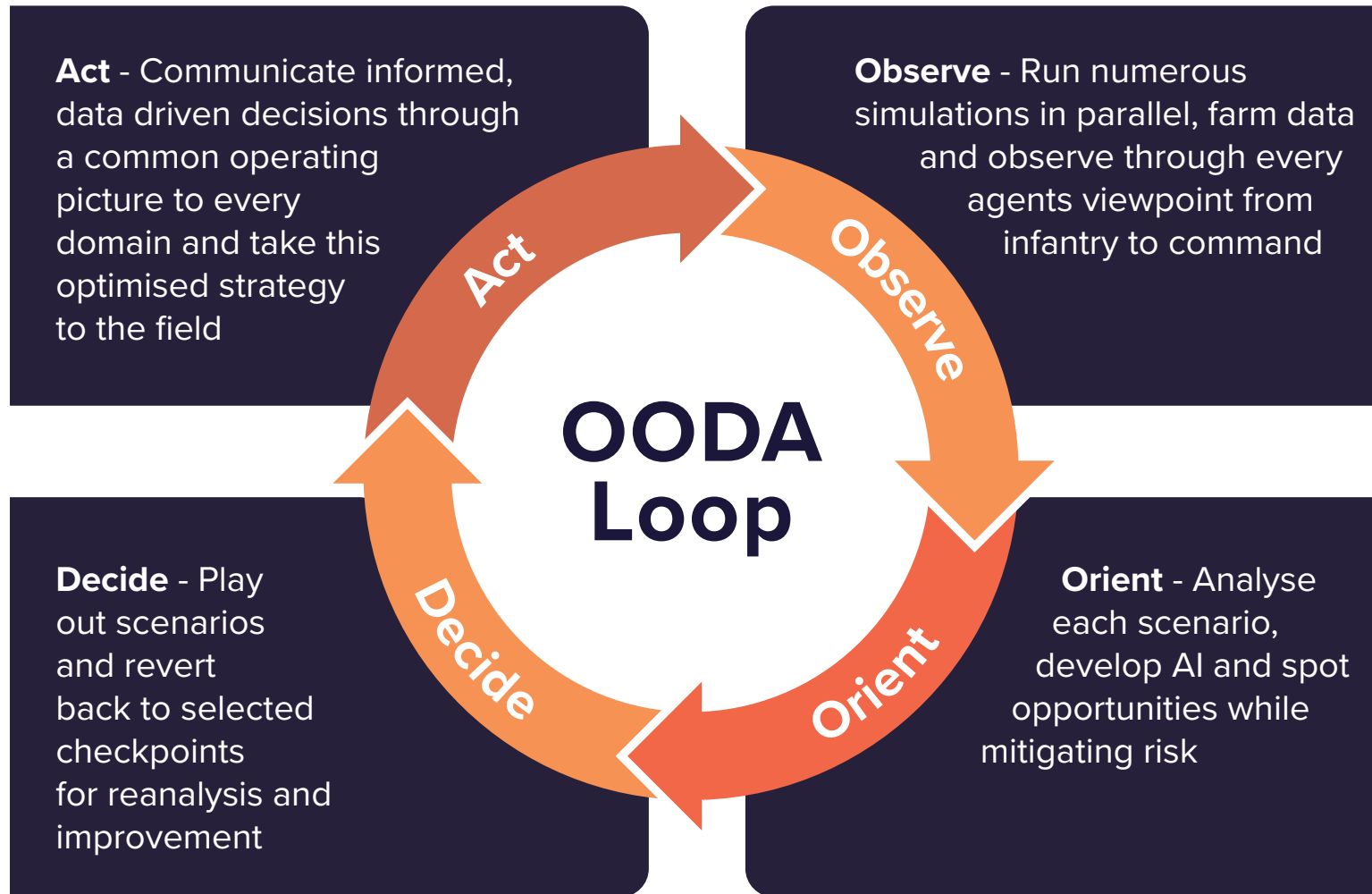
Governments and defence organisations everywhere are united in their belief of the need for change. The UK Chief of the Defence Staff, General Sir Nicholas Carter, said that the UK forces “must fundamentally change” - but just how exactly? As with any huge overhaul, a deep analysis is required of the key limitations of current systems in terms of facing these new challenges ahead.

Digitalising the battlespace has been the central role of Major General Tom Copinger-Symes, Director of Military Digitisation at the UK Ministry of Defence. Copinger-Symes cites the vast importance of the OODA loop, created by the highly influential military strategist John Boyd. Keeping in mind how digitalising is working to enhance the loop is a key part of this and he describes that “John Boyd used to talk about people, ideas and technology,” he says. “But today, I think he’d talk about people, ideas, data and technology, in that order. Ultimately a data driven OODA loop will provide optimum alignment with a digitalised defence model.



The OODA Loop

Observe - Orient - Decide - Act





Providing a Common Operating Picture

The modern battlefield is more complex than ever, and the evolving nature of warfare demands combined training and operational exercises with allied partners across different domains.

Providing a common operating picture enables greater synchronisation during mission training, but currently the ability to 'zoom in and out' of the simulations to view different perspectives is typically restricted. Integrating multiple data sources and multiple simulations / training scenarios into a single coherent architecture allows for multiple users to interact with the simulation environment or witness events from different viewpoints. Not only are multi-echelon interactions possible, but international allies can share and work securely across borders and domains, providing accurate tactical deployments and connect ground units with each other to test behaviours and actions based on scenarios more frequently at a fraction of the cost.

Bringing Training to the Point of Need

Interoperability between domains, geographies and training environments is crucial to training exercises. The traditional approach of organising facility-based training for large scale, cross domain missions involves huge logistical costs in assembly due to the dispersion of different forces. As it stands, different domains fundamentally use different simulation technology; simulations underpinning a typhoon fighter jet are quite different from those being used by ground troops.

Clearly therefore advances in distributed simulations provide a great opportunity to bring training to the point of need and reduce the complexity created by siloed domains. It enables forces across all domains to synchronise with each other and command headquarters. Bringing multiple simulations into a common coherent architecture will also simplify international cooperation and remove the barriers of physical distance. The logistical issue of carrying out large scale multi-domain exercises created by a lack of available nearby troops is removed.

Moverover, through the use of VR and AR troops can train with the people they will actually be fighting alongside and remove the concept of 'home advantage' where hostile, unfamiliar terrain such as the arctic can create unforeseen obstacles. Moreover, whereas in-person training often endangers personnel and assets, a virtual approach offers an entirely risk free procedure.



Speed and Precision in Decision Making

Lacking an entire view of the operation leads to poorly informed decisions, whereby guesswork and intuition are too prominent. The spectrum of this uncertainty can be huge, ranging from unnecessary casualties, the success or failure of the mission or simply incurring higher financial costs. Current approaches do not accurately account for the many variables in increasingly chaotic battlespaces, and oftentimes analysis and insight is predicated on outdated technology that leads to siloed operations

However, through a common architecture, forces can work securely with international allies, providing accurate tactical deployments and connecting ground units with each other to test behaviours and actions in any given scenario. Inhospitable conditions, such as the arctic - where changes in temperature can affect machinery or even behaviour - can be analysed repeatedly and quickly, without dropping personnel into hostile environments unprepared.

Battlespaces can be analysed and the impact of decisions can be updated as changes to weather, enemy positions and the physical environment all evolve. Strategic decisions are thus based on accurate, detailed and reliable analysis, which elucidate risks and enables joint command operations to adapt to changes in real-time.



Uses Cases

Synthetic Training Environments

- Complex, high-fidelity virtual simulations that effectively train and prepare personnel for real world scenarios
- Brings training to the point of need and removes risk to personnel and assets
- Distributes resources across domains and geographies

Decision Support

- Interactive multivariate models designed for real-time decision making in complex scenario planning
- Identification of emergent, unexpected behaviours not captured in existing models
- Bad decision are made in simulations not combat

Gamification

- Remote controlled systems, such as drones and unmanned surface vessels, are becoming increasingly common
- Skills developed from games are used through recruitment programmes
- Sophisticated risk free game-like training programmes offer team building and valuable education

Wargaming

- Moving away from mapboards and the Vassal engine towards interactive headsets
- New massive scale multi-echelon simulations
- View the entire operation through one instance

Situational Awareness

- A common platform and coherent architecture that provides a single source of truth for multi-domain operations
- Track enemy movements and operations
- Avoid enemy plans and traps



Realistic training environments involve millions of simulated civilians, vehicles, troops and other entities. They must cater for commanders coordinating the entire operation across vast theatres, as well as soldiers on the ground breaking through doors and carrying out tactical operations. Recreating the complexity of the world at this scale is a hugely compute intensive activity that is only now being addressed through distributed models. Indeed, distributed simulation is facilitating persistent training platforms with connectivity and interoperability. By providing a common training platform that can scale to meet the demands of the modern battlefield, the next generation of synthetic environments will effectively train and prepare personnel in real world scenarios for the emergence of new unprecedented threats.



Synthetic Training Environments

Unparalleled Performance at Massive Scale



Synthetic Training Environments

Persistent, Single-Sharded and Fully Integratable

Previously, simulations needed to be stitched together to form the full picture; but now an entire operation can be viewed in one instance. They can now scale to the size of cities and involve millions of entities, with the ability to zoom in and out of any location seamlessly. Every domain interacts with the same simulation, meaning that information can be communicated in a meaningful, logical way as the channel it is done across is common to all. These all-in-one solutions are also holistic in the ease of integration with other industry leading platforms such as Unreal Engine, Unity and VBS. This ensures that there is no sacrifice in the wealth of tools and assets that these platforms offer. Multi-domain operations crucially happen on a large scale. Cloud-native solutions offer this scale with a flexible and accessible infrastructure.

Space



Air



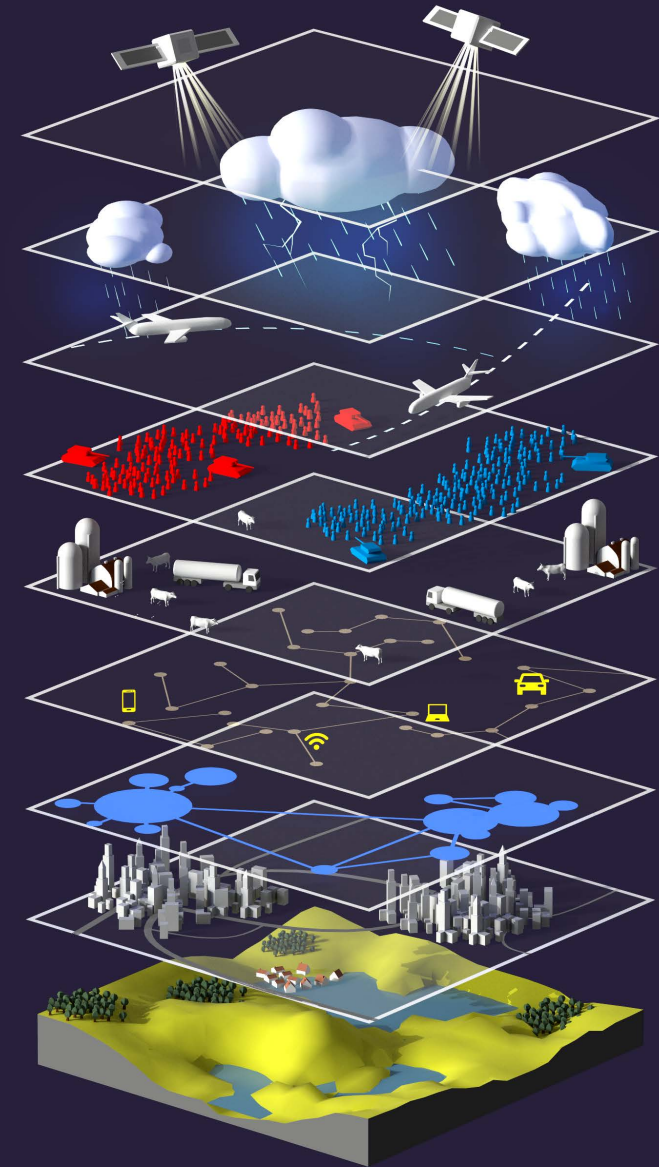
Cyber



Sea



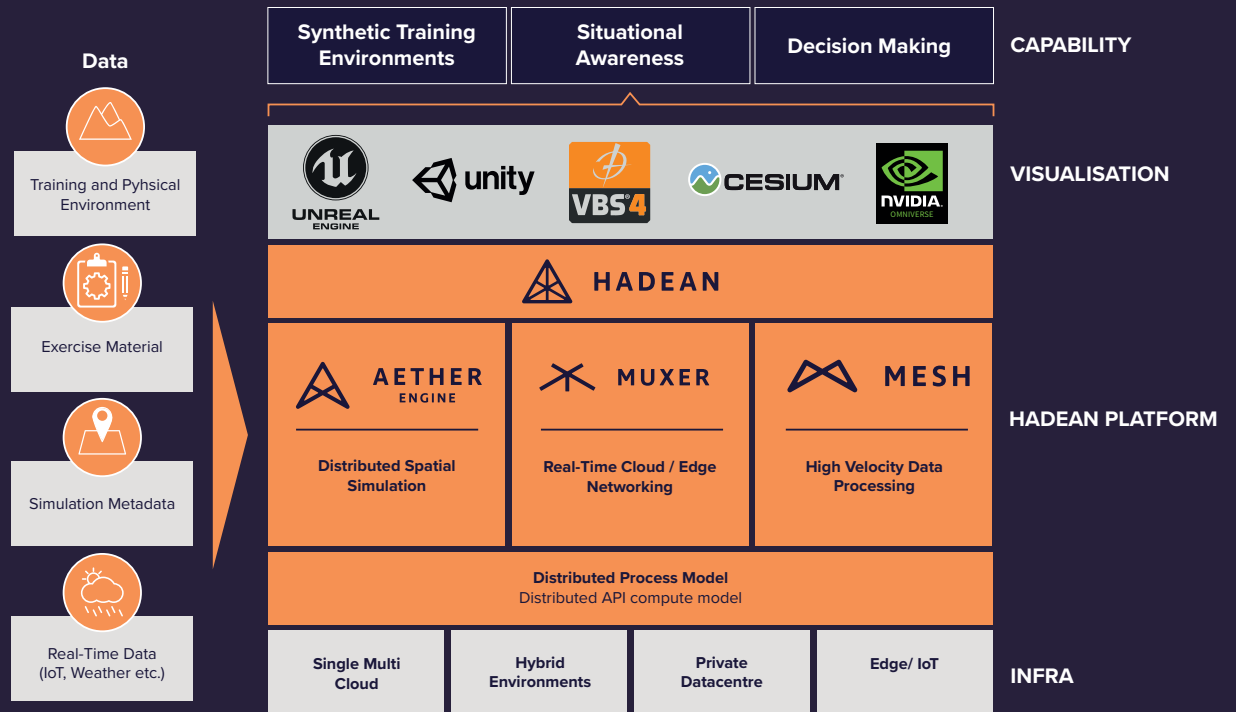
Land



Decision Support System

Multi-Layered Data and Massive Connectivity

Providing a common operating picture demands synthesising the numerous layers of data that affect the world as well as the various multi-location inputs from its engaged actors. Every data type from land, sea, air, space and cyberspace needs to be synthesised into one cohesive structure. They can be accessed and shared across locations through the single persistent world that has been created. But connecting so many actors in different locations within the same operating picture requires reimagining the networking model. With the recent advent of distributed cloud and edge networks, previous limitations around connected clients have been beaten significantly. Thousands of people across the globe can now interact simultaneously in the same simulation, while experiencing low latency to ensure rapid communication and deployment of action.



Decision Support System

Simulation Parallelisation and Data Analysis

The power available in distributed systems means multiple simulations can be run at once, allowing for much faster analysis of scenarios. Different branching paths can be simulated and studied at the same time, with the results being immediately available to view by any connected user around the globe. Using a data capture system, meaningful insight about the exercise can be determined and shared quickly and easily. Things like how well individuals performed, the effectiveness of the training and potential risks can all be derived in order to enhance future capabilities. It's key to understand the relationship between fidelity and functionality and when to prioritise one over the other. Achieving high levels of textural detail and complexity in worlds is essential for immersion, but similarly, focus on insightful, practical communication of information when



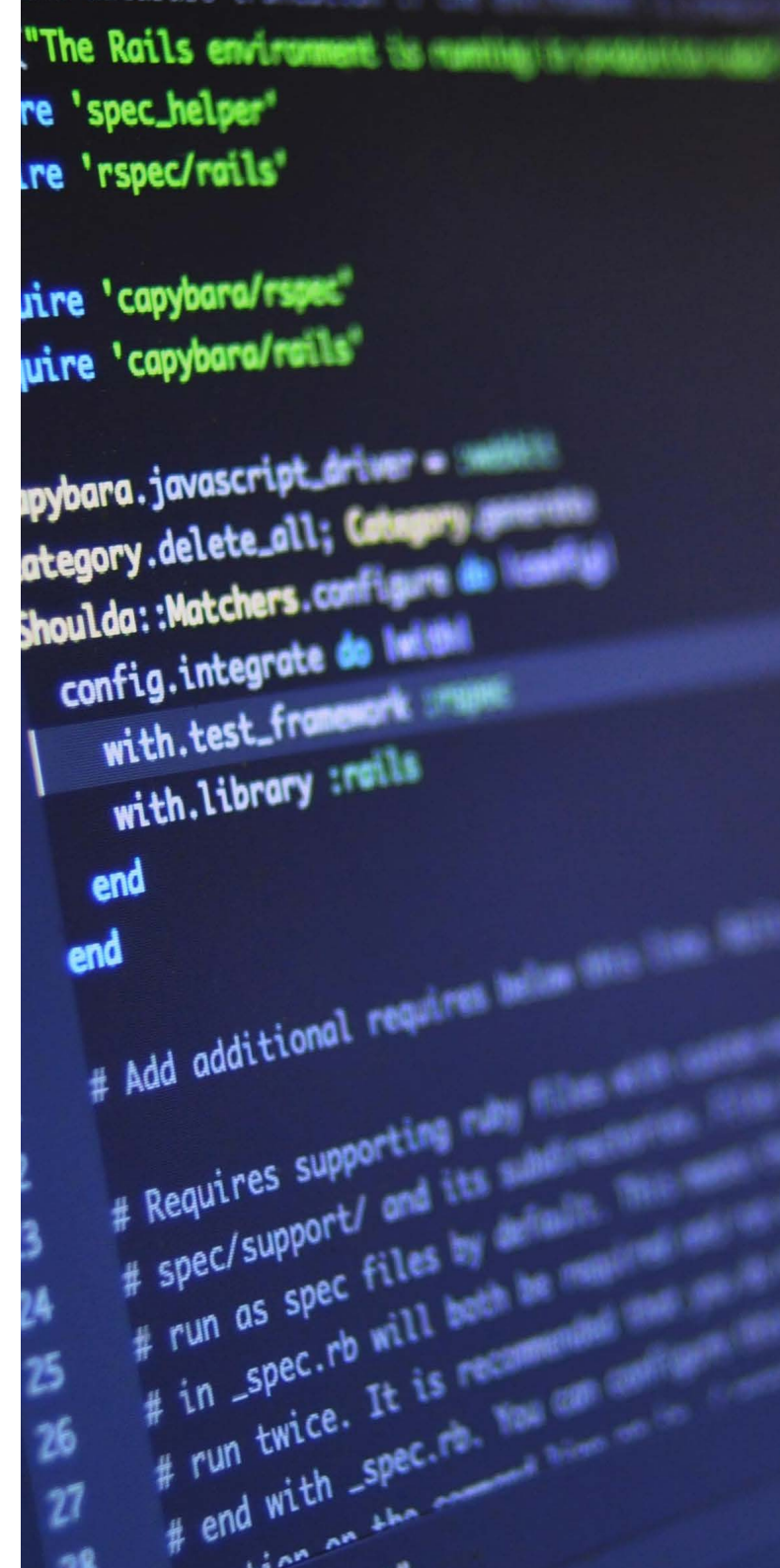
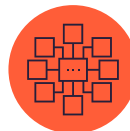
Situational Awareness and Visualisation

Data Farming and AI Training

Through parallelising and repeating simulations from predefined checkpoints, an enormous amount of data can be farmed from simulations. This data can then be used to model and train artificial intelligence within the simulation to improve the realism. When combined with historic data, this model allows the creation of highly realistic behavioural models for entities such as enemies or civilians within the simulation. Modelling civilian behaviour can help predict how they will react to certain scenarios, helping decide on the best strategy to ensure their safety. By developing the behavioural AI of enemies, it's easier to predict their movements and intentions. Intercept them when they are vulnerable, predict and destroy their traps and ultimately see every move before they've even made it.

VR and AR Integration

VR and AR is of course playing a vital role in transforming training operations in defence. At one end, these technologies allow soldiers, pilots and sailors to gain an immersive experience with zero risk of harm. Similarly, at a higher level they enable a better visualisation of defence scenarios. Next generation platforms must integrate with these functions to allow an immersive way of viewing the common operating picture through the various different lenses.



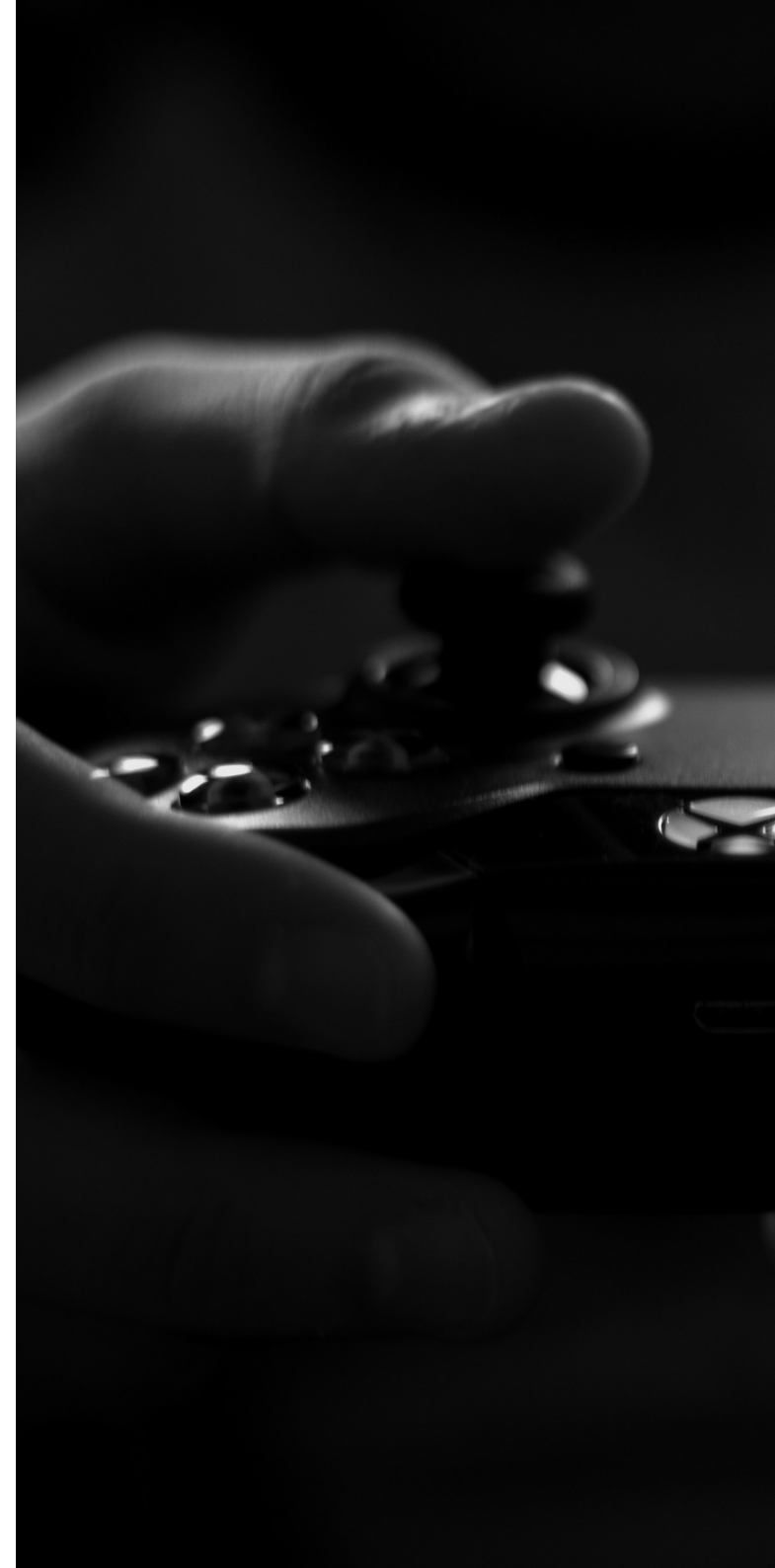
Wargaming and Gamification

Advanced Wargaming

Wargaming has long played a significant role in defence operations, but has largely remained an independent exercise. An all in one platform better enables informed conclusions from wargames to be used in training. Strategic decisions are based on accurate, detailed and reliable analysis which ultimately makes their discovery in wargames more valuable. Elucidate risks and adapt quickly to changes in real world scenarios and the emergence of new unprecedented threats. Decisions with bad consequences are made merely in the simulation rather than live action itself and they can be analysed in relation to the tactical decisions to help make improvements. Greater technological capabilities are helping create larger, more complex games that can span across multiple teams in different locations.

Gaming Technologies

The gaming industry has long been aligned with the defence industry due to the key technological innovations that gaming has provided. Gaming engines have provided high fidelity simulators and advancement in control systems has also been taken advantage of by militaries. With remote controlled systems being increasingly common, the importance of training using controls similar to gaming has become more significant. The skills developed by gamers are increasingly valuable and furthermore tactical team games offer risk free training exercises.



HADEAN'S NEXT GENERATION PLATFORM





Hadean's Next Generation Platform

Hadean delivers the final word on synthetic training and decision support. A distributed compute model provides the scale and performance needed to create a common operating picture that simulates the massive complexity of every scenario in one persistent world. By synthesising disparate data sources and running simulations in parallel, the optimum decision and strategy can be reached quickly.

Hadean provides an open and extensible framework for large-scale and complex multi-domain simulation and modelling

- Spatially orchestrates any frontend engine to deliver greater simulation scale and complexity
- Low-latency and performant data-streaming across any device for distributed operation
- Deploy in any cloud, hybrid, or on-prem environment
- Optimise cost-efficiency with dynamic allocation / de-allocation of resources

A platform for multi-domain training, situational awareness and decision support

Create multi-domain simulations with millions of entities to effectively train and prepare personnel in real world scenarios for the emergence of new unprecedented threats.

Better and faster insight in complex and unpredictable scenarios

Run thousands of simulations in parallel to enable precise analysis of complex battlespaces. Results and analytics can be accessed anywhere by anyone at a fraction of the cost.

A single source of truth for multi-domain operations

Provide a single source of truth by bringing together multiple tools, simulations and data points into a single coherent architecture. Integrate with government secure infrastructure - without requiring the need to rip up or change existing architectures.

PROOF POINTS

Hadean's technology has been trusted and validated by some of the world's leading defence and technology companies. In the push for greater digitalisation and de-centralisation in military systems, Hadean is providing a distributed system equipped to deliver the crucial changes that are needed in the infrastructure.





Hadean and CAE

Hadean delivered an at-scale interactive virtual training platform that can support multiple use cases with ultra high levels of realism.

- Simulation of over 2 million complex entities
- Over 300 concurrent interacting users
- Full scale city environment with realistic citizen behaviour
- Cloud and client agnostic

“Hadean is quickly developing a strong reputation based upon the real performance of its new and exciting products both in its core gaming sector and now in non-adjacent industry applications.”

**Andrew Naismith,
Managing Director CAE (UK) PLC**

Hadean, Imperial College London and University of Oxford

Hadean designed an interactive dashboard of COVID-19 spread across the UK to demonstrate the consequences of various government actions, ahead of time. With our platform, the resulting effects on speed of infection spread could be determined by adjusting the various variables. Thousands of simulations were run in parallel to achieve this, with a number of new emergent behaviours and effects discovered that were unknown to existing models.

Key Outcomes

- Thousands of simulations run in parallel to provide precise analysis for policy makers
- An Interactive multivariate model designed for real-time decision-making
- Identification of emergent behaviours not captured in existing models



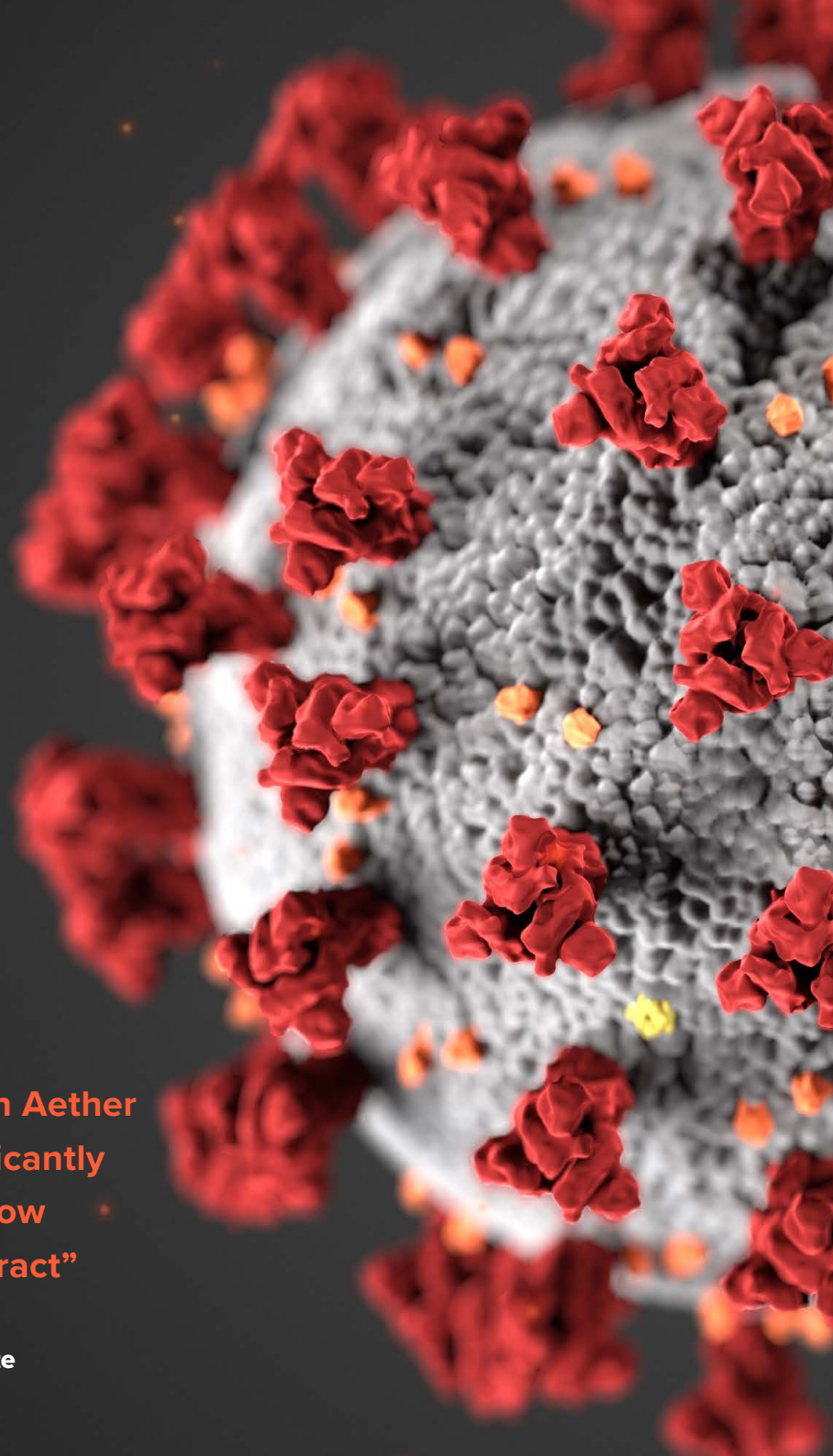
Imperial College
London



UNIVERSITY OF
OXFORD

“Simulations developed on Aether Engine enable us to significantly speed up predictions on how viruses like COVID-10 interact”

**Dr. Paul Bates, Francis Crick Institute
Biomolecular Modelling Laboratory**



Hadean and Microsoft D&I

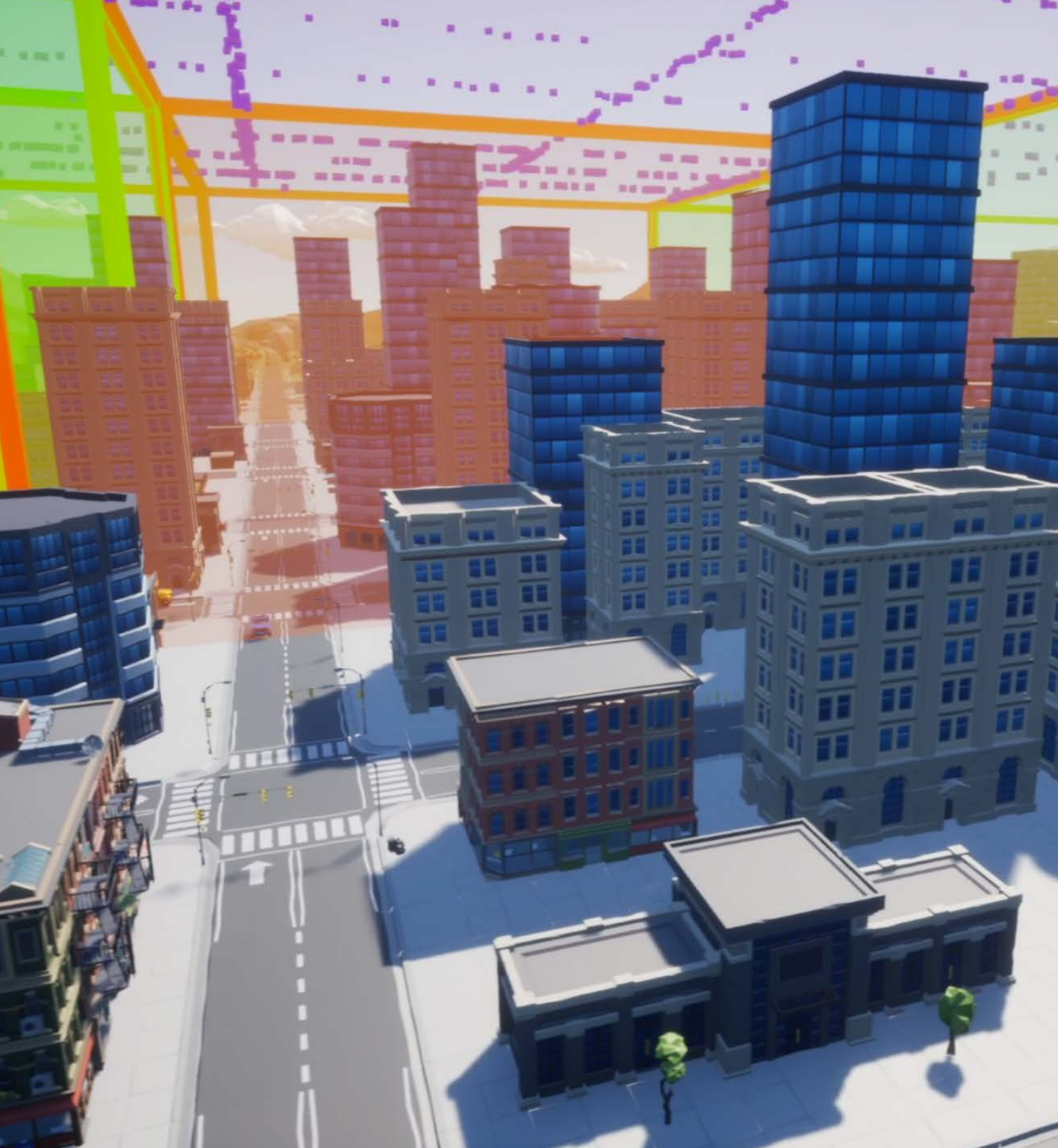
Aether Engine is the core simulation engine in a Microsoft platform for enterprise simulation.

- Continental-scale simulation with high-fidelity variables.
- Easy programming of parameters and scenarios for non-technical users.
- Extensibility to accommodate future planned integrations and de-risk vendor lock-in.

“Hadean has been selected by Microsoft for a USMC tender to develop a solution for a multi-level global conflict simulation.”

Military Simulation | STE | Scenario Planning





Hadean, Nukklear/Unreal Engine

Hadean underpinned the simulation of a city evacuation. The project provided an interactive analysis tool to understand the best course of action in complex scenario planning.

- Complex citizen behaviour responding to unfolding disaster
- Multiple simulations run to identify optimal course of action
- Tight integration with Unreal Engine, Grafana UI and real-time analytics

“This unprecedented scale means that we can approach simulation design with a fresh perspective - no limits on player counts and entities”

Kirk Lenke, CEO, Nukklear



Synthetic Training and Decision Support



HADEAN

Validated and used by some of the world's most pioneering organisations



Imperial College
London



Xsolla

MINECRAFT



For more information, please visit www.hadean.com