**Modeling, Simulation & Gaming (MS&G) Working Group**
March 2021
OGC 20-085r1

# Advancing the Interoperability of Geospatial Intelligence Tradecraft with 3D Modeling, Simulation, and Game Engines

## TECHNICAL PAPER OBJECTIVE:

USGIF and OGC are co-publishing this paper to identify gaps that can be filled through training and education to bridge the divide between communities of practice and spur the evolution of open standards and increased interoperability between geospatial analysis and modeling and simulation solutions for generating 3D synthetic environments.

# 1.0 Introduction

The emergence of the geospatially enabled enterprise has opened up new opportunities in the applications of 3D/4D analytics, artificial intelligence/machine learning (AI/ML) decision-support systems, and game-engine applications supporting mission rehearsal and virtual training. In this instance we define 4D as the time-domain of a parameter associated with a physical model of a feature in the virtual environment. Digital twin environments, such as the Rotterdam 3D Project[1] and the Nanjing Jiangbei New Area[2], are pushing forward the transformation of the 3D/4D modeling and geospatial analytics community at a staggering scale and pace. Whether it is urban planners, construction firms, environmental engineers, or transportation system designers, a wide range of professionals are embracing the integration of 3D geospatial data with real-time sensor feeds. The growing trend for 3D/4D geospatial-intelligence to supplement traditional 2D GIS and mapping approaches is accelerating because:

- 3D data provides higher spatial resolution and location accuracy than 2D data;
- 3D/4D applications provide faster conveyance of aesthetic and spatial relationships;
- 3D/4D applications support broader community enablement of unique types of geospatial analysis that cannot be done in 2D mapping environments; and
- 3D/4D approaches increase the visualization and understanding of complex spatial relationships by non-specialists.

The challenges in 3D/4D data management, data processing, and data exploitation are enormous as analysts are confronted with millions of observations of features changing in space and time. AI/ML approaches that leverage cloud-based architectures are capable of scaling to meet the challenges of the location-intelligence "data tsunami"; however, the tradecraft connecting communities of practice in geospatial analysis, 3D modeling, simulation (M&S), and gaming remains stove-piped. One of the principal objectives of this Technical Paper is to identify gaps that can be filled through training and education to bridge the divide between communities of practice and spur the evolution of open standards and increased interoperability between geospatial analysis and M&S solutions for generating 3D synthetic environments (Fig. 1).

## 1.1 Organization and Role of the USGIF MS&G Working Group

The USGIF Modeling, Simulation, and Gaming Working Group (MS&G WG) seeks to educate and inform the global geospatial intelligence (GEOINT) community on how 3D modeling, simulation, and gaming technology can be made more interoperable with GEOINT tradecraft. The MS&G WG collaborates with industry, academia, and government to highlight advanced research concepts and commercial technology trends across the GEOINT and M&S domains to identify solutions capable of delivering authoritative and relevant geospatial information at the point of need. A core tenant of the MS&G WG's collaboration strategy is to maintain close working relationships with both the Open Geospatial Consortium (OGC) Interoperability, Simulation, and Gaming (IS&G) Working Group and the Simulation Interoperability Standards Organization (SISO). Leveraging these relation-

Image courtesy of Esri

**Figure 1. GIS and high-resolution BIM and reality capture can be combined in game engines for XR experiences.**

1. https://www.gim-international.com/content/article/digital-city-rotterdam
2. https://medium.com/51vr/another-national-benchmark-landed-29f8285fbef

ships, the MS&G WG is building a broad community of interest by focusing on relevant topics and issues including:

- **Interoperability** of software, workflows, and data across the GEOINT and M&S communities to improve mission responsiveness through a growing and diverse array of geospatial information such as just-in-time delivery of information from drones, body cameras, phones, and other IoT sensors.
- **3D Reality Modeling and Analytics** of 3D geo-specific and 3D geo-typical environments including terrain (urban and non-urban), buildings, roads, hydrology, vegetation, and other cartographic features used to generate GEOINT analytical products and databases.
- **Simulation Technologies** supporting 3D geo-synthetic environments for training, mission planning, scenario testing, and intelligence analysis in real-world context.
- **Virtual Reality (VR), Mixed Reality (MR), and Augmented Reality (AR)** capabilities for immersive training, generation of immediate context and information awareness in the field, remote mission monitoring, and other applications.
- **Gaming Technology**, including game engine software platforms, supporting the visualization, asset generation, and hybrid-streaming of 3D geospatial data integrated with virtual environments. The objective is to combine optimized performant content with dynamic geospatial events and conditions.
- **3D Geo-synthetic Environments** supporting machine learning and artificial intelligence (ML/AI) approaches for generating labeled training data through sensor fusion and 3D modeling. The focus here is GeoAI approaches leveraging 3D spatially explicit models constructed from geo-specific and geo-typical content.

## 1.2 Objectives of Technical Paper

With this background in mind, the objectives of this MS&G Technical Paper are focused on identifying technology trends that are influencing the convergence of GEOINT and M&S tradecraft. The purpose is to advance ideas and techniques, such as reality modeling of 3D environments, which increase the knowledge-base and capacity of the geospatial analyst community writ large by:

1. Identifying high-priority areas for basic and applied research topics that will address real-world requirements and emerging opportunities for production of 3D terrains that are "mirror worlds"[3] of operational environments.
2. Promoting applications of 3D/4D analytics that enhance the situational awareness of first responders and warfighters as well as urban planners focused on health, energy, mobility, and livability issues.
3. Encouraging research in geospatial AI/ML (GeoAI) approaches supporting spatially-explicit 3D models, next-generation reality modeling, and the production of digital twins at all scales to increase organizational effectiveness within the National Security community.
4. Advancing technology innovation such as commercial game engine software platforms that support multi-sensory attributes (visual, audio, sensory touch) with geospatially accurate terrain, feature data, and entities for next-generation GEOINT analysis and tradecraft education.

3. https://archive.nytimes.com/www.nytimes.com/books/99/01/03/specials/gelernter-worlds.html

# 2.0 Tradecraft Gaps Between GEOINT and M&S Communities of Practice

## 2.1 Geospatial Analytics and 3D/4D Data Services

The goal of this section is to identify emerging trends and tradecraft gaps in 3D/4D geospatial analytical methods, aligned modeling and simulation applications for decision support systems, mission rehearsal, and situational understanding. Over the past 10 years, technology advances in the miniaturization of LiDAR sensors, drone-based collection capabilities, and increased revisit rates for global high-resolution imaging satellites indicate the time for "true 3D" analytics is now at hand. The "connectedness" of IoT sensors, cloud-based geo-processing services, and powerful mobile devices, all supported by efficient 3D data streaming formats such as i3S and 3D Tiles, enable the delivery of 3D/4D geospatial analytics to support a new generation of GIS applications. Accordingly, within this framework of these technology innovations we discuss trends in Change Analysis, Mobility Analytics, and Contextual Analysis or topsight. The goal is to spark a conversation regarding new methods for 3D/4D analytics that advance the tradecraft of both the M&S and GEOINT communities.

Our approach is to call out potential areas of 3D/4D research across multiple commercial, industry, and government domains such as 3D high-definition mapping, architectural, engineering and construction (AEC) trends, and support for the warfighter and first responder communities. In so doing, we reference previous work by the OGC Innovation Program on 3D/4D analytics and mixed reality solutions support for the warfighter and first responder communities. The 2019 OGC Concept Development Study (CDS) provides an excellent overview of the key stakeholder issues in the convergence of geospatial 3D modeling, simulation, and gaming integrated with machine learning (ML) for automated 3D workflows. Mixed reality is both intriguing as well as highly relevant when considering the expansion of game engines for geospatial visualization, multi-sensory immersion, and GeoAI approaches using real geospatial data. For example, the use of geo-specific 3D terrain models to generate labeled training for synthetic models such as partially-obscured vehicles in cluttered 3D environments.

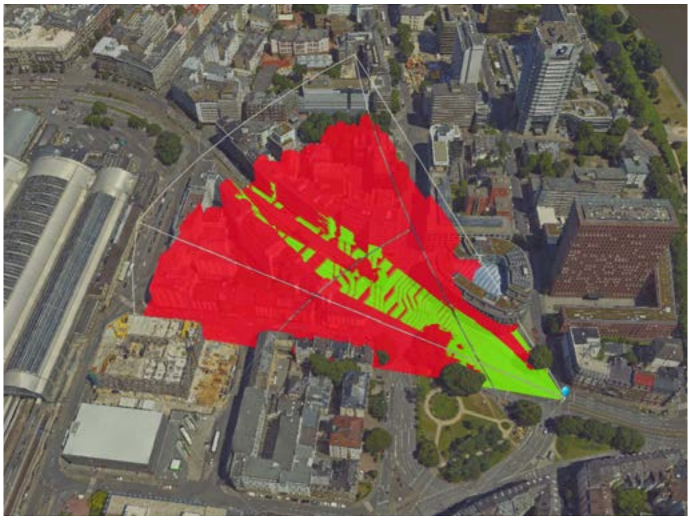

Image courtesy of Esri

**Figure 2. Lightweight desktop and mobile experiences put reality mesh in the hands of non-expert GIS users.**

## 2.2 3D/4D Change Analysis

Traditional geospatial change analysis analytics using satellite or aerial imagery are typically 2D in nature. Pixel-based methods, whether 2D or 3D, require accurate geo-registration of imagery collected at different times, and analysis must account for typical artifacts such as clouds, shadows, seasonal differences and other attributes in order to derive an accurate estimate of land-based changes in the scenes such as the amount of land inundated by a flood. Feature and thematic-based change analysis methods, using imagery or raster map products, also require accurate co-registration; however, these approaches can provide object-specific metrics, such as "changes in the number of cars in a Walmart parking lot on Saturdays," and have become increasingly automated due to advances in segmentation and machine learning-based feature extraction. These types of 2D analytics are valuable in the detection of patterns of life (POL), which support evolving geospatial intelligence and business analytic models about changes over time. Commercial small satellite constellations operating in lower Earth orbit in non-sun-synchronous modes now provide intra-day revisit over geographic areas and sites for 4D analysis of changes.

High spatial resolution DEMs derived from LiDAR, point cloud photogrammetry, or satellite imagery, such as the Vricon 3D Surface Model, provide a geospatially accurate 3D foundation terrain layer for a wide-range of 3D analytics that can be paired with temporal change analysis of feature datasets. For example, monitoring changes in water storage reservoirs for large hydro-electric dams on a volumetric basis versus a surface area basis, or assessing flood-plain risk for real estate with 3D data versus 2D imagery. Other areas of public safety that would benefit from 3D/4D change analysis would be improvements in geologic hazard risk analysis, such as predictions of hillside slumping or mud flows, wildland fire modeling, earthquake damages, and flooding from extreme rain events. In summary, the increasing availability of high-resolution 3D DEMs, IoT sensor data, and high-revisit satellite imagery collection opens up multiple new opportunities for research in 3D/4D analytics.

**Research Ideas Callout for Analytics: 3D/4D Change Analysis**

- New approaches and methods for integrating 3D/4D analytics within mission planning and mission rehearsal training environments.
- New ideas and methods for the integration of environmental models with 3D terrain, land-cover, and subsurface data (geology, hydrology, built-infrastructure).

## 2.3 3D/4D Mobility Analysis

Investments in the autonomous vehicle market over the past 10-plus years have accelerated the growth of high-definition (HD) street-level 3D mapping and mobility analytics for navigation. Companies such as Uber, HERE Technologies, Google, and many others use mobile LiDAR sensors, full motion video cameras, and stereo-based photogrammetry to collect 3D data for urban environments and road networks.

The connected nature of intelligent transportation networks—cars, sensors, cloud-based map services, etc.—are opening the aperture for innovative 3D/4D mobility analytics to support urban planning, event planning, and improvements to livability in dense urban settings. Contributing to this flood of 3D street-level data collection are drone and aerial collections of LiDAR and multi-band imagery for creation of high-resolution DEMs, which enable increased accuracy in the design of civil engineering and public works projects. A widely available, up-to-date DEM with history and provenance provides an intelligent substrate that can be combined with dynamic sensor data and HD 3D data to provide a system for monitoring and analyzing mobility requirements (Fig. 3). In summary, this wealth of 3D data collected from street-level and building-level views opens up multiple new opportunities for research in 3D/4D mobility analytics.

**Research Ideas Callout for Analytics: 3D/4D Mobility Analysis**

- New methods for the incorporation of pattern of life (POL) change analytics into 3D synthetic environments such as automated alerts triggered by simulation. For example, dynamic visualization of traffic accident/congestion patterns during a transportation routing simulation for a planned public event.
- Incorporation of street-level LiDAR data into 3D/4D urban mission planning simulations that show changes over time such as street congestion, construction activities, line-of-sight (LOS) views, and other analytics.

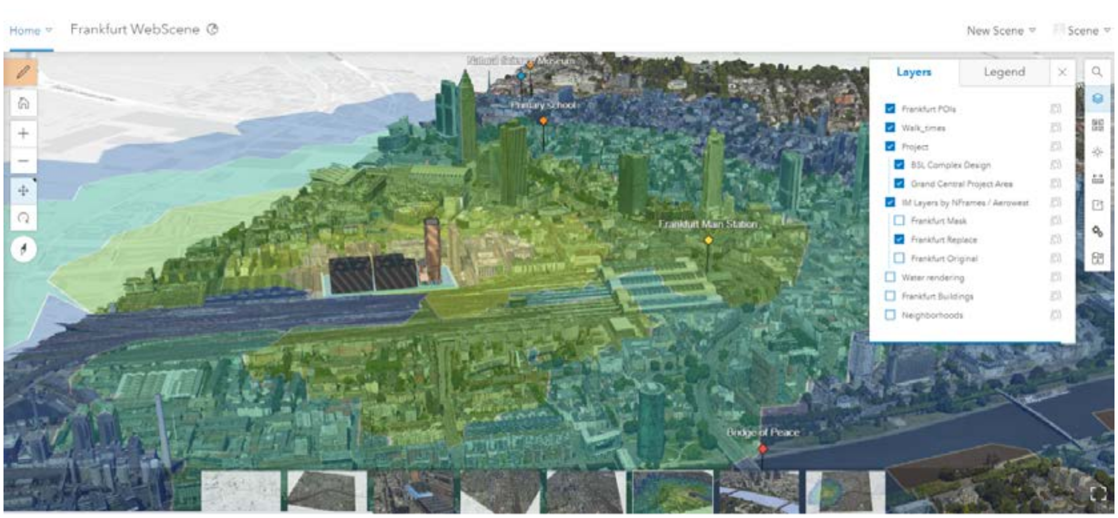


Image courtesy of Esri

**Figure 3. Draped GIS content greatly enhances reality mesh and provides for easy-to-use web experiences to support mobility analytics.**

## 2.4 Contextual Analysis (Topsight)

Advances in 3D geospatial mapping, modeling, and visualization approaches provide new opportunities for contextual awareness applications capable of delivering topsight for commanders, planners, and analysts. Topsight is the capacity to "see the forest through the trees" and is a highly valued leadership commodity when assessing complex operational scenarios. The emergence of digital twins, which often include feature-level systems such as building information models (BIMs), geologic substrate models, or IoT sensors connected to analytical dashboards in a GIS, provides new approaches for contextual awareness (Fig. 4). Topsight does not preclude the inclusion of subsurface information such as geology or utility infrastructure into 3D digital twins. Quite the opposite, many urban digital twin models are now recognizing the need for subsurface data to complement the "big picture" view of managing large cities.[4] In summary, the integration of high-resolution 3D data insets opens up multiple new opportunities for topsight in 3D/4D contextual analysis.

| Research Ideas Callout: Contextual Analysis (Topsight) |
| --- |
| ▪ New methods and approaches for geo-registration of 3D point cloud features into 3D scenes to enhance contextual analysis and situational understanding. |
| ▪ AI/ML approaches for contextual-based tipping and cueing of threats by leveraging multi-dimensional 3D information and time-series attributes of entities. |
| ▪ Decision-support tools and services designed to operate in 3D/4D environments that fully leverage the contextual information of richly-attributed scene layers to deliver topsight. |

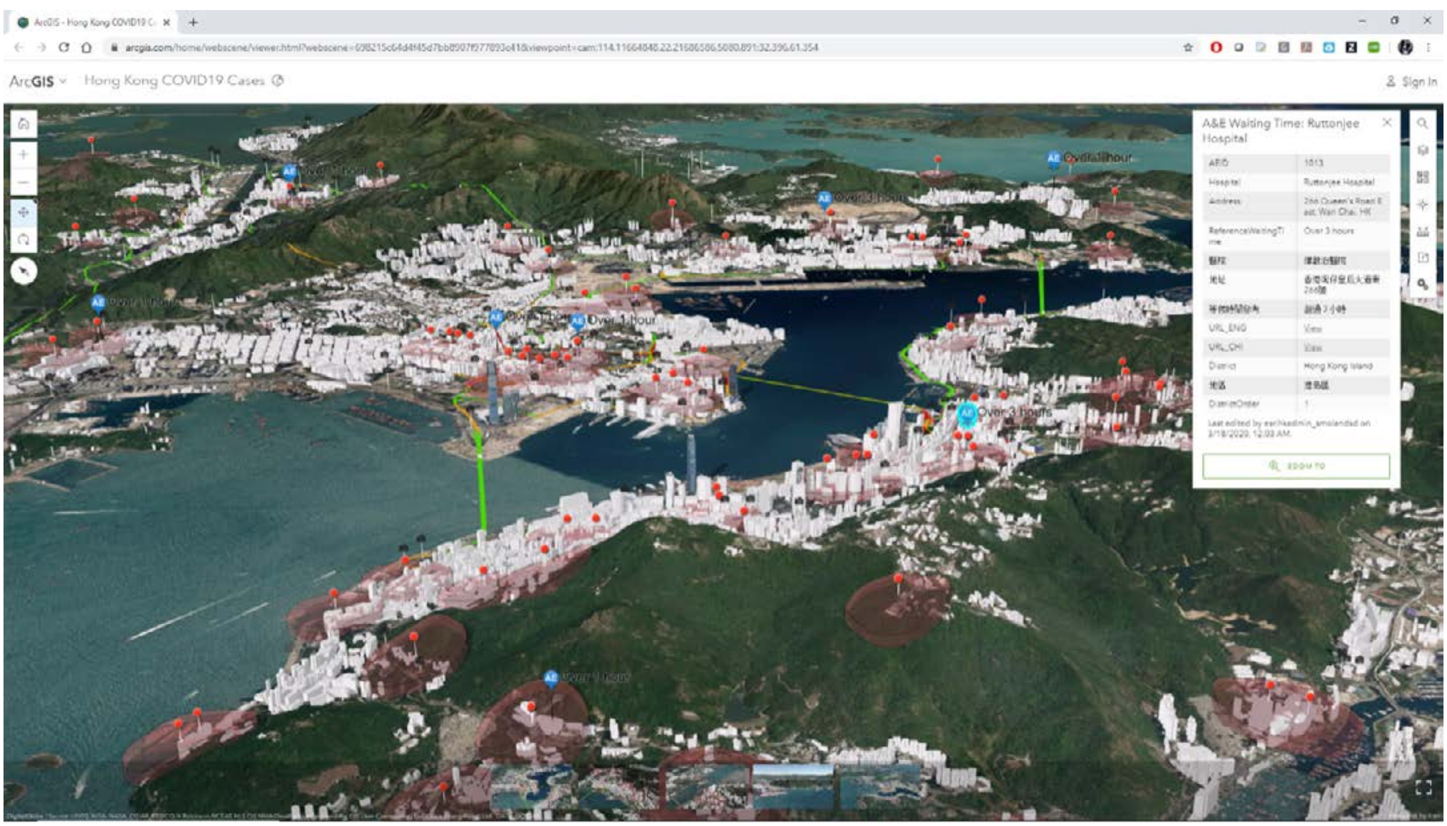


Image courtesy of Esri

**Figure 4. A 3D topsight approach used for COVID-19 situational awareness in Hong Kong.**

4. Proceedings of the OGC Location Powers Summit at https://www.ogc.org/ogcevents/location-powers-urban-digital-twins

# 3.0 Next-Gen Reality Modeling and Database Production

Regardless of the fidelity and spatial resolution of a 3D dataset, if it exists solely as geometry, textures, and imagery, then a large amount of human effort becomes necessary for any level of analysis and use. Accordingly, without additional attribution and annotation, machines don't have much use for the raw polygonal data. The more realistic and feature-rich the geospatial dataset, the more effective it will be for an expanded number of use cases involving machines, which is specifically helpful for use in simulation and analysis. As the semantic fidelity of the geo-specific dataset increases, including rich feature attribution, classification and segmentation, terrain realism, and data conflation from a variety of sources, the AI/ML-based planning and decision-making will become more and more accurate when measured against the virtual geospatial data's real-world analogue.

## 3.1 Current State of the Art in Automated Extraction of Terrain Features

A large number of algorithms and tools for automated classification and feature extraction exist today, especially for 2D imagery. However in the 3D space, there are far fewer solutions as the level of tradecraft is less mature. There are a number of approaches for this type of feature extraction, utilizing machine learning mesh data segmentation and analysis and point cloud analysis. In particular, a majority of 3D-oriented extraction efforts are focused on LiDAR segmentation with very little research into photogrammetric reconstructed 3D data. Recently, researchers at the USC ICT have focused on this particular use case of enabling rapid generation of terrain using inexpensive UAS and capture sensors with a direct path to photogrammetric feature extraction. Some very promising efforts involve a 2D-3D hybrid approach on both sides of the feature extraction pipeline, supporting the creation of training data for the machine learning models as well source data for the 3D extraction pipeline. Machine learning data models have incredible appetites for data in order to properly train them. Labeling and annotating a 3D dataset is a very time-consuming process that also requires a high level of analyst training in the process and software used. Labeling and annotating 2D datasets is much more straightforward and can be easily crowd-sourced using methods like Mechanical Turk. The 2D-3D hybrid annotation process also enables rapid annotation of 2D source imagery, for which camera poses can be estimated and the classification labels can be projected back into the 3D space. For the extraction pipeline, 2D imagery provides a method to quickly identify small features as well as complex ground and building materials in ways that the 3D data doesn't support. Again, by estimating camera poses from the 2D imagery metadata, this classification information can be projected into the 3D data space for qualifying and creating both extraction and segmentation information. Esri, and others, have been working on direct feature extraction from mesh after production of imagery through SFM and other workflows. Machine learning approaches benefit greatly from data reduction that is inherent in the mesh-generation workflow.[5]

## 3.2 Conflation of Sources to Support Terrain Database Production and Updates

Various levels of semantic classification and feature attribution may have already been evaluated and produced for datasets available through commercial, public, and government sources. Although these data are produced occasionally through automated pipelines, it is more likely the data have been painstakingly created by hand-digitizing or through crowd-sourced initiatives. A great example of this is Open Street Maps (OSM), a large and detailed database of terrain features. The crowd-sourced nature of the data means it's inherently incomplete, and not always authoritative or true to the ground truth. On the other hand, a source such as the NGA's NOME program is a more GEOINT-friendly version of OSM where the crowd-sourced data becomes verified and authoritative. A more richly featured dataset is the Army's SECORE program data, which is fully authoritative and feature-rich though it requires a large amount of resources to create hand-tuned simulation-ready databases. Disregarding any of this data leaves a trove of value untapped for terrain database production including roads, buildings etc. Accordingly, current feature extraction research relies on sourcing information from various private, public, and government sources that can be conflated to verify extracted results (compare automated road extraction vs. OSM road data), identify specific features that inherently require external data (bathymetry, no-fly zones), as well as provide automated ground truth annotation for ML model training datasets.

5. https://medium.com/geoai/3d-cities-deep-learning-in-three-dimensional-space-29f9dafdfd73

## 3.3 Tracking Feature-level Pedigree and Authoritative Data Sources

Of critical importance, especially within a GEOINT workflow and application for use, is the understanding where usable data has originated from, including its provenance and chain of custody. This can be a complex and frustrating process even when tracking down source information for a single unattributed 2D image. Understanding the inherent source of the metadata holistically can include how an image may have been transformed from the raw source, where it may have been transmitted or converted, what sensor captured it, and when. This task becomes even more complex when the image has user-added metadata, or has gone through automated image classification processes to enrich the data with relevant and pertinent information. Source data identification complexity increases a number of magnitudes when you begin looking at 3D data, whether it was derived from 2D photogrammetrically or via 3D native data sensors. Adding in conflated information from multiple sources, 2D, 3D, and otherwise, you can quickly arrive at an incredibly feature-rich dataset with a multitude of sources of information that have led to its creation. The ability to track, verify, and understand how this data was combined and implemented is a crucial gap in the GEOINT realm, especially when a lot of this information is sourced and applied fully autonomously either through basic computer applications such as information scraping, or through opaque but powerful processes such as deep learning. Fortunately, there are a number of technology initiatives available today such as block-chain, which can help track and ensure the data pedigree; however, a large number of challenges exist along the way as higher fidelity data increases the degree of difficulty in understanding data pedigree, provenance, and custody.

## 3.4 Round-tripping Geospatial Data from Source to 3D Database to Simulation to 3D Database (Modified Data)

Modified data is one of the more complex issues surrounding the maintenance of authoritative data while also allowing for versioning and derivative information. A number of issues revolving around guaranteeing custody and modification of the derivatives apply to this topic that include challenges previously discussed in ensuring data pedigree. In particular, as these data can be modified via human or machine interaction, there must be a number of solutions in place to understand how to best control the versioned information and determine when to re-apply information to the original authoritative source. There are a number of communication, networking, and transmission issues that must also be ensured such as: (1) validating the data as it is pulled from a 3D database; (2) determining the security and processing of the data while in-use; (3) ensuring the data and its subsequent derivative modifications are recorded, verified, and secured back through transmission; and (4) achieving fully authenticated and processed data at the source point, completing the round trip.

**Research Ideas Callout for Reality Modeling: Modified Data**

- Machine-based methods for validating the version history of data and tracing modified to authoritative sources.

# 4.0 Game Engines and GEOINT: Redefining Multi-Dimensional Analysis.

## 4.1 Multi-Sensory Simulation Contextualization

When it comes to predicting the future of simulations, there's no hidden secret or all-knowing crystal ball. The simple truth is the immersive training and simulation standards of tomorrow are rooted deeply in the innovations of today. For example, we know that the simulation community has been an early adopter of XR (VR, AR, and MR), and were among the first communities of practice to also experience their limitations. Thankfully, innovations in XR—such as the Open XR initiative—now allow for flexible deployment to all methods of XR. This advancement allows simulation creators to focus on the curriculum at hand, and not on the display of a pixel for a head mounted display (HMD) or unique display device. For consumers going forward, the method of choosing an XR experience will soon be as trivial as "mono vs. stereo vs. 5.1 sound," and this will unlock all kinds of new opportunities over the next 10 years. If we take one more step in this direction, we ultimately arrive at the question of stimulating a larger set of senses in the simulation domain to derive greater insights. Audio and visual senses are the first ones to be accessible, but moving forward, the push from new use cases is advancing the importance of including kinesthetic cues to augment training transfer. Although motion-cueing systems have been used for ages now in the field of immersive training, new micro-haptic devices that produce heat variation, impact impressions, as well as pressure or electrostimulation of our muscles, are providing augmented signals that humans can readily adapt to during training. In closing, simulation and XR are not co-dependent technologies. In fact, many types of simulations are used for analysis and predictive modeling tasks that do not involve human immersive experience.

## 4.2 The Metaverse and the Digitalization Evolution

Advancements in GPU capabilities are ushering in a new era of display techniques (ray tracing, PBR, photogrammetry, virtual humans), ensuring that simulations not only behave realistically but also with a high level of authenticity and believability. The next generation of trainees demand a more immersive training experience, and real-time is the preferred solution. The transition between virtual and live is still very noticeable, however, because of the complexity of the devices being used and their formats. Imagine instead the next stage of technology development when HMD systems are not needed anymore nor head-mounted to be in your face all the time.

## 4.3 Education and Training Programs for the MS&G Discipline

Education programs at colleges/universities and online/residential training programs can support these developments by using collaborative learning experiences. A number of disciplines contribute to the collective knowledge base necessary to be effective in this growing field including but not limited to: Computer Science, Software/App Design, Modeling/Simulation Studies, Electrical Engineering, Spatial Science, Data Science, Psychology/Sensory Neuroscience, Animation Design, and the Visual Arts. Although there are not specific programs today that are tailored specifically to this field, there are increasing opportunities within education and training to build custom studies (via curriculum management) that support the knowledge needs and outcomes for the next-gen MS&G specialist/developer.

## 4.4 Enter the Game Engines

While new simulation trends such as multi-sensory stimulation of trainees, very large open worlds, and visual realism are becoming more and more of a challenge for legacy simulation systems, commercial solutions are constantly innovating to alleviate these technology challenges. Only 10 years ago, modeling and simulation techniques for defense and aerospace applications were ahead of the technology curve. Independent of the commercial computer graphics industry, the M&S sector continued to develop applications to solve its own challenges. The evolutions of the operation doctrines and tactics have been the drivers of innovations for CGFs, SAFs, and GEOINT analysis, and still continue to drive technology innovation to this day. Paradoxically, traditional simulation training and analysis software, while focusing on application layers, has incurred a technology debt at its core level over the past 10 years. In comparison with what is called "traditional training solutions," the next era of digitization will be less hardware-intensive and more software-intensive, which will cause it to incur even more technology debt if the issue of software is not resolved. In order to reconnect the opportunities presented by high-performance hardware and the inherent limitations of older modeling and simulation software, game engines have emerged as an important element of the solution.

Experienced modeling and simulation creators and specialists have identified phases in the evolution of virtual training, going from monolithic prime-delivered solutions to defense-industry-grown COTS solutions. Because of the large technology and content creation effort assumed by actors of the simulation niche, the industry never had a chance to change its mindset and its business model. The authors believe we are now at the beginning of a new phase not only because the technology is ready, but also because new actors are entering the M&S ecosystem. Some game engine creators are taking an open source software route and teaming with the GEOINT community to support content creation and minimize the burden of requiring a "new standard" supporting a walled-off garden ecosystem of industry developers. This open source approach is leading to a strong change both in the technology as well as in the business model which has become accessible to startup gaming entrepreneurs around the globe. In this new paradigm, the traditional training and simulation companies and organizations are beginning to augment their expertise in game engines to draw a bridge between these two worlds and generate training experiences that mix a high level of trainee involvement with the accuracy of a well-defined curriculum.

**Research Ideas Callout for: Game Engines and GEOINT**

- New concepts for multi-sensory applications and training solutions that fully leverage material properties of terrain and cultural features as well as the contextual settings of geospatial environments.
- New concepts in Geomatics in Game Engines: At present, Game Engines are optimized for high-fidelity representation of objects in a local (game extent) environment. New methods and approaches are being introduced to transform or interpret GEOINT source data from a complex Earth-centric Coordinate Reference System to game performance extents.

## 5.0 Conclusions

The goal of the USGIF MS&G Working Group is to educate and inform the geospatial community on how 3D modeling, simulation, and gaming technology can be made more interoperable with GEOINT tradecraft. In this Technical Paper, we have identified multiple new areas of geospatial science research including:

- Applications that incorporate high-resolution DEMs for reality modeling and 3D database production to increase the operational effectiveness of warfighters, first-responders, and others who depend on terrain-based analytics for mission rehearsal, training, and operational planning;
- 3D/4D analytics for change analysis, mobility analysis, and contextual analysis for topsight in support of urban planning, AEC applications, national security, disaster response, and other time-sensitive applications;
- Reality modeling and 3D database production using AI/ML methods which fully leverage overhead and ground-based imagery and other ISR sensors to model indoor, outdoor, and subsurface environments;
- Next-generation high-definition (HD) 3D maps produced from low-cost mobile LiDAR sensors and cameras supporting the autonomous vehicle market;
- Multi-sensory and geospatially accurate synthetic environments that leverage game engine platforms to support training, simulation, and enhanced decision-support applications; and
- Temporally-aware coordinate systems capable of supporting complex Earth models and continuous data collection at ever higher spatial resolution.

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The United States Geospatial Intelligence Foundation (USGIF) is a 501(c)(3) nonprofit educational foundation dedicated to promoting the geospatial intelligence tradecraft and developing a stronger GEOINT community with government, industry, academia, professional organizations, and individuals who develop and apply geospatial intelligence to address national security challenges. USGIF achieves its mission through various programs and events and by building the community, advancing the tradecraft, and accelerating innovation.

### About the Modeling, Simulation & Gaming Working Group

The Modeling, Simulation & Gaming Working Group educates and informs the global Geospatial-Intelligence (GEOINT) community on how modeling, simulation, and gaming technology can be made more interoperable with GEOINT tradecraft. We seek to collaborate with industry, academia, and government to highlight advanced research concepts and commercial technology developments supporting geospatial modeling, simulation, and gaming systems that are capable of delivering authoritative and relevant GEOINT at the point of need. A core tenant of our collaboration strategy is to maintain close working relationships with both the Open Geospatial Consortium (OGC) Interoperability, Simulation, and Gaming (IS&G) Working Group and the Simulation Interoperability Standards Organization (SISO).

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