WGIC POLICY REPORT: 2022-01

Spatial Digital Twins: Global Status, Opportunities, and the Way Forward

WGIC
World Geospatial Industry Council

On behalf of WGIC, this report was prepared by
Integris Group Services

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Contributors:

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Executive Summary

A Digital Twin is more than a 3D model or a simulation. It is an evolving, virtual representation of an object or process that uses data from, and observations of, its physical counterpart. Sensors enable analysis across a variety of metrics, typically enabled by a flow of data from its physical counterpart that is used to analyze, simulate and study the physical object[1].

The concept of Digital Twins has been applied in various industries globally for many decades, particularly in the manufacturing environment. Recent advances in technology and reduction in costs of sensory devices (e.g., Internet of Things) for data collection has created an uplift in interest, application and breadth of use-cases.

Practically speaking, the common component across all Digital Twins, culminated with ongoing data feeds and analytics capability, is a level of visualization that allows (and enables) interacting with the digital replica for the benefit of its physical counterpart (asset), system or process. When the Digital Twin visualization includes dimensionally accurate and spatially positioned elements, sensor positions and componentry; additional applications are unlocked that also enable isolated systems to be aggregated into Regional and even Global scale ecosystems.

This report refers to Spatial Digital Twins as those which include a specific spatial context and provide a holistic; dimensionally accurate and location-based representation of assets, infrastructure and systems. Spatial Digital Twins refer to much more than the built-environment and can exist at various levels of accuracy, detail and aggregation. Spatial Digital Twins can cover buildings, clusters of buildings or other infrastructure, entire networks, cities, countries and even the globe.

1 Source: What is a digital twin? | IBM

Research has identified that in 2021, there was an estimated USD$12.7B revenue associated with Digital Twins, with an ~$8B Total Addressable Market[2] for the Geospatial Industry. This is projected to rise to $45B by 2026, with ~$25B Total Addressable Market[3] for the Geospatial Industry.

With the anticipated growth of the Digital Twin market, as well as its ability to improve feasibility of smart cities, utilities, infrastructure and smart agriculture, taking principles of Digital Twins developed in Aerospace and Manufacturing[4] "out of the facility" and applying them in wider use-cases requires more information to truly align the digital and physical worlds.

Recent digitization experiences, however, across varying industries worldwide (such as Building Information Modelling in Asset Design, Construction and Management) are warranting caution in the adoption of Digital Twins "as a silver bullet" solution by investors. Furthermore, with the heavy investment often required for developing Digital Twins, additional perspectives of the global geospatial industry and beyond has driven WGIC to undertake this study. Obtaining feedback and insights from the industry was also important to obtain, particularly when establishing policy or investment rationales.

Research and input from SMEs has found there is a strong benefit to both unlocking value and enabling increased usability of almost all Digital Twins through the fundamental use of spatial data.

Figure 1: Report Findings

All advanced Digital Twin use-cases rely on spatial data (Spatial Digital Twins)

Geospatial data is fundamental to unlocking more applications from existing or individual Digital Twin ecosystems

Spatial data capture services by the geospatial industry can enable improved visualization with low-cost alternatives

2 Source: Juniper Research, 2020 and – footnote reference
Calculated by subtracting the estimated Manufacturing Revenues from the total revenues. The Serviceable market is estimated to be a fraction of this figure attributed to the Geospatial Industry, with the remaining portion attributed to other stakeholders (e.g., Technology Providers, Sensory Device Providers, Consultants, Service Providers such as Engineers, etc.)

3 Source: Digital Twin Market Size Global forecast to 2026 | MarketsandMarkets™ and analysis for portion of Total Addressable Market, calculated as per note 3.

4 Source: Juniper Research, 2020 and – footnote reference
Calculated by subtracting the estimated Manufacturing Revenues from the total revenues. The Serviceable market is estimated to be a fraction of this figure attributed to the Geospatial Industry, with the remaining portion attributed to other stakeholders (e.g., Technology Providers, Sensory Device Providers, Consultants, Service Providers such as Engineers, etc.)

By leveraging geospatial data to create an 'applications pull' that encourages wider applications and use-cases for Digital Twins, it has been found that more socio-economic value can be derived than the original inception use-cases (manufacturing and aerospace). High-level assessment of socio-economic criterion in this report has also confirmed that spatial data are key contributors to adoption, value and scalability across the 27 use-cases assessed for Digital Twins.

In 2020, the Geospatial Industry contributed over $440B[5] to the global economy and is arguably at the center of current digital transformations and global shifts towards sustainability. With the right promotion of the benefits gained by including spatial data within Digital Twin ecosystems, additional value, applications and ease of visualization will be unlocked to:

1 Improve uplift and return on investments in DigitalTwins,
2 Improve adoption, aggregation and scalability of Digital Twin ecosystems,
3 Uplift socio-economic outcomes from individual systems right through to global Digital Twins, and
4 Continue to underpin the value provided globally by the Geospatial Industry.

5 Source: GeoBuiz 2019 Report

Introduction

The concept of Digital Twins has been applied in various industries globally for many decades, particularly in the manufacturing environment. Recent advances in technology and reduction in costs of sensory devices[6] for data capture (e.g., Internet of Things) has created an uplift in interest, application and breadth of use-cases.

A Digital Twin is more than a 3D model or a simulation. It is an evolving, virtual representation of an object or process that uses data from, and observations of, its physical counterpart.[7]

A Digital Twin is a dynamic, digital replica of a physical object, process or system that provides up to real-time status and performance monitoring from sensors and observations – which aid decision-making processes, planning and predictive capabilities.

The opportunity space for Digital Twins, through increased access to data and information across products, systems, assets, processes and production, has led to many services and technology providers worldwide promoting Digital Twin capabilities. Thought leaders around the globe have been focusing efforts on estimating and/or quantifying the benefits of Digital Twin adoption; typically finding that drivers include driving productivity, reducing costs and providing an improved understanding of the performance of physical assets and systems.[8]

Minimizing the Gap between the Physical and Digital World

The convergence of the Digital World and the Physical World, independent of size of the product, asset, ecosystem or process, mirrored within a digital environment, generates a range of benefits.

These benefits include (but are not limited to) enabling owners and decision makers to simulate and model performance in varying scenarios, predicting outcomes with higher certainty, identifying and analyzing issues for up keep, updating and upgrading physical items or assets; as well as unlocking latent value from systems, processes, technologies and people.

The common component across Digital Twins, culminated with ongoing data feeds and analytics capability, is a level of visualization that allows (and enables) interacting with the digital replica for the benefit of its physical counterpart. This visualization capability enables both a deeper understanding, and engagement, across multiple tiers of stakeholders. This permits new insights previously not possible to deduce consistently from analytics alone, and currently are typically applied within single, isolated ecosystems.

6 Source: https://www2.deloitte.com/us/en/insights/focus/tech-trends/2020/digital-twin-applications-bridging-the-physical-and-digital.html

7 Source: Refer to What is a Digital Twin? section for further information.

8 Source: https://www2.deloitte.com/us/en/insights/focus/tech-trends/2020/digital-twin-applications-bridging-the-physical-and-digital.html

Visualization in some instances can be as simple as a low-definition model, ranging to intricate networks of assets and components, all of which display near- time or real-time performance of the physical item or asset.

As detailed in this report, Spatial Digital Twins include a specific spatial context and provide a holistic dimensional and location-based representation of assets, infrastructure and systems. This refers to much more than the built-environment and exist at various levels of accuracy, detail and aggregation. Spatial Digital Twins can cover buildings, clusters of buildings or other infrastructure, entire networks, cities, countries and even the globe.

Global Driving Forces of Digital Twins

Public authorities as well as governmental and multilateral agencies are increasingly important driving forces in the funding and development of Digital Twins that serve a wide variety of organizational needs and public interest. Through research and engagement with SMEs and others on key inclusions of Digital Twin ecosystems, when the Digital Twin visualization includes dimensionally accurate and spatially positioned elements, sensor positions and componentry; additional applications are unlocked that also enable isolated systems to be aggregated into Regional and even Global ecosystems.

Perspectives on the evolution of Digital Twins and wider applications outside Manufacturing have seen a natural progression from paper plans to 2D/3D CAD, to Building Information Modelling (BIM) and now from BIM to Digital Twins[9] and ultimately the Metaverse (Virtual / Augmented Reality)[10]. In parallel to this, we're seeing gamification capabilities converge that bring a life-like visualization, driving further development of Digital Twins and beyond.

Additionally, technology providers and industry participants are continuously adapting existing solutions, services and innovations to allow wider adoption of Digital Twin solutions. Among these solutions and services are asset management, to enable and integrate models, data repositories, uplift stakeholder participation and leverage ongoing updates of data to better monitor the physical world within the Digital Twin ecosystem, as well as identify risks and opportunities that can predict and quantify improvements prior to needing to take any action.

Emerging Uncertainty and Lessons Learned

The recent digitization efforts across various industries worldwide such as Product Lifecycle Management (PLM), Building Information Modelling (BIM) in product/asset design, Construction and Management as well as simulations across processes and workflows, have a lot of "lessons learned" to utilize in Digital Twin applications. Investors, project teams and stakeholders aware of the new technological "promises" use caution in the adoption of Digital Twins "as a silver bullet", particularly because previous comparable transformations (e.g. BIM) have ended up (for most) as being more a cost-saving exercise than a revenue-generating one[11].

9 Source: WGIC Engagement Survey Responses and Interviews with Subject Matter Experts

10 Source: What Is the Metaverse, Exactly? | WIRED. WGIC acknowledges that the metaverse is more than a technology such as Augmented/Virtual Reality however for the purposes of accessibility and report context have looked at the enabling capabilities to interface with the metaverse.

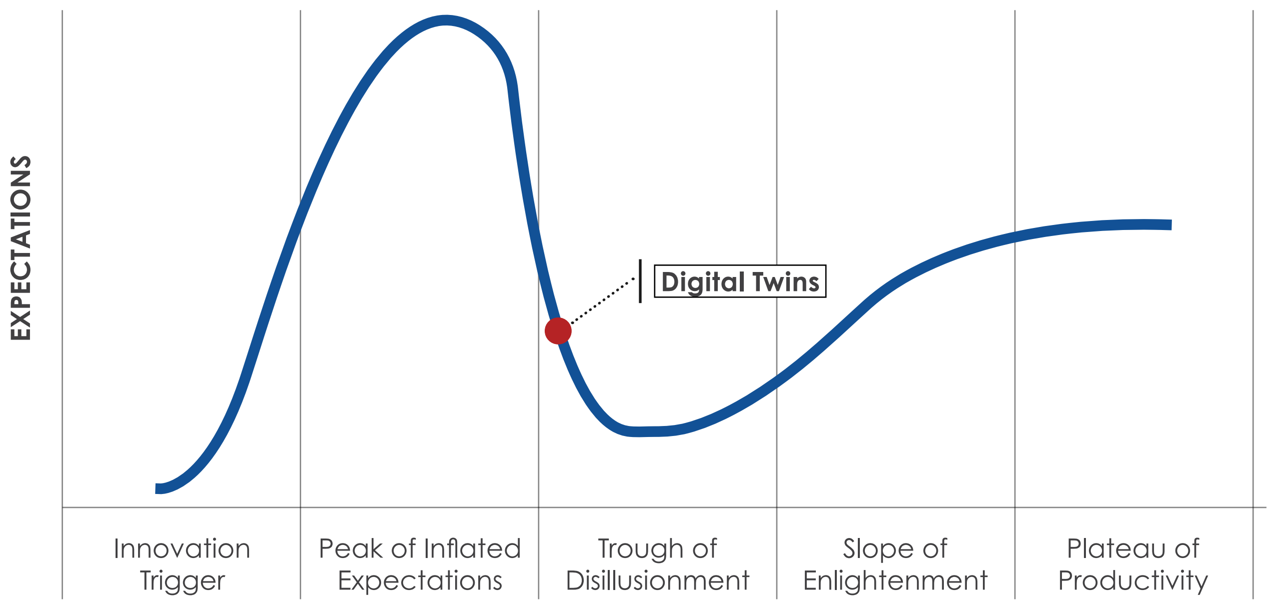
11 Source: 2103-au-bim-perspectives-brochure-bsi0535-web.pdf (bsigroup.com)

As with all emerging technologies, Gartner's Hype Cycle[12] demonstrates a standard maturity and evolution of technologies, from inception to normalization, for which Digital Twins are not immune.

With the 'technological push' of Digital Twins via automotive/aerospace manufacturing applications now entering the trough of disillusionment (as of August 2021), it is critical that the time spent in this phase of the Hype Cycle is minimized as much as possible.

By leveraging geospatial data to create an 'applications pull' that encourages wider applications and use-cases, more value can be derived from Digital Twins than the original inception use-cases[13].

Figure 2: Gartner Hype Cycle



Source: Gartner (July 2022)

Assessment of socio-economic criterion in this report has also identified that a key contributor to adoption, value and scalability is unlocked when Digital Twins are underpinned by Spatial Data that can minimize the time to productivity.

In several use-cases and industry examples researched, adoption of Digital Twin solutions provide high value and benefit. However, the impact of the current phase of maturity across Digital Twins and the promotional behaviors of some stakeholders have created uncertainty in adoption, application and uptake. Examples include:

12 Source: Gartner

13 Based on revenues alone, the Digital Twin economic market is already beginning to generate more revenue outside manufacturing (as demonstrated by Juniper Research)

- An over-use, and adaptation, of synonymous terminology for Digital Twins such as "the mirrored world" and others;
- Service Providers are also calling 3D and 4D models Digital Twins;
- Industry players are "hacking" existing models, or applying simplified meshes, to deliver Digital Twin visualization layers that impacts the integrity and usability of the Digital Twin; and
- Common practice is often to seek methods to export and import data, rather than integrating systems that create a single source of truth.

Investment Considerations

With the heavy investment often required to develop Digital Twins,[14] additional perspectives of the global industry (from both WGIC Members and from the global Digital Twin community at large) was a driving force for WGIC to undertake this study to:

- Gain an understanding of existing trends, standards and codes of practice;
- Validate perspectives of the value-add that Spatial Data adds in Digital Twin solutions for end-users and at various stages of maturity/development;
- Consolidate current research by institutions into applications of Digital Twins broadly, and Spatial Digital Twins specifically; and
- Engage with influencers and advocates to governments, policy makers and global organizations developing and maintaining Digital Twins.

14 Source: Cost to build a Digital Twin (consultengsurvivor.com)

The Opportunity for Digital Twins

Introducing Digital Twin capabilities across industries and sectors will create wider-scale benefits to society as a whole. Diving in too quickly, however, without determining the problem to be solved, identifying stakeholders and decision maker needs, quantifying the success factors of implementation and opportunities for wider adoption all impact the socio-economic benefits of Digital Twin implementation.

WGIC has identified benefits including reduced risk and optimization across lifecycle management, increased transparency and uplifted stakeholder participation, which all drive: benefits realization, return on investment and increased breadth of application of the Digital Twin ecosystems.

There is a strong benefit through the fundamental use of spatial data to both unlocking value and enabling increased usability of almost all Digital Twins. With the anticipated growth of the Digital Twin market, as well as its ability to improve feasibility of smart cities, utilities, infrastructure and smart agriculture; taking principles of Digital Twins developed in Aerospace and Manufacturing[15] "out of the facility" and applying them in wider use-cases requires more information to truly align the digital and physical worlds.

A Foundation for Unlocking Value from Digital Twins: Geospatial Data

When Digital Twins include two key aspects to their visualization and attributes, they continue the evolution kick-started by BIM and Digital Engineering by leveraging dimensionally accurate and spatially positioned elements, sensor positions and componentry leads to additional applications that add scalability to investment and benefits from Digital Twins, in addition to the visualizations and insight not possible from 2D plans or 3D models.

The Role of Geospatial Data and Information in Digital Twins

To support and enable the direct (and wider) applications of Digital Twins, there is a proven benefit in the use of geospatial data to rationalize the effort in measuring and associating global positioning of digital replicas of the physical item or asset.

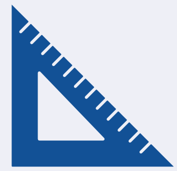
Spatial Digital Twins enable the integration and aggregation of multiple Digital Twin items or assets, and underpin the ecosystems developed to support broader engagement with, and insights from Digital Twin ecosystems.

15 Juniper Research, 2020 and – footnote reference
Calculated by subtracting the estimated Manufacturing Revenues from the total revenues. The Serviceable market is estimated to be a fraction of this figure attributed to the Geospatial Industry, with the remaining portion attributed to other stakeholders (e.g., Technology Providers, Sensory Device Providers, Consultants, Service Providers such as Engineers, etc.)

Figure 3: Attributes of Spatial Digital Twins

Spatial Positioning Attributes

Information to position the Digital Twin in a reference frame (position and orientation)



Dimensional Accuracy

Ability to understand, visualize and analyze the Digital Twin's size, geometry and distances

It is critical throughout the development, that the use of terminology and various options to design, develop, deploy, operate, maintain and update Digital Twins, that an effort be made to align, unite and convey a clear picture of the following:

- What a Digital Twin actually is;
- How to apply good-practices in Digital Twins development and use;
- Where the direct and indirect benefits from geospatial data are sourced across various use-cases and industry applications;
- The current state and future trends of Digital Twins; and
- The role the Geospatial Industry can play in uplifting value derived from Digital Twins.

Key Questions investigated in this Policy Paper

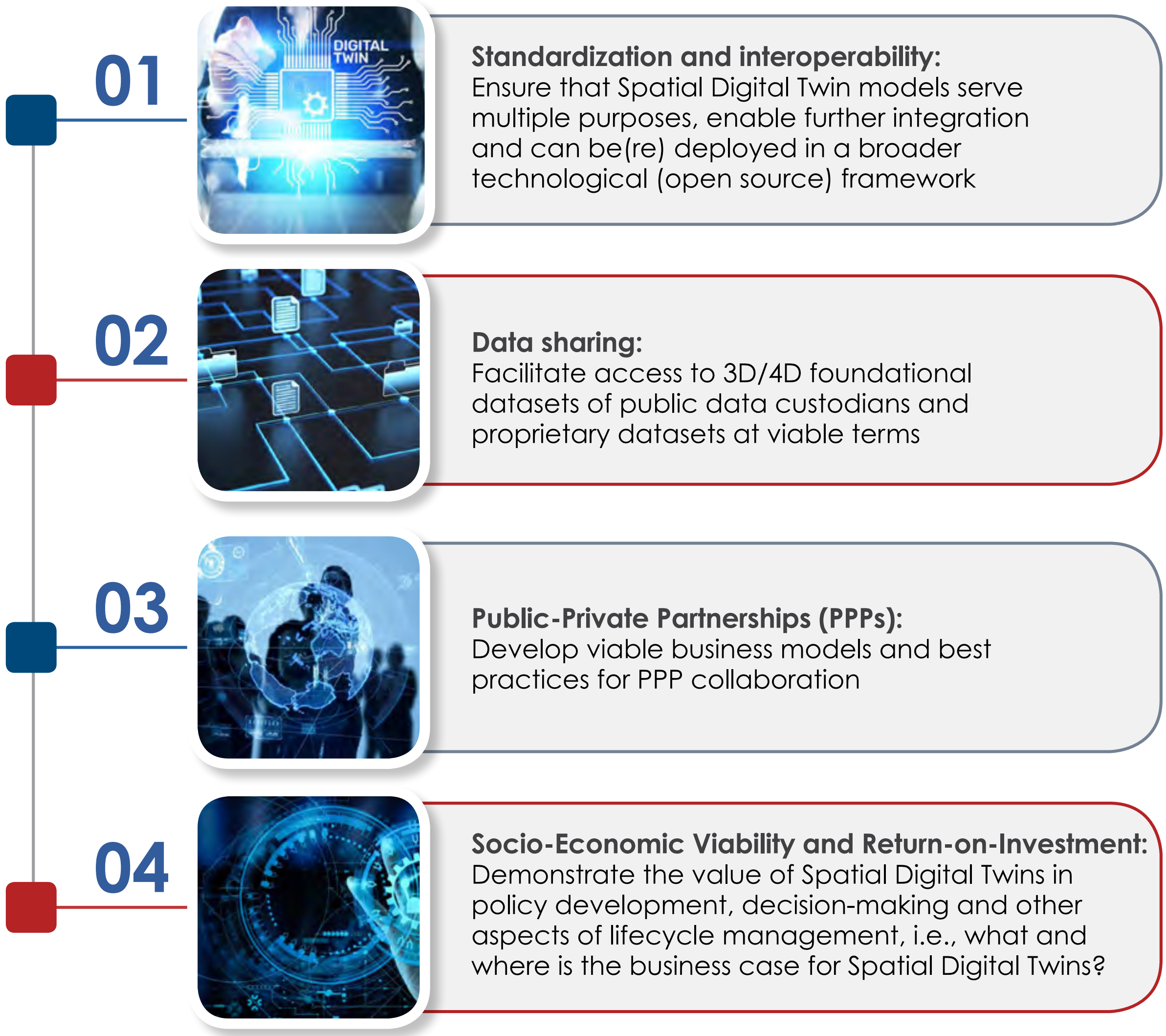
The research conducted by WGIC was aimed at structuring and developing answers to the following key questions:

1 How much value does (or could) spatial data add to Digital Twins applied by government, industry and multilateral agencies?
2 What socio-economic value does spatial data add to Digital Twins?
3 Which use-cases could add value if they held spatial data?
4 What does the global geospatial industry need to embrace so that spatial data services add and, demonstrate the value of Digital Twins?

Other Research Considerations

As a result, thought leaders and WGIC have identified the need to focus more on the following research considerations:

Figure 4: Research Considerations

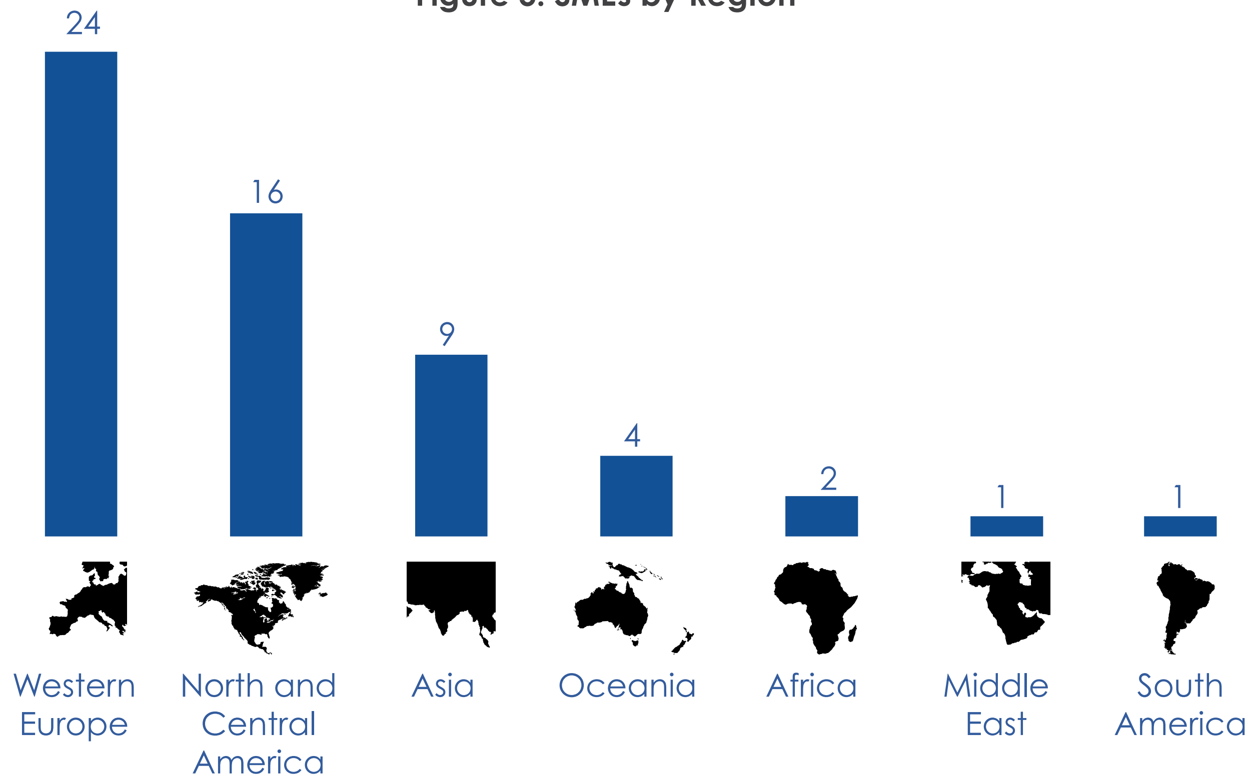


Profile of SMEs

WGIC engaged with more than 60 experts (19 WGIC Members and 43 others) across multiple industries worldwide to provide input and feedback on Spatial Digital Twins. Demographics of the respondents is shown below:

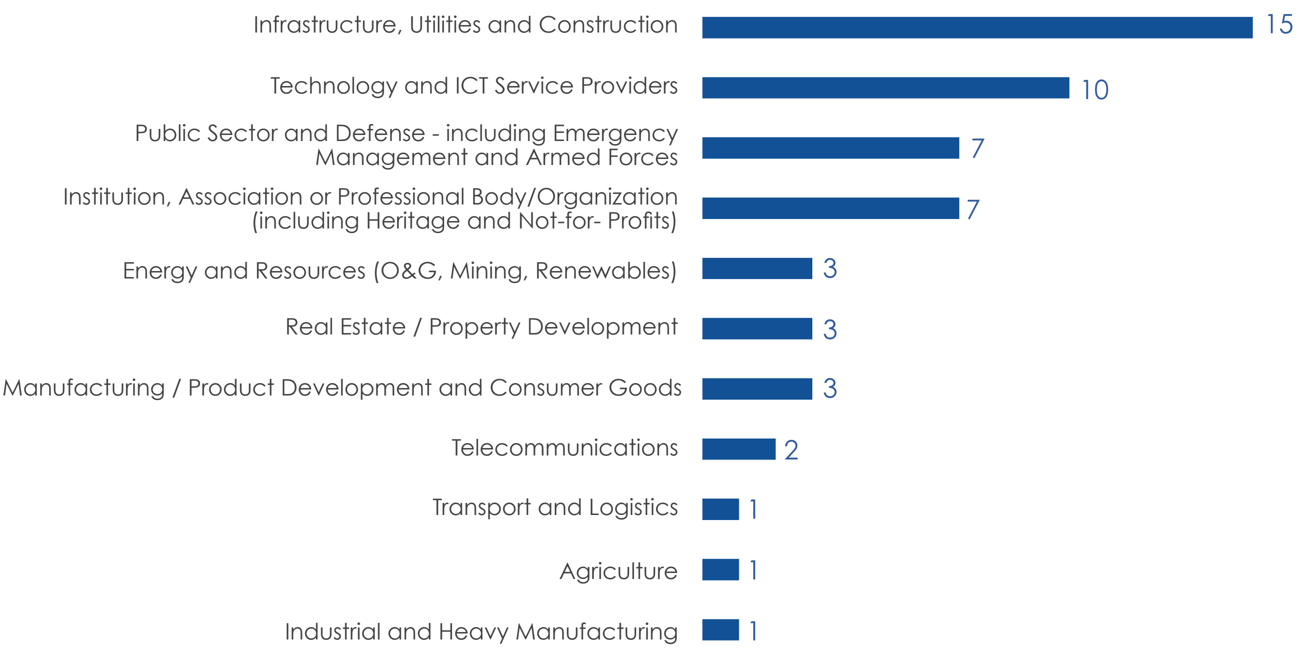
Additional (more detailed) interviews were also conducted to better understand use-cases, investment considerations, policy recommendations and current-state industry maturity with both respondents and other SMEs.

Figure 5: SMEs by Region



Source: WGIC Engagement Survey and Interview feedback

Figure 6: SMEs by Industry



Source: WGIC Engagement Survey and Interview feedback

What is a Spatial Digital Twin?

A Digital Twin is a dynamic, digital replica of a physical object, process or system that provides up to real-time status and performance monitoring from sensors and observations – which aid decision-making processes, planning and predictive capabilities.

A Digital Twin is more than a 3D model or a simulation. It is an evolving, virtual representation of an object or process that uses data from, and observations of, its physical counterpart. Sensors enable analysis across a variety of metrics, typically enabled by near- or real-time flows of data that are used to analyze, simulate and study the physical object.

Digital Twins are promoted as an approach or methodology that aids more informed decisions, increases productivity and improves outcomes through the use of visual interaction[16].

Spatial Digital Twins include a specific spatial context and provide a holistic dimensional and location- based representation of assets, infrastructure and systems. This refers to much more than the built- environment and exist at various levels of accuracy, detail and aggregation. Spatial Digital Twins can cover buildings, clusters of buildings or other infrastructure, entire networks, cities, countries and even the globe.

Although Spatial Digital Twins are often used for planning, lifecycle management and monitoring tools in a "Smart City" or similar context, Spatial Digital Twins can also be applied in other domains and/or broader ecosystems (e.g., agriculture, energy, natural resources management, transport, etc.).

For example, the European Union, in late 2020, announced an initiative called Destination Earth (DestinE) to build a "Digital Twin" of the globe at a 1-kilometer resolution to simulate the atmosphere, ocean, ice, and land, and to forecast floods, droughts, and fires, from days to years in advance, and attempt to model human behavior, enabling leaders to see the impacts of weather events and climate change on society, as well as gauge the effects of different climate policies[17].

As there are several available sources of definitions for Digital Twin in the public domain and through various standards organizations[18], WGIC conducted a global scan to synthesize the definition, attributes and benefits from a range of sources across academia, industry, and the public sector to establish the definition of a Spatial Digital Twin:

16 WGIC identified similar themes and sources for benefits during research into definitions of Digital Twins

17 Source: https://digital-strategy.ec.europa.eu/en/policies/destination-earth

18 Over 11 varying bodies and organizations have been identified by WGIC through global scans to be developing standards associated with Digital Twins.

Figure 7: Definition of Spatial Digital Twin

Definition

Spatial Digital Twins build on the virtual representation of real-world entities and processes by using positioning and dimensions to uplift the value, insight and integrity of the virtual model which, in many instances, may be continuously updated at a synchronised frequency and fidelity.

Attributes

Whether implicitly or explicitly, most Digital Twins include in their virtual representations, the precise location and relative dimensions of elements included in their models.

Benefits

Spatial Digital Twins improve visualisation, are faster to interpret, enable socio-economic applications and insight at a scale that outweighs the additional investment of a spatially accurate and positioned digital model of physical entities and processes.

Figure 8: Feedback on WGIC Definition of Spatial Digital Twin

4.1 out of 5 SMEs respondents believe this is a good definition of a Spatial Digital Twin

Source: WGIC Engagement Survey and Interview feedback

Research Findings

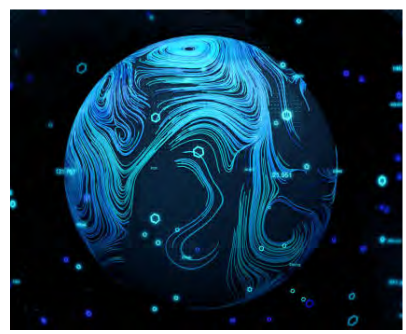
The remaining sections of this paper include research and analysis that define the future vision, assess the current state of Spatial Digital Twins and establish recommendations for their investment, governance and application.[19]

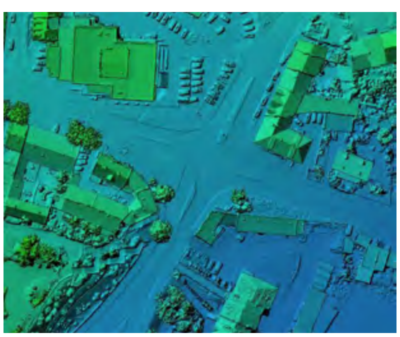
Three key findings were identified:

Figure 9: Report Findings

All advanced Digital Twin use-cases rely on spatial data (Spatial Digital Twins)

Geospatial data is fundamental to unlocking more applications from existing or individual Digital Twin ecosystems





Spatial data capture services by the geospatial industry can enable improved visualization with low-cost alternatives

19 Whilst most respondents within non-geospatial industries identified during interviews the preference for highly accurate and intricate 3D models, low-cost alternatives that have a lower dimensional accuracy, spatial positioning integrity and are lower fidelity (e.g. 3D Meshes or textured models) are directly applicable alternatives to as-designed models or cost-prohibitive models.

A Future Vision of Spatial Digital Twins

Every Digital Twin across the globe is updated in real-time, with information flows from sensors/inputs underpinned by spatial data. Benefits, impacts and opportunities available to humanity can be identified by aggregating every Digital Twin based on their position, size and level of detail.

In the future, information, underpinned by spatial data (positioning and dimensioning), information is shared across Digital Twins, so every Digital Twin can be aggregated or connected to inform, uplift and influence stakeholders and Digital Twins around them.

In this future state, Digital Twins can be connected into a global ecosystem (just like the physical world) so that data from individual and aggregated Digital Twins can be used to forecast, measure and realize opportunities that drive socio-economic and environmental improvements.

Each Spatial Digital Twin on the planet, when combined through their physical location and context of the product, physical asset, network, processes and data; creates a true reflection of the Earth that continuously evolves through data and inputs enabling forecasting on a global (macro), regional and site-specific (micro) level.

Asset owners, policy makers, the public sector, defense, decision-makers and citizens more broadly can access this ecosystem, navigate to their area of interest and access information that is continuously maintained, updated and upgraded, at the right level of detail for their use.

The spatial data underpinning this ecosystem accurately dimensions each Digital Twin and positions it on the globe with high certainty.

Spatial data also supports the network of sensors providing live data, measurements and trends to inform the performance, utilisation, benefits and impacts at a site, region and/or global level, which when aggregated create an accurate Digital Twin of Earth.

Deeper Dive – Future Vision

Analysis into the characteristics of the relation and interplay of the three "voxels" (or bounding areas) outlined in this future vision demonstrates the importance of geospatial data that enables the aggregation and integration of Spatial Digital Twins in a combined, connected and global ecosystem.

While this future vision may seem optimistic, evidence suggests that there are examples of applications across all three scales occurring independently; that have been aggregated in isolated use-cases[20].

Figure 10: Details of Future Vision

Micro (Site-Specific)

Site-Specific or Product-Specific Spatial Digital Twins are empowered by the ability to be visualised at scale and in-position through metaverse (Augmented and Virtual Reality) applications.

It is used by asset/property owners and custodians to provide detailed information for site-specific, operational and project status and monitoring; applicable through all project lifecycle stages and held in secure technology systems with varying access profiles.

The information is not used in isolation or “skimmed” across project lifecycles, so information and reliability gradually improves over time to enable future use-cases and aggregation.

Owners volunteer or operate under regulated requirements to enable aggregation by government or aligned stakeholders through "hybrid" Digital Twins.

Hybrid or Regional (Multi-site or Municipality)

The aggregation of Spatial Digital Twins drive project lifecycle decisions at a wider scale to support socio-economic factors, capacity management or performance measures set in legislative, municipality or precinct policies.

It is used by developers, municipal councils, regulators and public sectors to enable planning, development, regulating/auditing and assessing performance across sites or municipalities (e.g.City Planning). It establishes links and connectors with a selection of live, site-specific data to provide up-to-date information that build a wider view across precincts or municipalities and are linked via secure ecosystems/interfaces.

Selected information and details are aggregated from sites or products to enable reporting with live information; and data and information provided by site-specific DT's based on voluntary/regulatory requirements to "skim" the Digital Twin for hybrid-application purposes.

Municipalities volunteer or share information from the Digital Twin ecosystem to inform and enable aggregation by higher tiers of government or aligned stakeholders.

Macro (State, Region, Country or Global)

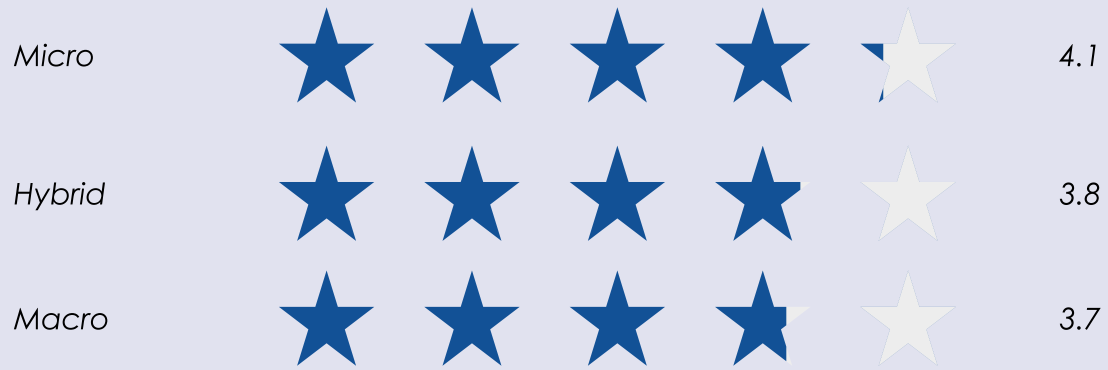
Ongoing data feeds from sensors, real-time access to micro/hybrid Digital Twins and other datasets enable trend analysis using spatial data as primary keys that inform humanity-level decision-making.

It is used by the Public Sector, Global Community and Defense to provide a suite of information on public assets (e.g.utilities), coordinated fleet/operations and environmental measurements, all made available through spatial-data-infrastructure that are at a suitable level of detail for use in context.

The publicly available data is not granular enough to be used in a way that compromises public safety or security, and can be aggregated as a “clipped” subset with micro-or hybrid-level data sources (e.g.3rd party data) to improve precinct development, simulation and visualisation.

20 Direct example from the City of Wellington in New Zealand obtained during WGIC interviews

Figure 11: Feedback on WGIC Future Vision



3.9 out of 5 SMEs respondents align with the future vision across Micro, Hybrid and Macro voxels Engagement

Source: WGIC Engagement Survey and Interview feedback

Examples of existing initiatives that align with the future vision

This list is not exhaustive, however does demonstrate how spatial data is currently underpinning Digital Twins being developed and invested in for the benefit of owners, regions and humanity as a whole.

European Union

The vision of DestinE is to develop a high precision digital model of the Earth to model, monitor and simulate natural phenomena and related human activities[21]. As part of European Commission's Green Deal and the Digital Strategy, DestinE will contribute to achieving the objectives of the twin transition, green and digital.

With modelling and analytics at the global scale, use-cases include modelling effects of climate change, water and marine environments, polar areas, cryosphere, biodiversity or extreme weather events, together with possible adaptation and mitigation strategies.

DestinE is also looking to (similar to other examples presented in this section) open up access to public datasets across Europe, enabling stakeholders at all levels to:

- Continuously monitor the health of the planet: For example, to study the effects of climate change, the state of the oceans, the cryosphere, biodiversity, land use, and natural resources.
- Support EU policy-making and implementation: For example, to assess the impact and efficiency of environmental policy and relevant legislative measures.
- Perform high precision, dynamic simulations of the Earth's natural systems, focusing on thematic domains such as marine, land, coasts, and atmosphere.
- Improve modelling and predictive capacities: For example, to help anticipate and plan measures in case of storms, floods and other extreme weather events and natural disasters.

21 Source: [Destination Earth | Shaping Europe's digital future (europa.eu)]

- Reinforce Europe's industrial and technological capabilities in simulation, modelling, predictive data analytics, artificial intelligence (AI) and high-performance computing (HPC).

DestinE aims to develop a user-friendly and secure cloud-based digital modelling and simulation platform that provides access to data, advanced computing infrastructure including AI applications and analytics. It will enable integration of its datasets with individual Digital Twins to provide information a from wider context for the benefit of sites, municipalities and regions.

Germany

The German Federal Agency for Cartography and Geodesy (BKG) is creating a Digital Twin of Germany that can be used to simulate various future scenarios to adequately address societal challenges, such as the increasing use of land, rising energy demands and extreme weather[22].

Leveraging the European Commission (EC)'s plans to create a digital replica of Earth within the next decade; on a more local level, several Digital Twin initiatives for cities and municipalities are also underway. BKG aims to position its Digital Twin Germany as the gap between international and local initiatives. As such, interoperability of services and data and the sharing of knowledge, data and tools are considered crucial steps in realizing the full potential of the future vision.

New Zealand

In Wellington, New Zealand, when an earthquake of a specific magnitude occurs, private sensor data is aggregated from building owners and combined with public-sector data within a highly visual Spatial Digital Twin ecosystem, assisting emergency management efforts. The benefits of this solution primarily come from a reduction in the "closure time" of the city's buildings through a triaged sensor-data analysis that identifies priority risk zones[23] within the city, reducing inspector workloads and enabling the public to return to their homes and offices more quickly.

Singapore

The Smart Nation and Virtual Singapore Initiatives have established the foundation for aggregation and access to a backbone of spatial data that can support additional applications developed by Industry and other stakeholders.

The fundamental approach used by the Singapore Government enables users from different sectors to develop sophisticated tools and applications for test-bedding concepts and services, planning and decision-making, and research on technologies to solve emerging and complex challenges for Singapore[24].

Additionally, 94% of existing government processes have been digitized by the Smart Nation Initiative, which will help establish Digital Twins of processes moving forward[25].

22 Source: Building a Digital Twin for Germany | GIM International (gim-international.com)

23 A reduction from 3-day closures on 7.0-magnitude earthquakes down to 1-day closure is possible using aggregated sensor data from across the city to identify high-risk buildings for inspection.

24 Source: https://www.nrf.gov.sg/programmes/virtual-singapore

25 Source: https://www.smartnation.gov.sg/

United Kingdom

The UK's National Digital Twin initiative, in collaboration with BSI is aiming to deploy a future vision for Spatial Digital Twins. The Centre for Digital Built Britain (CDBB) is leading a National Digital Twin Programme on behalf of the UK Government that aims to help harness the power of Digital Twinning for the national good.

The endgame is to achieve better interventions and to unlock greater value from the physical asset by improving or perhaps extending its performance and services. BSI[26] have established 'BSI Flex 260'in January 2022 that is aimed for further development as a Standard across Britain, part of the UK input into the development of a European standard or potential international standard in future.

The goal is to document a common language that will align stakeholder expectations, mitigate friction when information is exchanged between Digital Twins and ultimately accelerate innovation.

Its publication marks the beginning of an exciting journey that has the potential to deliver significantly better outcomes for the economy and society if we get Digital Twinning right[27].

United Nations

The Vision of the DITTO Programme is a world where Digital Twins of the Ocean are used to support ocean protection, ocean governance and a sustainable Blue Economy[28].

The Mission of DITTO is to develop and share a common understanding of Digital Twins of the ocean (DTO); to establish best practice in the development of DTOs; and advance a digital framework for DTOs to empower ocean professionals from all sectors around the world including scientific users, to effectively create their own Digital Twins.

Other Initiatives

Similar to DITTO, there are multiple initiatives led by the public sector (such as State-based Governments in Australia[29] and other parts of the world) where 'open access' to information is made available to supplement analysis and collaboration across industry, public sector, education and the community.

26 Source: BSI Flex 260 v1.0 | BSI (bsigroup.com)

27 Source: BSI Flex 260 v1.0 | BSI (bsigroup.com)

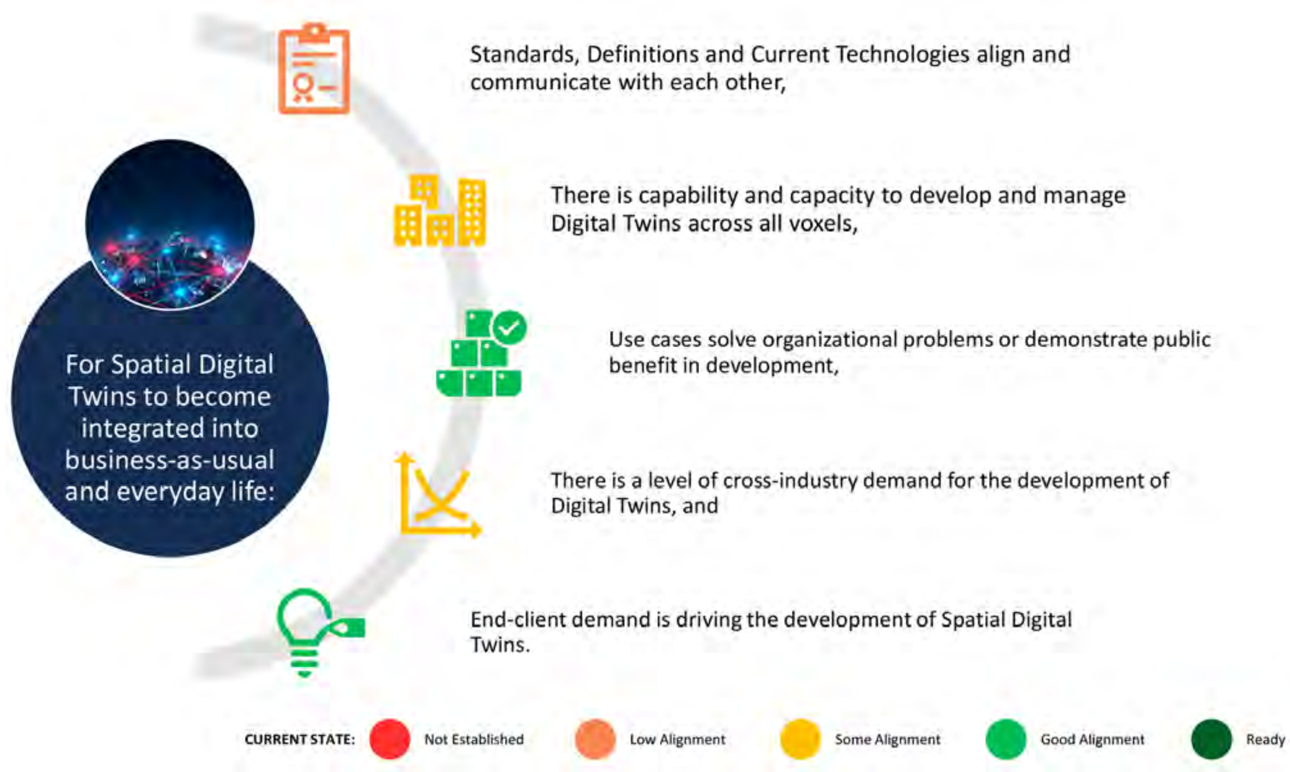
28 Source: DITTO – Digital Twins of the Ocean – DITTO a Global Program of the UN Decade of Ocean Science for Sustainable Development (2021-2030) (ditto-oceandecade.org)

29 Source: Digital Twin Victoria (land.vic.gov.au)

Current Trends, Use-Cases and Industry Maturity

To enable the future vision, there are key areas that WGIC see needs to be established for Spatial Digital Twins to become integrated into business-as-usual and everyday life. The following five segments are expanded in the remainder of this section:

Figure 12: Current State Assessment



Standards, Definitions, Current Technologies

Establishing standards in the deployment of technologies, processes and ways of working is critical for collaboration, connectivity and communication across people, assets, systems and applications. To enable the identified future vision, standards need to be flexible enough to apply in multiple contexts; as well as rigid enough to enforce data transfer and information exchange in meaningful formats.

Research into approaches used by industry standards bodies[30] has identified that there are generally two (main) ways standards are developed, both of which evolve through an iterative and consultative approach over a long-term horizon:

- Employing a ***structured approach*** that follows four key steps of defining the meaning; identifying all possible use-cases; establishing frameworks that fit/apply to the use-cases; and then defining the exchange protocols and standards across technologies; or
- Using a ***collaborative and user-demand-driven*** approach that prioritizes the establishment of an interest in data exchange and information sharing before "normalizing" on use-cases, frameworks, definitions and data formats/standards.

While each approach may have benefits or considerations, it is apparent from the research that there are multiple organizations working on standards for Digital Twins and Spatial Digital Twins.

Further review and research, particularly into the lessons learned from recent technology implementations and associated standards work, has shown that during the early years of new technology development, technology providers have to establish their own ecosystems and frameworks in isolation, or establish partnerships[31] which impact wider adoption and establish barriers to industry alignment when standards-development processes don't keep up with end-client demand.

Usability of existing standards

Despite these challenges in the development and alignment of standards, when asked how important standards are across industries, 4 out of 5 SMEs considered standards as essential in Spatial Digital Twin Development:

Figure 13: Standards

Source: WGIC Engagement Survey and Interview feedback

30 Such as ISO, IEC, BSI, BuildingSMART and OGC.

31 Such as ESRI and Autodesk's partnership

Research findings and feedback from SMEs identified that accessing standards for Spatial Digital Twins is reasonably feasible[32], and agree there is an opportunity to use precise location attributes associated with assets and components as primary integrators of data. Location attributes should be considered as part of any Spatial Digital Twin standards attributes framework.

As seen in the National Digital Twin Initiative UK[33], where Governments have adopted a standard and provided investment into use-cases research through the Centre for Digital Built Britain; industry has a north-star direction and can invest with confidence in further opportunities associated with Spatial Digital Twins.

Current Capacity/Capability

Interviews and research identified that the current capability and capacity for the development and deployment of Spatial Digital Twins is also dependent on the industry, personnel and process maturity, global region and the availability of and access to technology[34].

That said, there have been consistent "themes" and "requirements" drawn from various sources that apply across people, processes and technology factors to consider when designing, developing and deploying Spatial Digital Twins.

People and Processes

Feedback from SMEs on successful implementations of Digital Twins (and Spatial Digital Twins) are linked to two common themes[35]:

- Understanding a clearly defined problem or use case, and
- A high level of enthusiasm for the opportunities Spatial Digital Twins provides.

Additionally, there is evidence of the struggle of readiness organizations have associated with Digital Twins:

- Some organizations don't understand what Digital Twins are, and promote 3D models as Digital Twins
- Some don't have the appropriate data (including 2D - 3D - 4D data sources) to use as part of analysis and the Digital Twin Value Stream
- Some understand the concept of what constitutes a Digital Twin but not how to develop, implement or maintain one, and
- Some are unclear on who the end client is and instead promote what is possible, not linked to a particular need, identified problem or quantified benefit.

32 Source: Feedback from WGIC Engagement Survey and Interviews
33 Source: https://www.bsigroup.com/en-GB/blog/Built-Environment-Blog/bsi-flex-260-blog/
34 Source: Feedback from WGIC Engagement Survey and Interviews
35 Source: Feedback from WGIC Engagement Survey and Interviews

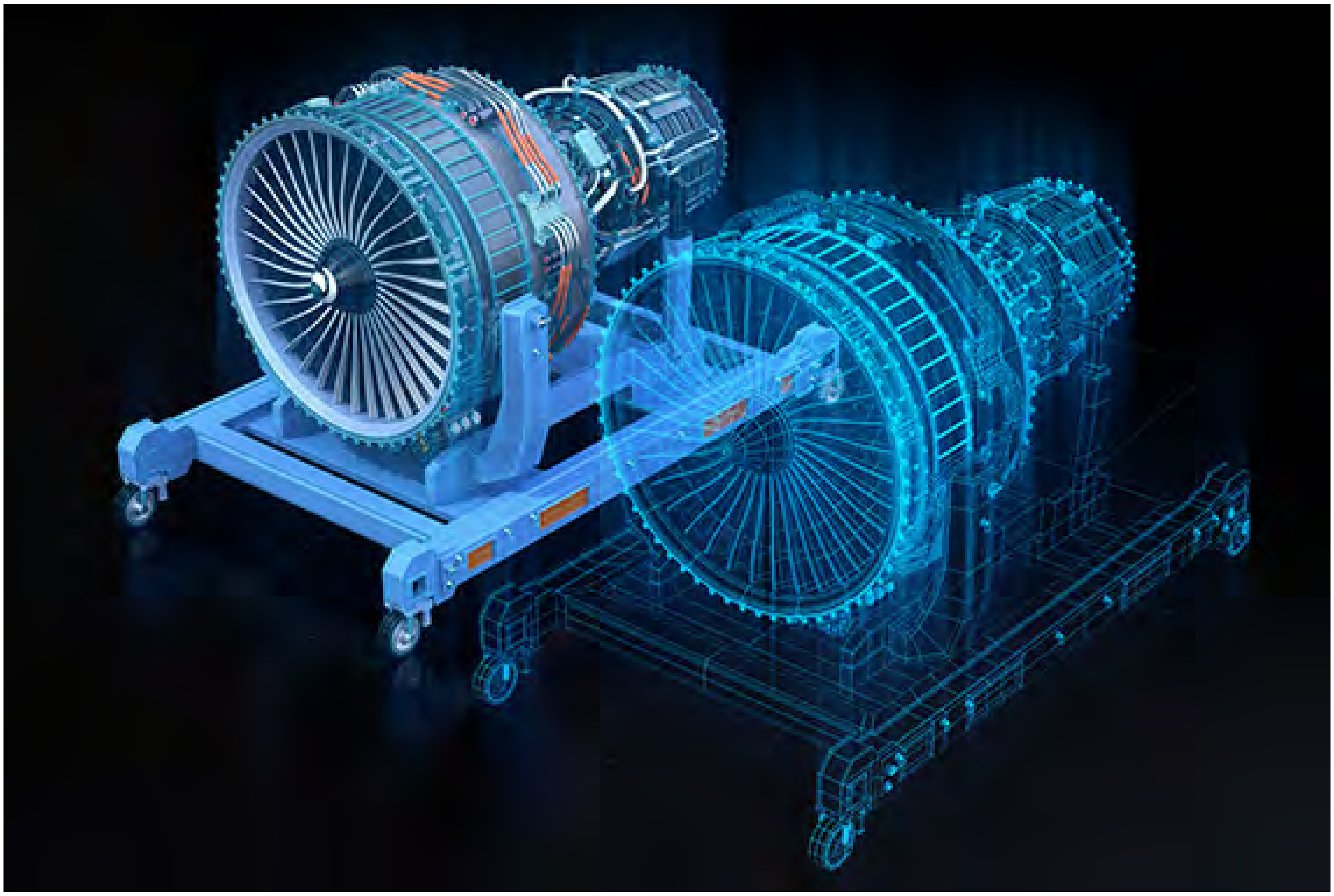
Finally, other consistent areas for improvement identified with SMEs and through research include:

- Quantifying benefits,
- Working with limited access to data and inputs or the varying data format requirements across technologies;[36] and
- Where implementations either attempt to:
  - → deliver too much, and/or
  - → do not adequately manage expectations across stakeholders.

Technology

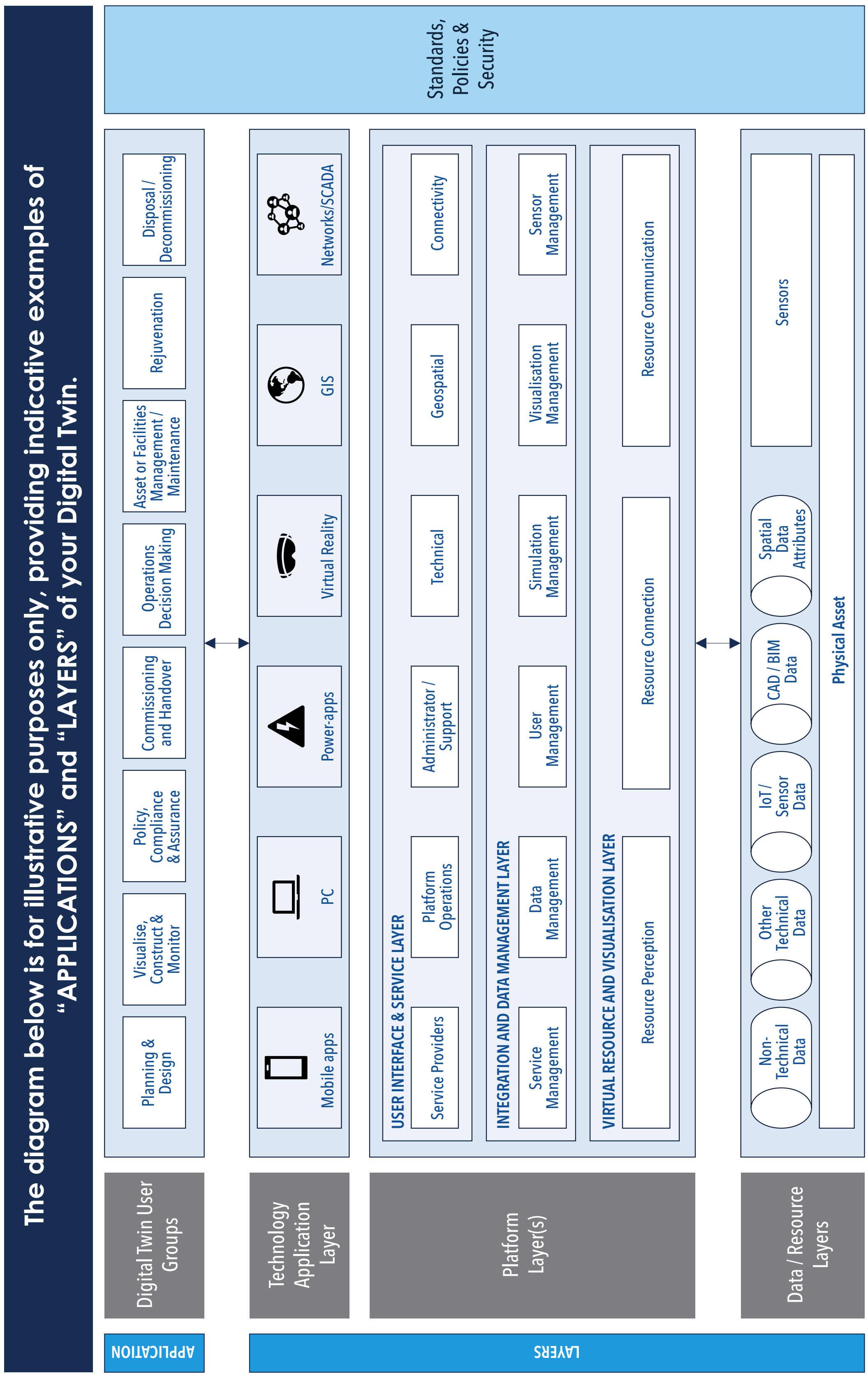
The following technological capability framework serves as a blueprint for development of Spatial Digital Twins; validated through this research and the SMEs responses.

This generic framework should apply across all Spatial Digital Twins, and we welcome feedback and its use by policy makers and Standards Organizations.



36 Whilst this challenge has been identified, majority of SMEs who faced this problem were able to resolve this using integration platforms.

Figure 14: Tech/Capability Stack | Spatial Digital Twins

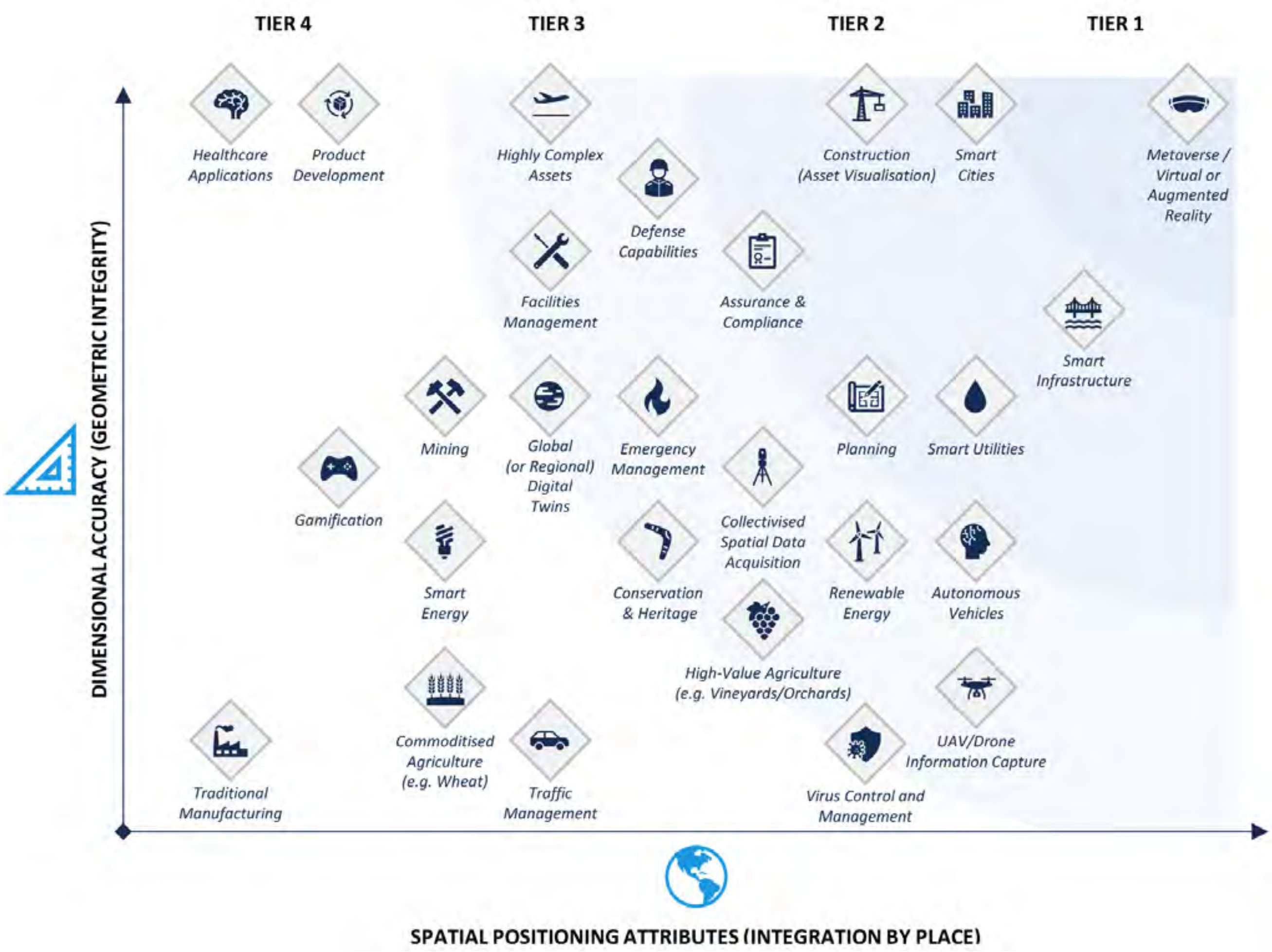


Use-Cases

Through extensive research and global scans, as well as input from SMEs, 27 use-cases were identified for Digital Twins, linked to various business or organizational needs[37]. Almost all of these use-cases leverage or utilize spatial data in some way. Each use case had at least one identifiable business problem and/or met an identified organizational need.

The purpose of each "tier" was to identify the current (relative) reliance on spatial data across use-cases, so that further research and analysis could more easily identify new opportunities[38] from uplifting the availability or reliability of spatial data accessible for, and on, the specific Spatial Digital Twin.

Figure 15: Use-cases (Based on Research & Surveys)



37 Refer to "Deeper Dive into Digital Twin Use-cases" section for further information.

38 Refer to "Roadmap to Value (and Recommendations)" section for further information.

As a part of this study we identified four tiers of use-cases. These tiers are identified below:

Tier 1:

The Metaverse and Virtual or Augmented Reality use case relies heavily on accurate dimensions and positioning to align the digital overlay of the user (e.g., Microsoft HoloLens or Google Glass).

Tier 2:

Advanced and urban-based applications have a high reliance on spatial data, noting that some use-cases rely on one spatial aspect more than the other (e.g., dimensional accuracy).

Tiers 3 and 4:

This wide-ranging set of applications are candidates for further analysis. There may be future opportunities where increased use of spatial data within the Digital Twin can add value through improved outcomes on an individual basis, and/or opportunities to combine or aggregate information across multiple use-cases (see future vision).

Deeper Dive into Digital Twin Use-cases

Further details on each of the 27 use-cases have been identified in the table below:

Table 1: Use Case Initial Assessment

Tier	Use Case	Description	Layer
1	Augmented/Virtual Reality	Providing instruction during Maintenance Activities through remote SMEs support, such as presenting data on "covered" or "shrouded" assets through use of AR/VR	Asset Maintenance Visualisation
2	Construction (Asset Visualisation)	Improved data visualisation capabilities through geospatial data	Visualisation
2	Smart Cities	Development of Building/Asset Infrastructure underpinned by digital datasets	Product/Asset/Systems
2	Smart Infrastructure (Transport)	Development of Building/Asset Infrastructure underpinned by digital datasets	Product/Asset/Systems
2	Smart Infrastructure (Utilities)	Development of Building/Asset Infrastructure underpinned by digital datasets	Product/Asset/Systems
2	Assurance and Compliance	Applying Digital Twins during the commissioning stages of asset lifecycle (BIM)	Product/Asset/Systems
2	Planning	Applying Digital Twins during the design stage of asset lifecycle (BIM)	Product/Asset/Systems
3	Facilities Management (Managing Assets)	Applying Digital Twins during the operations, maintenance and decommissioning stages of asset lifecycle	Product/Asset/Systems

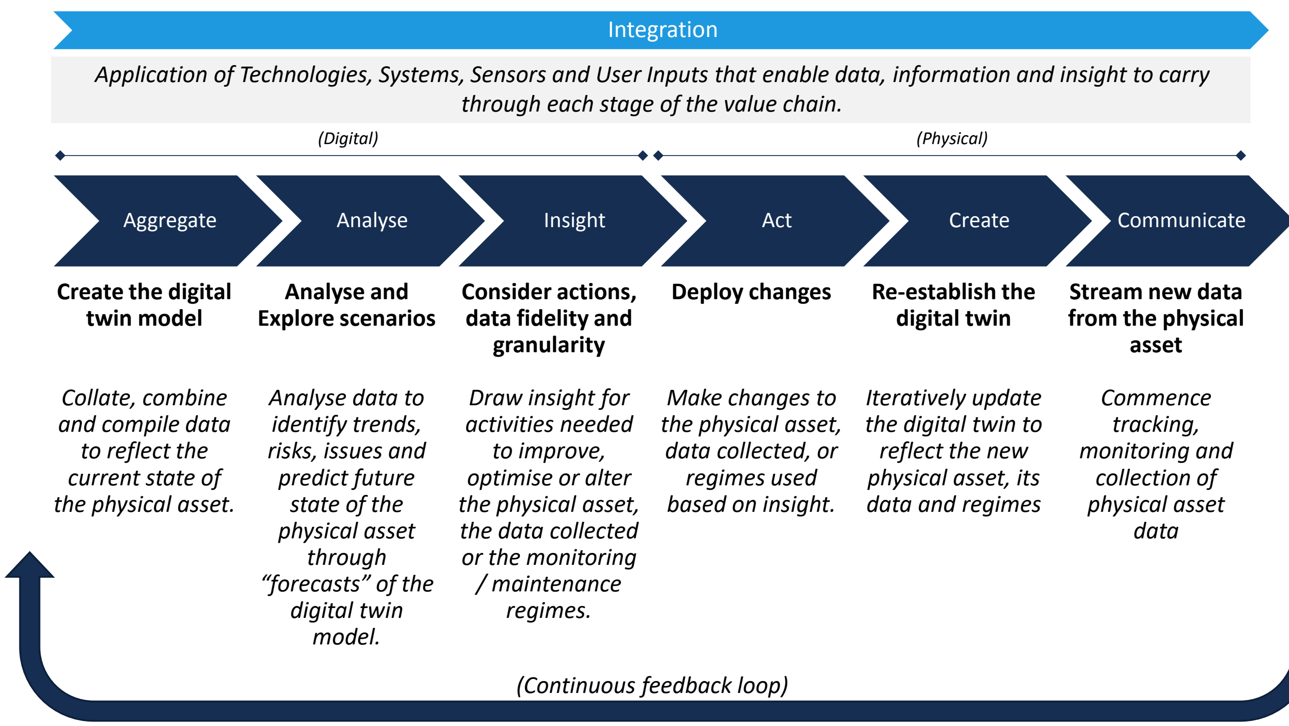
3	Emergency Management	Developing a Spatial Dataset of assets for response actions	Socio-Economic
3	Conservation and Heritage	Protection of significant sites through improved positioning, mapping and monitoring of the site	Socio-Economic
3	Global (or Regional) Digital Twins	Collating publicly available information (e.g., weather)	Socio-Economic
3	High-value Agriculture (e.g., vineyards/orchards)	Use of UAV's and Sensors for information collection for targeted condition monitoring of high-value agriculture	Socio-Economic
3	Defense Capabilities	Monitoring and Positioning Assets used for Defense (e.g., warships)	Product/Asset/ Systems
3	Collectivised Spatial Data Acquisition	Using Geospatial Data as the "link" for aggregation and bonding data together	Visualisation
3	Autonomous Vehicles	Creating a "just in time" Digital Twin for informed decision making on road safety hazards when driven autonomously	Telemetrics
3	Highly Complex Assets	Heavy Manufacturing (e.g., Ships), Aerospace/Aviation	Product/Asset/ Systems
3	Renewable Energy	Positioning sensors on renewable energy sources highlighting their condition and current utilisation	Utilities and Comm's
3	UAV's / Drone Information Capture	Use of UAV's and Drones for information collection (e.g., in remote settings) instead of static sensors	Telemetrics
3	Virus Control and Management	Tracking people and contagion spread to simulate forecast impacts and effectiveness of controls	Socio-Economic
4	Traditional Manufacturing	Conventional production facilities Traditional Manufacturing, Process/Operations, Conventional Energy Production	Product/Asset/ Systems
4	Healthcare Applications	Presenting data from Digital Twins to assist in health care applications	Visualisation
4	Product Development	Use of Digital-to-Virtual-to-Digital Workflows in product development and Product Lifecycle Management	Product/Asset/ Systems
4	Mining	Safety Management, Production Monitoring and locating resources and assets in real time to identify risks, opportunities and efficiencies in production	Socio-Economic
4	Smart Infrastructure (Energy)	Development of Infrastructure network underpinned by digital datasets	Product/Asset/ Systems
4	Commoditized Agriculture (e.g., Wheat)	Use of UAV's and Sensors for information collection for large scale condition monitoring	Socio-Economic
4	Traffic Management	Use sensor data inputs to manage detours around live congested traffic	Telemetrics
4	Gamification	Use low-detail modelling with highly developed gaming engines to offset costs of 3D modelling and positioning of assets relative to a real-world coordinate system	Visualisation

Cross-Industry Demand

Given the findings of the relative importance of spatial data across these identified use-cases, it is essential that the value perception of the benefits of spatial data be high, and that the geospatial industry is recognized by other professions who design, develop and deploy Digital Twins.

When asked for specific feedback on the value and confidence in the information provided by the geospatial industry for application, SMEs outside industry scored the geospatial profession strongly (4 out of 5 stars)[39] .

Figure 16: Digital Twin Value-chain Process[40]



39 Source: WGIC Engagement Survey and Interview feedback

40 Source: "https://www2.deloitte.com/us/en/insights/focus/tech-trends/2020/digital-twin-applications-bridging-the-physical-and-digital.html" Digital twins: Bridging the physical and digital | Deloitte Insights

Figure 17: Digital Twin Value Chain by Sector - Analysis of Survey Respondents

Integration

Application of Technologies, Systems, Sensors and User Inputs that enable data, information and insight to carry through each stage of the value chain.

(Digital) *(Physical)*

	Aggregate	Analyse	Insight	Act	Create	Communicate
Academia	Somewhat Involved	Somewhat Involved	Heavily Involved	Somewhat Involved	Not Involved at all	Somewhat Involved
Architecture, Engineering & Construction (AEC)	Heavily Involved	Heavily Involved	Heavily Involved	Heavily Involved	Heavily Involved	Somewhat Involved
Asset/ Facilities Management	Somewhat Involved	Somewhat Involved	Heavily Involved	Somewhat Involved	Somewhat Involved	Somewhat Involved
Business Administration or Business Management	Somewhat Involved	Somewhat Involved	Not Involved at all	Not Involved at all	Somewhat Involved	Somewhat Involved
Geospatial Measurement	Heavily Involved	Somewhat Involved	Somewhat Involved	Involved Sometimes	Heavily Involved	Involved Sometimes
Geospatial Technology & Analysis	Somewhat Involved	Somewhat Involved	Somewhat Involved	Somewhat Involved	Somewhat Involved	Somewhat Involved
ICT	Heavily Involved	Essential	Essential	Somewhat Involved	Somewhat Involved	Somewhat Involved
Institution / Regulatory or Standards Bodies	Somewhat Involved	Somewhat Involved	Somewhat Involved	Somewhat Involved	Somewhat Involved	Somewhat Involved
Public Sectors	Heavily Involved	Somewhat Involved	Somewhat Involved	Somewhat Involved	Somewhat Involved	Somewhat Involved
Scientist	Heavily Involved	Heavily Involved	Heavily Involved	Heavily Involved	Heavily Involved	Heavily Involved

Source: Analysis of SMEs Survey Respondent Self-Assessment

These results validate the importance of the Geospatial Industry in the development of Spatial Digital Twins.

Maturity Spectrums

Using a value chain assessment approach, we leveraged research and stakeholder engagement to identify any missed opportunities, as well as any identifiable value-adds that the geospatial industry provides to other industries.

A breakdown of industry involvement across the value chain has been developed with the following results:

As demonstrated above, there are two areas the Geospatial Industry should focus to assist other industries (Aggregate and Create). However, it is important to observe the wider activities that other industries must also undertake when engaging with industry and providing services in the Digital Twin lifecycle.

End-Client Demand

We also found that while SMEs largely agree with the identified future vision, they were less optimistic about the current investment demand from clients based on responses to the engagement survey and interviews.

Through research and consultation, we attributed the 27 use-cases across the relevant future vision "voxel" to identify the gap in end-client demand. As outlined below, given the majority of use-cases lay within the Micro and Hybrid Use-Case categories, the risks of a lull in end-client demand are marginally reduced, further validating the opportunities and use-cases that the geospatial industry can focus on to create more value.

Figure 18: Categories of Use-cases Identified during Research

Future Vision

Every digital twin across globally is updated in real-time, with information flows from sensors/inputs underpinned by spatial data. Every benefit, impact & opportunity available to humanity can be identified by aggregating every digital twin based on its position and size.

Size/ Scale

Current Use Cases & Examples

Micro-level Digital Twins have a wealth of detail for Site- or Product-Specific decision-making

Use Cases & Current Examples:

- *Products, Manufacturing & highly-complex assets*
- *Healthcare*
- *Metaverse (AR/VR Applications)*
- *Individual sites (E.g. Construction sites, Plants, Facilities Management, etc.)*
- *High-Value Agriculture*
- *Conservation & Heritage*
- *UAV / Drone Information Capture*

Hybrid-level Digital Twins aggregate selected data from micro-level or municipality/gov't datasets

Use Cases & Current Examples:

- *Smart-Cities and Energy/Utilities*
- *Collectivised Spatial Data Acquisition*
- *Infrastructure & Multi-Site Developments*
- *Localised Network Applications*
- *Energy & Resources (incl. Mining & Renewables)*
- *Autonomous Vehicles*
- *Planning, Assurance and Compliance*
- *Commoditized Agriculture**
- *Defense Applications (e.g. coordinated fleet/operations)*

Macro-level Digital Twins aggregate public (and/or Hybrid-Level) data from all available data sources.

Use Cases & Current Examples:

- *Spatial Data Infrastructure (SDI) enabled use cases:*
  - *DestinE (European Space Agency)*
  - *UK Digital Twin,*
  - *NSW Digital Twin (Australia)*
- *Major Network Applications*
  - *Traffic Management*
  - *Underground Utility Networks, etc.*
- *Weather & Emergency Management*
- *Socio-economic use cases*
- *Gamification*
- *Virus Control and Management*

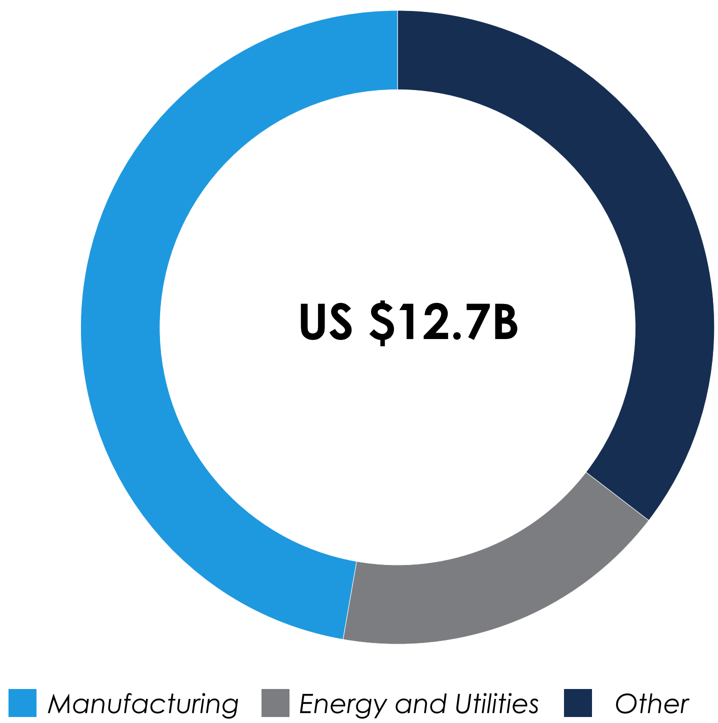
Figure 19: Mapping of Use-cases by Spatial Scale

	Micro Use Cases	Hybrid Use Cases	Macro Use Cases
Tier 1	1	0	0
Tier 2	1	5	0
Tier 3	5	4	3
Tier 4	3	3	2

Investors in Digital Twins

Research has identified in that in 2021, there was an estimated USD$12.7B revenue associated with Digital Twins, with ~$8B Total Addressable Market for the Geospatial Industry. This has been calculated by subtracting the estimated Manufacturing Revenues from the total revenues.[41] The Serviceable market is estimated to be a fraction of this figure attributed to the Geospatial Industry, with the remaining portion attributed to other stakeholders (e.g., Technology Providers, Sensory Device Providers, Consultants, Service Providers such as Engineers, etc.). This is projected to rise up to $45B by 2026, with ~$25B Total Addressable Market[42] for the Geospatial Industry.

Figure 20: Digital Twin Market Size



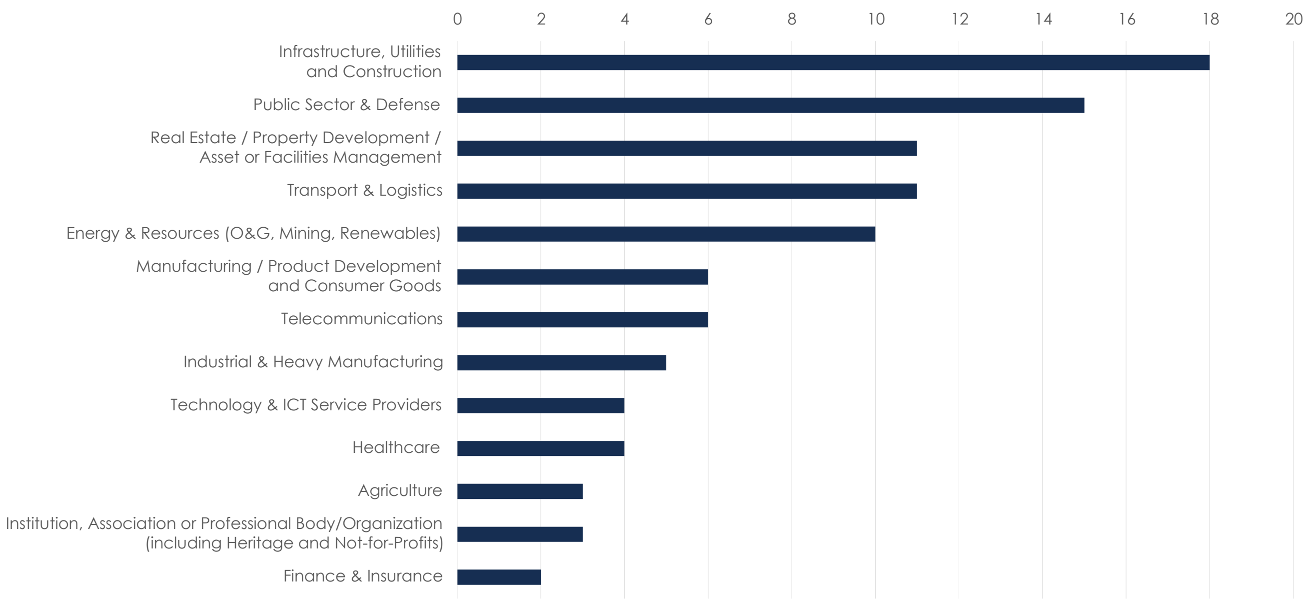
Source: Juniper Research

41 Source: Juniper Research, 2020 and – footnote reference
Calculated by subtracting the estimated Manufacturing Revenues from the total revenues. The Serviceable market is estimated to be a fraction of this figure attributed to the Geospatial Industry, with the remaining portion attributed to other stakeholders (e.g., Technology Providers, Sensory Device Providers, Consultants, Service Providers such as Engineers, etc.)

42 Source: Digital Twin Market Size Global forecast to 2026 | MarketsandMarkets™ and WGIC Analysis for portion of Total Addressable Market, calculated as per note 2

Findings from the engagement with SMEs[43] appear that construction, infrastructure and utilities appear to be strong contributors to the development of Spatial Digital Twins, as well as energy and resources, property development, the public sector and transport and logistics:

Figure 21: Digital Twin Use-cases by Sector



Source: WGIC Engagement Survey and Interview feedback

It is also understood that there are additional investments in technology solutions and services by venture capital firms and start-ups that were not included in the Survey.

43 This may be skewed due to the number of respondents and their industries. It can be considered a rough approximation of the breakdown of the Total Addressable Market for the Geospatial Industry.

Roadmap to Value and Recommendations

Successful investments in Spatial Digital Twins all start with a clear business problem or organizational need. While both Digital Twins and Spatial Digital Twins can be effective and provide positive outcomes for decision-makers and the community as a whole, they often require heavy investment[44] across a full value chain with ongoing costs to maintain and improve the ecosystem.

To justify these costs, there needs to be a clearly defined:

1 Benefit that outweighs the investment;
2 Business case that outlines the roles, responsibilities, costs, risks and timelines for implementation and ongoing up keep; and
3 Rationale as to why a Digital Twin or Spatial Digital Twin is the correct "tool" to use.

Considering a (Spatial) Digital Twin as an analytical and insight generating tool can help decision-makers understand whether the solution is, first, appropriate in the context of the operations, then determine if there are any synergies or opportunities through integration with other ecosystems or services to strengthen the benefits realization of the solution.

Socio-Economic Value of Spatial Data

In 2020, the Geospatial Industry contributed over $440B[45] to the global economy and is arguably at the center of current digital transformations and global shifts towards sustainability. With the right promotion of the benefits gained by including spatial data within Digital Twin ecosystems, additional value, applications and ease of visualization can be unlocked to:

1 Improve uplift and return on investments in Digital Twins,
2 Improve adoption, aggregation and scalability of Digital Twin ecosystems by companies and governments,
3 Uplift socio-economic outcomes from individual systems right through to global Digital Twins, and
4 Continue to underpin the value provided globally by the Geospatial Industry.

44 Global Scans and Research has found that a Digital Twin for a Grade A Commercial Office building of around 600,000 ft2 (60,000 m2) can cost between US$1.2m and US$1.7m and a more complex and larger General Hospital building of around 2,100,000 ft2 (200,000m2) can cost between US$3m and US$4.2m. Additional costs may be required for updates to the spatial component of the digital twin above this estimate.

45 Source: GeoBuiz 2019 Report

To further substantiate the value of spatial data, an assessment framework was used to qualify which use-cases add socio-economic value, categorized as:

1 **Spatial Digital Twins**, which will highly likely add value through uplifted spatial data,
2 **Potential Candidates,** which may add value through uplifted spatial data, and
3 **Generic Digital Twins,** where additional spatial data will likely not add value:

Figure 22: Spatial Digital Twin Use-cases

Digital Twin Use Cases

Advanced Use Cases (Spatial Digital Twins)	Potential Spatial Digital Twin Candidates	Generic Digital Twins
• Metaverse • Construction (Asset Visualisation) • Smart Cities • Smart Infrastructure (Transport) • Smart Infrastructure (Utilities) • Planning • Facilities Management (Managing Assets) • Emergency Management • Global (or Regional) Digital Twins • High-value Agriculture (e.g. vineyards/orchards) • Defense Capabilities • Collectivised Spatial Data Acquisition • Renewable Energy	• Assurance & Compliance • Conservation & Heritage • Autonomous Vehicles • UAV's / Drone Information Capture • Virus Control and Management • Mining • Smart Infrastructure (Energy) • Commoditized Agriculture (e.g. Wheat)	• Highly Complex Assets • Traditional Manufacturing • Healthcare Applications • Product Development • Traffic Management • Gamification

Source: WGIC Engagement Survey and Interview feedback

The following section outlines some high-level examples of assessed[46] use-cases, where additional synergies and opportunities could be obtained by users and the community at large if the use-cases employed more spatial data[47], ultimately unlocking additional benefits to support the investment case:

Qualitative Value of Current Advanced Use-Cases

Tier 1: Metaverse (Virtual and Augmented Reality)

The metaverse has been described as a transformational shift in the way humans' interface with technology. Whilst there are many channels to do this (including gaming consoles and PC's) the primary technology associated with the metaverseis Augmented and Virtual Reality[48] (AR/VR).

To truly enable the overlay of the physical and digital worlds through AR/VR, highly accurate models and positioning attributes are needed to create a seamless experience.

Additional Applications enabled through spatially accurate AR/VR include Remote maintenance, Resource Management, however with additional spatial positioning sensors on personnel wearing AR/VR Headsets and interfaces; new data inputs that feed the Digital Twin (including condition assessments and other observational sources) can be integrated into the ecosystem to complement other sensor data available on the physical counterpart.

Tier 2: Smart Cities/Utilities/Infrastructure, Construction, Assurance/Compliance and Planning

By adding spatial positioning details to sensors that monitor the physical assets, not only does data from these Digital Twin use-cases enable decision making on progress and performance from Digital Twin, but there are also additional benefits available through unlocking access to data by wider stakeholders, enabled by spatially positioned assets[49] including:

- Permit/commissioning improvements

46 Socio-Economic assessment criteria based on – footnote reference and qualitative aspects of "Increased, Neutral and Decreased" across the following criterion:
- **Social**
  - Improvements to Employment/income
  - Reduced reliance on resources (personal and commercial/industrial)
  - Uplifted Working Conditions
  - Improvement of / Access to social services (enabled by government)
- **Environmental**
  - Reduction in emissions
  - Decreased waste
- **Economic**
  - Optimising or improving consumption and production levels (supply/ demand)
  - Return on Investment
  - Improved quality
  - Reduced time to delivery

47 Refer to Appendix for Socio-Economic assessment across Tier 1 to 4 Use-cases.

48 Source: [What Is the Metaverse, Exactly? | WIRED]

49 Subject matter experts interviewed by WGIC identified that majority of the Digital Twins developed from BIM or other design models (as the visualization) have a local (or grid-system based) reference system that is typically not positioned in a geospatial reference frame.

- Uplifted City Planning and iterative design,
- Improved asset ratings and uplifted compliance
- Reduced Congestion and efficiencies in flow and usage

Qualitative Value-Uplift of Other Use-Cases

Tier 3: Opportunities for improved collaboration and application

There are three sources of opportunities unlocked through either improved dimensional accuracy or establishing spatial positioning attributes across Tier 3 use-cases:

- **Recreate**
  → Use of Digital Twin to relocate or recreate replicas of significant sites

- **Monitor**
  → Yield forecasting and pricing/analytics
  → Real-time asset conditioning and improvements to maintenance routines
  → Temporal analysis of changes (including environmental)

- **Predict**
  → Future Planning and Energy/Usage Analytics that serve as input to SmartCities
  → Forecasting, Simulating and Predicting emergency impacts for support in mitigation and controls

Tier 4: Selected use-cases could add wider benefits with increased spatial data attributes

In addition to similar opportunities identified in Tier 3 above, there are spatial attribute opportunities for product development and manufacturing using the concept of a Digital Thread[50]. By leveraging the spatial position of the product, object or asset as it progresses through the development process, it is possible to monitor trends and trigger corrective actions and improvements:

- Monitoring performance of smart TV's and connected appliances worldwide to understand user demand and improve design (product life cycle management)
- Implement product recalls for under performing products in a proactive way
- Understand buyer and usage behavior for products-as-a-service based on regions or other profiles.

The current trends for the use of GIS and Spatial Technologies for visualization of Digital Twins/BIM/3D Models

There was a consistent trend among interviewees on the use of spatial technologies and services such as Geographic Information Systems (GIS) to enable easy access and visualization of the analytical content within a Digital Twin ecosystem.

50 Source: What Is a Digital Thread? | PTC

In these use-cases, GIS was used as the data aggregator combining BIM, sensory device and analytical data and were also the insights generator and visualization layer for the Digital Twin.

Figure 23: Trends in Geospatial Systems

ArcGIS or similar technologies as a visualization tool and source of truth	Multiple interviewees highlighted the use of ArcGIS or similar technologies to effectively store the data for analysis, remote intervention, visualization and reporting as the central source of truth. *This included Sensor data and switch capabilities ran directly from the desktop interface.*
Establishing a 3D TIN/Mesh of a site to support visualization of the physical asset in a Digital Twin ecosystem	Multiple interviewees highlighted the low-cost alternative for visualization purposes in adopting a 3D TIN/Mesh of a site to help secure the Digital Twin implementation. Whilst the limitations of the 3D TIN/Mesh model were known, the alternative solution enabled an effective visualization of the site.

Source: WGIC Engagement Survey and Interview feedback

These solutions not only demonstrate the importance of spatial data, enable improved visualization, import/export[51] capabilities and offer a lower-cost implementation that reduces the initial expenditure.

Monetization opportunities for accessing geospatial data captured were also identified, including Las Vegas, Nevada[52] that can spread costs through collectivized spatial data capture and modelling activities to generate steady income streams.

Other Challenges and Opportunities

The following additional findings from this work present an opportunity for further research and investigation.

Collaboration

Digital Twins (and Spatial Digital Twins) involve multiple stakeholders, including government, construction, planning (urban, regional, national), transportation, energy, retail, fintech; the list goes on.

51 This may also require additional software or applications

52 https://www.smartcitiesdive.com/news/las-vegas-unveils-digital-twin-at-ces-as-part-of-sustainability-push/616947/

There is an opportunity for the Public Sector to establish guidelines for:

1 Establishing how organizations, industries and policy makers, contributes and maintain standards, and
2 Defining and facilitating forums for cross-industry cooperation and collaboration

Cyber and Information Security

As outlined in the previous WGIC report on information privacy, it is imperative that cyber security is considered as part of any transformation, which extends to Digital Twin initiatives.

Further information can be obtained via WGIC-Policy-Report-2020-01-Geospatial-Information-Policy-Report.pdf (wgicouncil.org)

Training and Development

As the complexities of (Spatial) Digital Twins increase over time, it will require continual uplift of skills and training for both new-entrants (graduates) and existing stakeholders across industry, academia and the public sector. A challenge to be overcome by training providers, industry and the public sector is determining the combination of talent required to continue progressing Digital Twin capabilities and use-cases/applications.

This requires a long-term, strategic plan and collaboration with industry and the public sector to support the development of Study Programs and Training in Digital Twins.

Further investigation into Standards

With the number of organizations currently undertaking activities to define, identify use-cases, establish frameworks and create data exchange standards, there is an opportunity for the public sector and policy makers to establish preferred (or single) relationships with standards bodies as part of policy mandates or endorsements.

Multiple stakeholders[53] have identified the benefits of mandates for digital transformations (e.g., Building Information Modelling) and if coupled with standards, will ensure interoperability among service users and providers, as well as aid the progression towards achieving the identified future vision.

There is a need for standards organizations to work with each other to ensure interoperability of developed standards for Digital Twins. As part of this, Industry and Public Sector should participate to ensure that Digital Twins can scale, communicate and contribute value for the community.

53 Please refer to "Policy Gaps to Close" section of this report for further information.

Research by the Digital Twin Initiative UK also identified a concept of creating data exchange standards at the digital level, instead of from the physical or asset level (current process)[54] *.This concept may assist sustained interoperability initiatives and should be considered as an opportunity for further investigation.*

Further investigation into end-user clients

The scope of this research has been focused on the current state and inputs from SMEs who develop, maintain, provide training or services for Digital Twins and Spatial Digital Twins. While the perspective of these SMEs on end client demand is valuable insight, understanding the end-client perspectives directly is an important complementary research activity to help provide wider context in the Spatial Digital Twin space.

Quantifying economic benefits of Spatial Data

To help policy- and decision-makers invest in new Spatial Digital Twin solutions and technologies; having sound economic bases upon which to build is essential, particularly for the public sector. By investigating and validating the quantitative and qualitative socio-economic benefits of Spatial Data to support Digital Twins, a publicly available reference needs to be created to support investments in Spatial Digital Twins, benefitting the geospatial industry globally and society at large.

Coupled with end-user client and standards research, quantifying economic benefits would provide a holistic perspective of the current Spatial Digital Twin space.

Flip the notion that 'Technology is King' to 'Sustained Interoperability is King'

Systemic to the geospatial industry globally is a desire to implement the latest technologies, applications and workflows[55] . While this is often a positive approach; when done too frequently or without suitable testing of impacts on other stakeholders, new technologies can make a large impact on implementation outcomes.

Simple examples of these unintended consequences include data exchange and attribute updates, with increasingly more complex examples adopting higher detailed sensor data that ultimately overwhelms existing systems and/or requires cleansing or manipulation prior to import.

54 Source: SMEs Interviews

55 Source: WGIC Engagement Survey and Interviews with SMEs

Using one of the following approaches to prioritize sustained interoperability, will help mitigate these risks and ensure that stakeholders are adequately consulted:

1 Conduct pilot programs or set up a testing environment to compare the detail, outputs and benefits/considerations of new data inputs to the Digital Twin ecosystem;
2 Use an integration platform solution within the ecosystem to ensure compatibility;
3 Establish clear business requirements linked to technological specifications when assessing new technologies to confirm their compatibility with existing ecosystems; and
4 All of this applies to standards and data exchange updates and upgrades, so that information is preserved or improved upon in a tested and well-considered transformation.

A focus on sustained interoperability creates an opportunity to establish a "data hub" for cross-industry collaboration, particularly whilst data exchange standards normalize through development by Standards Organizations and other regulatory bodies.

Establish frameworks to support Collection and Cleansing of asset data based on spatial attributes

Research and input from SMEs have indicated that 60% of the work associated with development of Spatial Digital Twins is in the collection, cleansing, translating and converting of spatial data into a usable format for the Digital Twin.

There are opportunities to embrace practices from other of industries/sectors that also manage data well; and apply them within a Spatial Digital Twin environment that should be further investigated:

- Big Data (Supermarkets/Retail, Finance/FinTech, Consumer Goods, etc.) – utilize Spatial Positioning attributes with little to no focus on dimensional accuracy and are very mature in managing data for extracting insight;
- Aerospace / Power Generation – focus on isolated, dimensionally accurate systems but are generally not easily accessible, nor in need of regular data updates from outside the ecosystem; and
- Defense and the Public Sector – look for "multi-layer" or "multi-technology" approaches to fuse data from various sources to create a holistic picture (e.g., airborne LiDAR sensors), but are often inhibited by what information is accessible "within private buildings" due to privacy restrictions

Utilizing good practices and adopting data lakes and data warehouses with additional spatial-based attributes (as primary keys or data integrators) can aid in prioritizing information to cleanse for faster minimum viable products and benefits realization.

A global spatial reference frame will be essential for defining and referencing Spatial Digital Twins within the ecosystem, particularly for achieving the future vision. There are presently two approaches (Voxel-based[56] and Vector-based[57]) that appear to establish suitable reference frames across different applications.

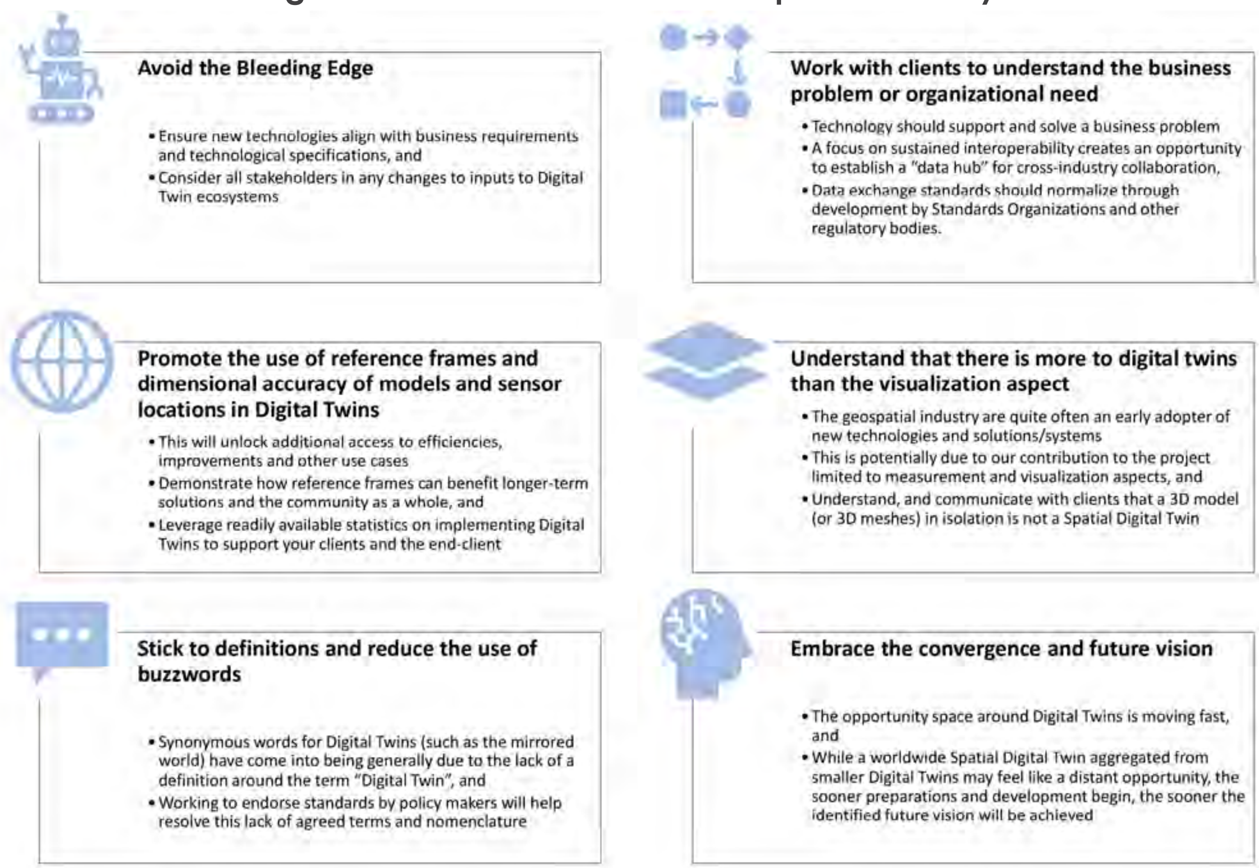
Voxel-Based (Multi-Resolution, Voxel Occupancy Grids) appear to be compatible with computer-based algorithms for fast processing of visual data to help establish the foundational spatial reference frames that deliver the identified future vision.

What the Geospatial Industry needs to do to continue adding and demonstrating value

Although SMEs engaged throughout this research scored, on average, the geospatial industry highly[58], there have been additional insights gained throughout the study to further improve the geospatial industry's approach, preserve its branding and its public perception.

Further recommendations made by SMEs engaged through report development dentified six (6)

Figure 24: Guidelines to the Geospatial Industry



Source: WGIC Engagement Survey and Interview feedback

56 Source: Voxelmaps | Our Mission and Team of Mapping Experts

57 Source: Global COGO, Inc.

58 Refer to the "Cross-Industry Demand" Section of this report for further information

key areas that will enable the Geospatial Industry to demonstrate, and continue to add value in the Digital Twin ecosystem:

Policy Gaps

Research into Digital Twins, Spatial Digital Twins and engagement with SMEs has also identified opportunities to establish or modify policies around Digital Twins and Spatial Digital Twins, to serve as input for consideration by the public sector and policymakers.

What Policy is working well?[59]

The following items have been identified as working well in the Digital Twin space:

- Innovation Policies and Agendas, such as
  - → Alignment of investment to city well being policies
  - → Digital by default policies for government services
  - → Developing National Data Strategies, National Infrastructure Strategies, Integrated Reviews, Construction Playbooks, and Transforming Infrastructure Performance

- Establishing or mandating "one standard" with "one Requirement"
  - → Analogous to "Digitally Built Britain" and Common minimum standards for construction that has mandated the adoption of BIM

- Understand it's an evolution
  - → Integrating as much as possible into business as usual,
  - → Forming agreements on data ownership openness, accessibility of data, etc., and.
  - → Being liberal with data policy, but firm on compliance to standards

What Policies are not working?[60]

The following items have been identified as gaps or challenges to address:

- No single set of standards and requirements globally and across regions
  - → There are no recognized or endorsed standards that are mandated for Digital Twins, and
  - → There are no clear technical definitions on standards to use or work from;

- There is varied (permitted) access to data and ecosystem data collections
  - → The challenges are related to getting organizations to adopt digital data sharing practices.
  - → Legislative mandates and policy to not ensure data is shared.
  - → Incentives are needed, such as making data access part of contract specifications and project deliverables, and
  - → Put data sharing as a formal part of the project sign off;

- Narrow scope of existing policies:

59 Source: WGIC Interviews and Responses to Engagement Surveys

60 Source: WGIC Interviews and Responses to Engagement Surveys

→ Policy tends to focus on technical solutions, rather than socio technical.
→ However, the technical solutions are necessary, but not sufficient, and
→ Human and organizational factors must also be considered.

What does each stakeholder need to do to address the gaps in Policy? (Roadmap)

Current hesitations globally in Policy interventions by governments[61] have been attributed to varying factors including trust, quality of data and computing power, however their impact is much larger than these operational factors.

> *The "void" in establishing narrow (e.g. innovation) policy requires at-risk investment or creates a hesitation by industry and into development of Digital Twins.*

With correlations between Digital Twins and Building Information Modelling (BIM), it is possible to leverage lessons learned for governments in BIM Policy[62] (particularly light-touch and policy mandates) when looking to establish Digital Twin Markets.

What has been identified as best-practice has been public sector policy effectively selecting or nominating a standard, such as that conducted in the UK[63] . It has been found that doing this provides stakeholders with a "direction" on Digital Twins, as well as a level of confidence for investment in Digital Twins. Additionally, factors that will uplift the benefits of Digital Twins include:

- Standards Organizations working with each other to ensure interoperability of standards (across standards and regulatory bodies)
- Participation by Industry and Public Sector in the development of standards and policy
- Ensuring "Open" data, information, standards and exchange forums and repositories
- Ensuring that any updates or changes over time minimize disruption for the community and have a clear purpose

61 Source: Why the Public Sector should Look to Digital Twins for Better Policy Making (digitalurbantwins.com)

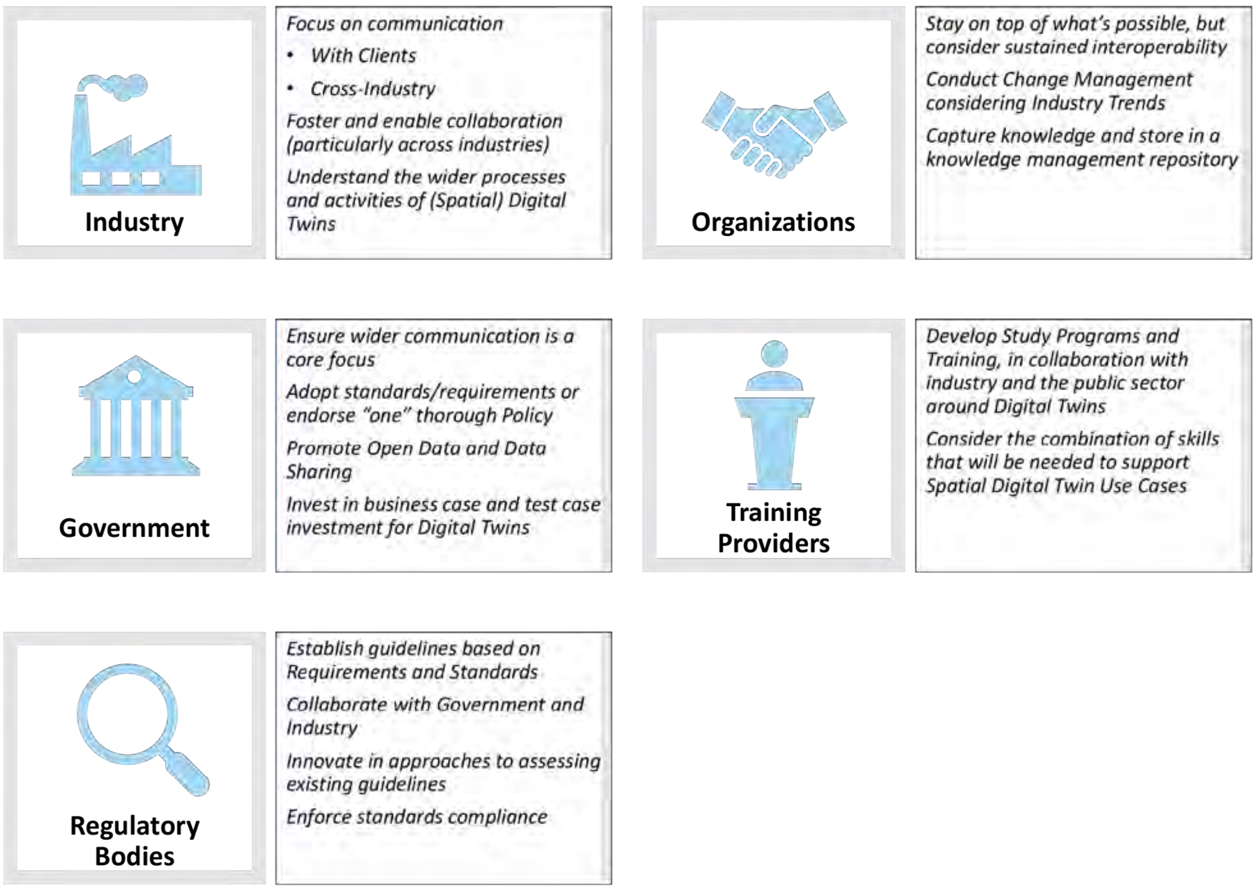
62 Source: A summary of the current BIM and digital engineering practices and policies in Australia and New Zealand. | NBS Australia (thenbs.com.au)

63 Source: BSI Flex 260 v1.0 | BSI (bsigroup.com)

The collaboration challenge is striking a balance across government (public sector), standards and regulatory bodies, industry, organizations as well as training providers that ensures each role contributes towards a collectively agreed future vision.

Finally, when Industry SMEs were asked to identify opportunities and gaps in existing policies 106, there was an overwhelming response for ensuring the "simple things" are adopted and enforced by relevant stakeholders as outlined below:

Figure 25: Policy Considerations



By putting these simple things in place, it will make the advanced things possible. When the advanced things are possible, the future vision can be achieved.

Appendix Socio-Economic Assessment

Tier	Use Case	Description	Improvements to Employment/ income	Reduced reliance on resources (personal and commercial/ industrial)	Uplifted Working Conditions	Improvement of / Access to social services (enabled by government)	Reduction in emissions	Decreased waste	Optimising or improving consumption and productionlevels (supply/ demand)	Return on investment	Improved quality	Reduced Time to Delivery	Outcome
1	Augmented/Virtual Reality	Providing instruction during Maintenance Activities through remote SMEs support, such as presenting data on "covered" or "shrouded" assets through use of AR/VR	Improved	Improved	Improved	Neutral	Improved	Improved	Improved	Improved	Improved	Improved	Spatial Digital Twin
2	Construction (Asset Visualisation)	Improved data visualisation capabilities through geospatial data	Improved	Improved	Improved	Neutral	Improved	Improved	Improved	Improved	Improved	Improved	Spatial Digital Twin
	Smart Cities	Development of Building/Asset Infrastructure underpinned by digital datasets	Improved	Improved	Improved	Improved	Improved	Improved	Neutral	Neutral	Improved	Neutral	Spatial Digital Twin
	Smart Infrastructure (Transport)	Development of Building/Asset Infrastructure underpinned by digital datasets	Improved	Improved	Improved	Improved	Improved	Improved	Improved	Neutral	Improved	Improved	Spatial Digital Twin
	Smart Infrastructure (Utilities)	Development of Building/Asset Infrastructure underpinned by digital datasets	Improved	Improved	Improved	Improved	Improved	Improved	Improved	Improved	Improved	Improved	Spatial Digital Twin
	Assurance and Compliance	Applying Digital Twins during the commissioning stages of asset lifecycle (BIM)	Neutral	Neutral	Improved	Neutral	Neutral	Improved	Improved	Improved	Improved	Improved	Spatial Digital Twin Candidate
	Planning	Applying Digital Twins during the design stage of asset lifecycle (BIM)	Improved	Improved	Improved	Neutral	Improved	Improved	Improved	Neutral	Improved	Improved	Spatial Digital Twin
3	Facilities Management (Managing Assets)	Applying Digital Twins during the operations, maintenance and decommissioning stages of asset lifecycle	Improved	Improved	Improved	Improved	Improved	Improved	Improved	Improved	Improved	Improved	Spatial Digital Twin
	Emergency Management	Developing a Spatial Dataset of assets for response actions	Improved	Improved	Improved	Improved	Neutral	Improved	Improved	Improved	Improved	Improved	Spatial Digital Twin
	Conservation and Heritage	Protection of significant sites through improved positioning, mapping and monitoring of the site	Neutral	Neutral	Neutral	Improved	Neutral	Improved	Improved	Improved	Neutral	Neutral	Spatial Digital Twin Candidate
	Global (or Regional) Digital Twins	Collating publicly available information (e.g., weather)	Improved	Improved	Improved	Improved	Improved	Improved	Improved	Improved	Improved	Improved	Spatial Digital Twin
	High-value Agriculture (e.g., vineyards/orchards)	Use of UAV's and Sensors for information collection for targeted condition monitoring of high-value agriculture	Improved	Improved	Improved	Neutral	Improved	Improved	Improved	Neutral	Improved	Improved	Spatial Digital Twin
	Defense Capabilities	Monitoring and Positioning Assets used for Defence (e.g., warships)	Improved	Improved	Improved	Improved	Improved	Improved	Improved	Improved	Improved	Improved	Spatial Digital Twin
	Collectivised Spatial Data Acquisition	Using Geospatial Data as the "link" for aggregation and bonding data together	Improved	Improved	Improved	Improved	Improved	Improved	Improved	Improved	Improved	Improved	Spatial Digital Twin
	Autonomous Vehicles	Creating a "just in time" Digital Twin for informed decision making on road safety hazards when driven autonomously	Decrease	Improved	Improved	Improved	Improved	Improved	Improved	Neutral	Improved	Improved	Spatial Digital Twin Candidate
	Highly Complex Assets	Heavy Manufacturing (e.g., Ships), Aerospace/Aviation	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	Generic Digital Twin
	Renewable Energy	Positioning sensors on renewable energy sources highlighting their condition and current utilisation	Improved	Improved	Improved	Improved	Improved	Improved	Improved	Improved	Improved	Improved	Spatial Digital Twin
	UAV's / Drone Information Capture	Use of UAV's and Drones for information collection (e.g., in remote settings) instead of static sensors	Decrease	Improved	Improved	Neutral	Improved	Improved	Improved	Neutral	Improved	Neutral	Spatial Digital Twin Candidate
	Virus Control and Management	Tracking people and contagion spread to simulate forecast impacts and effectiveness of controls	Improved	Improved	Improved	Improved	Neutral	Neutral	Improved	Neutral	Improved	Neutral	Spatial DigitalTwin Candidate
4	Traditional Manufacturing	Conventional productionfacilities Traditional Manufacturing, Process/Operations, Conventional EnergyProduction	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	Generic Digital Twin
	Healthcare Applications	Presenting data from Digital Twins to assist in health care applications	Neutral	Neutral	Improved	Improved	Neutral	Neutral	Improved	Neutral	Improved	Improved	Generic Digital Twin
	Product Development	Use of Digital-to-Virtual-to-Digital Workflows in product development and Product Lifecycle Management	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	Generic Digital Twin
	Mining	Safety Management, Production Monitoring and locating resources and assets in real time to identify risks, opportunities and efficiencies in production	Improved	Neutral	Improved	Improved	Neutral	Improved	Improved	Neutral	Improved	Neutral	patial Digital Twin Candidate
	Smart Infrastructure (Energy)	Development of Infrastructure network underpinned by digital datasets	Improved	Improved	Improved	Improved	Improved	Improved	Improved	Neutral	Improved	Improved	Spatial Digital Twin Candidate
	Commoditized Agriculture (e.g., Wheat)	Use of UAV's and Sensors for information collection for large scale condition monitoring	Improved	Improved	Improved	Neutral	Improved	Improved	Improved	Neutral	Neutral	Improved	Spatial Digital Twin Candidate
	Traffic Management	Use sensor data inputs to manage detours around live congested traffic	Neutral	Neutral	Improved	Neutral	Neutral	Neutral	Improved	Neutral	Improved	Improved	Generic Digital Twin
	Gamification	Use low-detail modelling with highly developed gaming engines to offset costs of 3D modelling and positioning of assets relative to a real-world coordinate system	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	Improved	Improved	Neutral	Improved	Generic DigitalTwin

WGIC Member Offerings on Spatial Digital Twins

AAM's LiDARnetics and Geocirrus

The foundation of spatial digital twins

Spatial Data forms the fundamental building blocks and foundation of Spatial Digital Twins. AAM's mission is to measure our world and map our future. AAM utilize leading edge LiDAR and imagery sensors to generate accurate and up to date digital representations of the real world. This is the core of our business since it began in 1959 (noting that sensors weren't quite in the digital age then).

Fast forward to today and one of the key challenges for capturing spatial data is speed. In a perfect world, decision makers would have access to data in real time. At AAM, we find ourselves constantly innovating and improving in an effort to meet this target. Driven largely by our clients in the mining sector, AAM has developed an automated processing application called LiDARnetics. Data is uploaded directly from the field into a cloud-based platform where automated routines and Artificial Intelligence (AI) produce results within 12 hours. In a world where time equals money, faster access to data and results is crucial.

The development of LiDARnetics and robust, scalable cloud processing has in turn benefited other areas of AAM. Imagery and LiDAR needed to create 3D building and city models can also be run through automated processes. The creation of 3D models and other spatial data products has traditionally been carried out using manual methods. With users wanting faster turnaround and repeatable results, AAM has started implementing AI Deep Learning / Machine Learning processes to achieve these outcomes. Combining AI outputs with AAM's decades of experience in spatial processing and quality assurance routines provides highly efficient and reliable datasets that our clients and end-users need.

These processes enable faster and more efficient project delivery and help to create spatial products in AAM's Geocirrus store. This serves as gateway to our vast library of spatial data-sets, which underpin Spatial Digital Twins.

Autodesk Tandem™

Harnessing BIM to realize Digital Twins

Creating a digital twin typically requires a costly bespoke process of data collection and system integration. Autodesk Tandem was created to harness BIM from design through construction to enable a highly repeatable process for curating digital twins.

For AEC professionals a digital twin can help deliver greater value to clients in the form of digital deliverable. For owners and operators, having this digital deliverable can accelerate operational readiness providing more insight and control of assets.

So, what is a digital twin?

At Autodesk, we define a digital twin as a digital replica of a built asset that is a dynamic digital reflection of its physical self. Digital twins possess the operational and behavioral awareness necessary to simulate, predict, and inform decisions based on real world conditions. More importantly, a digital twin provides the means to transform the built asset lifecycle by tracking a digital thread of information that links organizations and data with an end-to-end digital process spanning capital planning, architecture, engineering, construction, and asset management.

A connected ecosystem

In operations and maintenance, the digital twin connects silos of data providing a single pane of glass to understand and tune the performance of a portfolio of facilities. This can help answer questions such as:

- Is my facility achieving my sustainability goals and if not what can I do to course correct?
- Which systems, equipment, and materials perform better than others across my portfolio?

In capital planning, the digital twin can help inform what future planning and design decisions will maximize the ROI of a portfolio. For Autodesk, what's most inspiring is the potential to leverage all this rich knowledge to help inform future design and construction projects enabling our vision of a better world designed and made for all.

Autodesk Tandem

Autodesk Tandem was created to provide a repeatable process for creating and managing digital twins from BIM, empowering owners and operators to realize the benefits without the costly, bespoke effort. With Autodesk Tandem, you can create and execute a repeatable process for curating a descriptive digital twin through a well-defined digital handover process, accelerating operational readiness. Connecting Autodesk Tandem to operational workflows and systems breaks down data silos to provide a single pane of glass for smarter operations. Analyzing the operational data collected by Autodesk Tandem empowers you with greater insight to inform future decisions.

Discover Autodesk Tandem: www.intandem.autodesk.com

Use Case

A Futuristic Building Tests Agile Design — While Its Residents Actually Live There

NEST in Switzerland is a futuristic building and test lab under one (solar) roof. Replete with actual residents, NEST is exploring agile innovations for the digitized construction landscape. Project Dasher, an Autodesk research project BIM-based platform, was used to provide NEST building owners with greater insight into real-time building performance throughout the life-cycle of the building. This has allowed the Dasher team to create a compelling public demo that enabled anyone to explore the data being collected for this building. The research results and learnings from Dasher and NEST are some of the drivers that helped inform the development of Autodesk's digital twin software, Autodesk Tandem.

The center-built NEST's DFAB (short for digital fabrication) HOUSE residential unit has more than 30 partners and engaged researchers from eight departments at the Swiss Federal Institute of Technology (ETH) in Zurich, including architects, robotics specialists, materials scientists, structural engineers, and sustainability experts.

DFAB HOUSE, which opened in early 2019, embodies the future of housing construction. Planning and most of the construction process took place in the digital realm. Robots prefabricated nonstandard wooden elements, which were then assembled on-site. A 3D printer produced the formwork for the elegant concrete slab will serve as the first-floor ceiling, while an on-site mobile robot constructed the reinforcing mesh for a doubly-curved, formwork-free concrete wall.

Now that it has been completed, the DFAB HOUSE serves as apartments for visiting researchers and a test laboratory for smart-home solutions and Internet of Things (IoT) technologies. Everything in the unit is networked, from the appliances to the lighting. To save energy, heat in wastewater is recovered directly in the shower trays via heat exchangers. When not in use, warm water flows back into the boiler instead of cooling in pipes. This process eliminates the need to maintain a high-water temperature, saving energy and preventing bacterial growth.

At the modular research and innovation hub, new residential, office, and research units are constantly being installed and replaced, so the building—or at least its outer shell—is constantly changing. The solar facade exists as a digital model in Autodesk Fusion 360, and the entire NEST building was laser scanned by the Swiss company BIM Facility using Autodesk ReCap, creating digital twins in Autodesk Revit and BIM 360. Approximately 3,000 sensors on the building provide facility management data such as temperature and air quality, which is transmitted to the Revit model via the Autodesk Forge platform.

The project's proponents hope that in the future, buildings and the technologies that run them will have longer shelf lives, Gramazio says. "If you offer the necessary flexibility, if you embrace the unknown instead of defining everything, perhaps it will also be possible to construct buildings that are made to last longer again."

Learn about NEST here: https://redshift.autodesk.com/futuristic-building/

OpenCities™ Planner Powered by iTwin

Powerful Communication for Urban Development and Infrastructure Projects

Easily Share Information to the Web, Mobile, and Showroom Displays

Improve communication in infrastructure and urban development projects with OpenCities Planner. Powerful 3D rendering and streaming technology securely provides 3D project scenes of any size to web browsers and mobile devices. Easy access to updated project information supports better decisions and shorter feed- back loops with a broad reach to stakeholders and citizens. OpenCities Planner is scalable for all from individual users and project teams to entire city governments and larger organizations. The application is cloud-based on Microsoft Azure.

Detailed Views of Your 3D Data

Advanced data configuration features support setup, maintenance, and the ability to combine unlimited-sized data sets from files, web services, or databases to make them available within OpenCities Planner. Supported data includes reality mesh, semantic building models (for example, CityGML) imagery, and Digital Terrain Model.

Get Started Quickly with this Easy-to-use Application

A subscription and web browser are all that is required. The solution design is intuitive, with graphical menus and built-in documentation to help you get started after a short introduction. Easy-to-use tools enable you to quickly create scenes to visualize the project or evaluate planning options. Use libraries of 3D geom- etries, drag design models, or incorporate geodata into the scene. Add images, vector data, and documents to communicate your project. Connect with WMS to add GIS layers to the presentation. Export 3D for detailed design in third-party applications.

Customize the End-user Experience

Sharing options provide multiple information channels with the interactive 3D or the 360-panorama mode. Multiple customization features allow adoption to your preferred graphical profile. For the project office or for exhibition monitors, Showroom configuration provides the best 3D performance and visual quality, with support for virtual reality. Generate high-resolution 360-degree images or videos in OpenCities Planner for online publishing or as part of your report.

Engagement and Communication

You are in control. With just a few clicks, publish new projects and updates to specifically invited team members or a direct link for public access. The built-in form editor is designed for creating public surveys or interaction using the 3D scene as background. Fast-and-easy sharing with the public and stakeholders enables public consultation, surveys, events, or project issue tracking. You can manage content access based on user roles.

Use Case

Dublin Digital Twin Accelerates Digital Transformation

Dublin gets a twin

The Dublin Digital Twin project is a joint initiative among the City of Dublin, Bentley Systems, and Microsoft to create a large-scale digital model of Ireland's capital and largest city. Initiated in February 2020, the goal of the Dublin Digital Twin Project is to provide real-world context and visuals to enable engineers, architects, constructors, city planners, and civilians to identify, design, and execute on urban solutions for years to come. Dublin is proving that a city-scale Digital Twin can influence similar changes for future urban spaces anywhere in the world.

Potential use-cases

The potential use-cases are limitless. City leaders can use a city-scale Digital Twin to plan events and activities that are safer and socially distanced. Developers can also use Digital Twins to gauge the impact on climate and sustainability, while utility operators can use them to simulate and predict issues for preventative measures and quick responses. Additionally, emergency services can use a Digital Twin to manage pre-incident management across a city.

Cities are discovering that Digital Twins can help them become more efficient, and they can reinvest savings into enhanced services or for advancing sustainable development goals.

Data overload can make things worse

With the rise of smart technology and Internet of Things devices, cities are collecting electronic data in unprecedented volumes. However, they need to understand how to use that data to support their decision-making. Going digital presents a real opportunity for cities to change how they work by using their data more effectively. But without a way to manage and use their data effectively to support decision-making and address real problems, cities may find themselves drowning in data while thirsting for insight.

Managing and sharing data is key

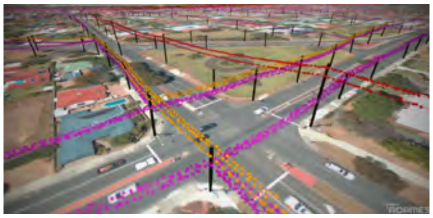
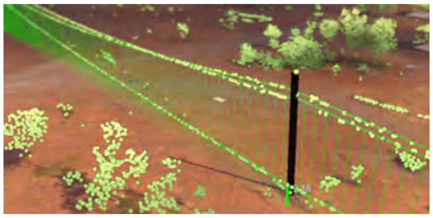
An emerging trend is the growing adoption of Digital Twins to enable cities to meet their challenges. Digital twins, which serve as living replicas of city infrastructure and systems, are redefining how cities plan and manage their infrastructure. They also encourage collaboration and engagement across departments as well as with other government agencies, businesses, and the public.

Fugro - ROAMES®

Fugro's award-winning technology designed specifically for power utilities is based on Remote Observation Automated Modeling Economic Simulation (ROAMES®)—which creates a Digital Twin of such fidelity that it can be used for asset inspection, identification, and condition assessment without the need to deploy personnel to the field. The ROAMES® Digital Twin supports our clients in improving safety around their networks while reducing risk and total cost of operation, furthermore, supporting the momentous task of modernising the grid as part of the energy transition.

ROAMES® technology combines pioneering geospatial mapping techniques with cutting-edge data processing and cloud computing capabilities to deliver the complete and accurate Digital Twin of a power company's assets.

Fugro was the first to market this revolutionary new technology and has been delivering ROAMES® to major distribution and transmission operators in Australia, UK, Europe, and North America since 2014. Fugro clients find value using ROAMES® for a broad number of use-cases including savings up to 40% on vegetation management with desktop scoping, reduction of vegetation management cycle by 1-2 years, and prioritisation of critical clearances network wide.

Fugro ROAMES® includes access to ROAMES® World for visualisation of the Digital Twin and ROAMES® Analytics for asset measurements and risk assessment.

ROAMES® World is a virtual world asset management platform built in the cloud – a high-performance 3D mapping environment that offers access to reliable, detailed information for better management and improved understanding of real-world context.

ROAMES® Analytics provides the ability to access and explore ROAMES® data. At times approaching millions of records, an asset register and any associated spatial data is typically too large to analyse at scale using traditional GIS or enterprise systems alone. As a result, it is difficult or impossible to detect broad trends, rapidly investigate an outlier, or share access with users in any location. ROAMES® addresses this need by offering a high-performance data investigation tool with a simple, intuitive interface so users can get better answers faster – critical for an optimised approach to asset and vegetation management.

Achieving and maintaining conductor clearance is an important safety and compliance issue. By precisely managing and monitoring the location of assets in the ROAMES® Digital Twin, power utility maintenance programmes can be more effectively managed to mitigate risk.

HEXAGON GEOSYSTEMS

www.hexagon.com

Reality capture for Digital Twin

Digital representations of the physical world that can be viewed anytime, anywhere provide significant benefits for all stakeholders involved in operations and maintenance. Stakeholders are often located remotely, with many priorities competing for their time. By using reality capture to create accurate, precise digital 3D replicas of the physical building, remote team members can get up to speed quickly and at their convenience without needing to travel to the job site for meetings or walk-throughs. The result is stronger alignment and better communication across stakeholders.

Hexagon delivers the sensor and software technologies needed to create a Smart Digital Reality of the physical building throughout every phase of the project lifecycle. This sophisticated and detailed Digital Twin of a property facilitates daily operations, with highly accurate visualisations and access to asset information to support preparation for planned facility management interventions. Whether tracking assets for fire protection, energy equipment, HVAC or other building installation-related issues, the digital realities of location-based asset tracking ensure you always have a single digital thread of all project information, records and changes that you can share with all stakeholders anytime, anywhere.

Benefits

Accurate virtual walkthroughs
Access facilities virtually with accurate dimensions of properties for stakeholders to review from any device, anywhere.

Fewer site visits
Limit your need for site visits with digital realities and indoor navigation you can access anytime, anywhere from any device.

Easy access to facility information
Remote virtual access of digital realities of your property supports high-quality preparations for facility management.

Products

Leica TruView Cloud
View, measure and share digital reality data anywhere, anytime, from any device.

Leica TruView is the industry leader for easily and intuitively sharing point cloud data, design models, mark-ups and more. TruView Cloud is available via Leica Geosystems' Cyclone Cloud portal for cloud-based software services.

Leica RTC360 3D Laser Scanner
Capture any building environment in 3D, improving efficiency and productivity in the field and the office.

The Leica RTC360 3D reality capture solution empowers users to document and capture their environments in 3D, improving efficiency and productivity in the field and in the office through fast, simple-to-use, accurate, and portable hardware and software.

Leica BLK360 Imaging Laser Scanner
Capture full-color panoramic images for upload to the cloud with this one-button-push, simple-to-use digital scanner.

The Leica BLK360 captures the world around you with full-colour panoramic images overlaid on a high-accuracy point cloud.

Use Case

Creating the first digital shipping center in Peru

Plaza Santa Catalina shopping centre in Lima, Peru, opened in April 2019. Dormeson SA, a subsidiary of Grupo Mulder, started developing this project in 2018. The shopping centre spreads across 11,000 square metres on three levels. Since maintenance of such a large building can be complex, Dormeson wanted to invest in an innovative digital facility management solution that enables effective, timely decisions and reduces operating costs while delivering an excellent visitor experience.

The facility manager needs reliable data to manage and track maintenance activities. To increase efficiency, avoid costly and time-consuming complications and enable remote management, all data must be stored in one system, and all stakeholders must have access.

Intelligent data capture and processing

Dormeson's needed reliable technology that could scan the building fast without interrupting the shopping centre's operation. Using a combination of solutions from Leica Geosystems, part of Hexagon, they scanned the entire building and its exterior, such as the parking lot, in two days. Most of the building (90%) was captured with the Leica RTC360 3D laser scanner. The Leica BLK360 imaging laser scanner captured areas with limited space, such as part of the control room. Dormeson also used the Leica BLK3D to take images of critical assets such as the air conditioning machine areas and plant room.

Facility and asset management transformation

Geomap, a cloud- and GIS-based Integrated Workplace Management System (IWMS), imported the scan data to enable visual 3D management via CAD support. Geomap checklists keep technicians informed on the building's maintenance requirements and help building and facility managers track the operations. The Geomap platform includes work order management, information on energy consumption, budget management and building documents which makes the management of the shopping centre much more efficient.

Making a building smarter

Accurate 3D Digital Twin combined with IWMS provides the facility manager with complete remote control of the physical asset. Using the Geomap Survey App on-site, Dormeson created an assets register and made digitised technical data of each asset, such as brand, model, last maintenance, location, etc., available to the building managers.

As a result:

1 Operations and maintenance are more transparent and efficient.
2 Better performance insights lead to reduced breakdown of assets and building systems.
3 Accurate 3D data enables remote assets creation and management.
4 Digital reality data supports space management.
5 Reliable and continuously monitored facilities result in a better customer visit experience.

Digital Twin Technology and *RIEGL*

Spatial Digital Twin Offering - Products (Software/ Hardware), Solutions and Services

Digital Twin technology helps to create virtual models designed to accurately reflect physical objects. It is a continuous up-to-date representation of an asset or facility, serving as a connection between the digital and real world. Digital Twins have opened the geospatial industry to a world of possibilities and opportunities over the past decade. *RIEGL* is on the cutting edge of Digital Twin technology with their proven Ultimate LiDARTM 3D scanners offering a wide array of performance characteristics, which serve as a platform for dimensional accuracy of Digital Twins.

Hardware and Software

RIEGL has developed hardware for multi-sensor solutions, such as the VZ-400i terrestrial laser scanner. For example, when paired with the RiPANO software, it produces fast and easy visualization of scan projects. It allows CAD users to easily extract ortho views and plots for further use in CAD software. *RIEGL* RiSOLVE software enables fully automatic registration and colorization of scan data. This streamlined process is the fastest solution to acquire, register, and colorize outdoor 3D scan data.

RIEGL's RiSCAN Pro software is project oriented where data acquired is organized and stored in the software's project structure. This data includes scans, fine scans, digital images, GPS data, coordinates of control points and tie points, and all transformation matrices necessary to transform the data of multiple scans into a common well-defined coordinate system. *RIEGL* also leads the market in unmanned sensors with the miniVUX Series, allowing the acquisition and processing of kinematic data in dangerous and/or hard-to-reach areas.

Point Clouds to the Twin Creation Path

Point clouds are datasets that represent objects or space. Once data is collected, QA/QC is done to ensure consumer expectations are being met. Point clouds then go through a registration process, where they are transformed into different perspectives and into a common coordinate system stitching them together. This is the preliminary step to the model creation necessary for Digital Twin creation.

Human visualization of this dimensional information is typically done in software applications such as Esri's ArcGIS software which enables organizations to see Digital Twins in the context of other information models, like electric and water networks or the environment. Another Digital Twin software for construction purposes is Autodesk Revit, a building information modelling software.

Benefits

RIEGL's Lidar and related tools offers high-speed, high-accuracy cutting-edge tools for Digital Twins. The innovative processing architecture enables data acquisition and simultaneous geo-referencing in real-time, and automatic on-board registration. The delivered high-resolution, high-accuracy point cloud data is a sound basis for further processing to provide meaningful data in as-built-surveying and construction monitoring. Paired with software to develop these data sets and the ability to utilize unmanned systems, *RIEGL* is pushing the needle forward for innovation in Digital Twin technology.

Use Case

RIEGL USA's headquarters utilized Digital Twin technology during the pre-construction and construction process. The construction firm, DPR Construction, used *RIEGL's* VZ-400i Terrestrial Laser Scanner and the miniVUX-2UAV Unmanned Sensor, throughout the building process to compare the actual work being put in place to the model, therefore avoiding costly rework in the future.

During the preconstruction phase, DPR Construction's subsidiary, vConstruct, created a Digital Twin (virtual model) of the project. The architectural plans, structural steel model, mechanical, electrical, plumbing, and fire protection models were all used to create a comprehensive model for complex coordination prior to individual items being fabricated. The use of this model allowed the MEP/FP systems to be fabricated and a significant portion of the work to be installed prior to the building being dried in or framed. The work was then able to be verified by laser scanning to ensure that it would not conflict with future installations. The *RIEGL* technologies used on the project supported quality assurance and quality control, resulting in more accurate and time-saving deliverables for the field.

The entire construction life cycle was captured via laser scanning including foundations, footings, bolt locations, utility infrastructure and tilt-wall panels. The virtual design and construction allowed for the safe delivery of a complex, high quality end product that was on time that all of the firms involved are proud of.

Road Asset Data Services

Business Challenges

Major cities are taking the most strain with metros becoming increasingly congested. The substantial number of vehicles entering and leaving the cities daily, pose serious wear and tear to road assets, leading to high maintenance costs to metropolitan municipalities if not managed. Because maintenance itself leads to even more significant congestion that leads to high rates of pollution due to the fossil fuels emitted by the combustion of fossil fuels by cars stuck in traffic, cities need new and innovative ways to manage and reduce the litany of maintenance and repair contracts.

Solution Overview

Roads Assets Data Service is a data-driven solution that identifies road feature data in real-time and simultaneously maps them with high positional accuracy. The map and road asset data features are interoperable and compatible with any GIS enabled information management system. The continuous camera sensors mounted on service vehicles and the location intelligence analytics enable regular updates on road networks and the creation of a living and constantly evolving map of road assets and their conditions.

Key Technology Features

1 Collision avoidance cameras mounted in ordinary vehicles.
2 Change detection to highlight where changes have occurred in the user-specified frequency range.
3 5G enabled to allow for high-speed connection and upload of data to the cloud for processing.
4 Artificial Intelligence and Machine Learning algorithms to identify, map and monitor road assets

Data Services

- Road Asset Survey

  → Automate inventory surveys with rapid, real-time asset data collection
  → Save time and money when planning maintenance programs with accurate asset mapping

- Pavement Condition Monitoring

  → Assess, monitor and improve pavement quality with real-time data on road conditions
  → Expedite pavement operations with accurate localization of surface distress

- Mobility Intelligence

  → Measure road safety risk in their jurisdictions and identify dangerous intersections and street segments
  → Support grant applications and updates to city and transportation plans with relevant mobility data

Business Benefits

- Automate inventory surveys with rapid, real-time asset data collection
- Save time and money when planning maintenance programs with accurate asset mapping
- Prioritize inspection and renewal programs with asset change detection notifications

Trimble

www.trimble.com

Trimble MX50 Mobile Mapping System

The Trimble MX50 mobile mapping system captures 360-degree color imagery and high-density point clouds to be used as inputs for digital twins.- Update this

The Trimble® MX50 mobile mapping system is a mid-range option for asset management and mapping. A vehicle-mounted LiDAR system, the MX50 is designed for first-time mobile mapping users and experienced providers to expand their equipment fleet with precise, high-volume data capture technology that works in conjunction with Trimble's geospatial software solutions.

By providing clean and accurate data of ground surfaces, the Trimble MX50 is a practical choice for highway and road inspection and maintenance organizations; city, state and local governments; public utilities; contractors; and survey companies wanting to expand their service capabilities.

The Trimble MX50 features new Trimble-designed profiling lasers for high-accuracy data collection, a 360-degree panoramic camera and a GNSS/IMU positioning system from Applanix, a Trimble Company. The system produces dense point clouds and immersive imagery for surveying and mapping accuracy, and works with Applanix POSPac, Trimble Business Center and the Trimble MX software suite.

The Trimble MX50 also expands the company's mobile mapping portfolio, which includes the widely adopted Trimble MX9 system for large scanning and mapping missions and the highly portable Trimble MX7 for capturing precisely positioned street-level imagery.

Trimble SX12 Scanning Total Station

The Trimble SX12 Scanning Total Station collects terrestrial data, which can be seamlessly merged with MX50 scans.

The Trimble® SX12 Scanning Total Station is the next iteration of the company's breakthrough 3D scanning total station that provides fast and efficient data capture for surveying, engineering and geospatial professionals. New features, including a high-power laser pointer and high-resolution camera system, expand capabilities in surveying and complex 3D modeling and enable new workflows in tunneling and underground mining.

The Trimble SX12 merges high-speed 3D laser scanning, Trimble VISION™ imaging technology and high-accuracy total station measurements into familiar field and office workflows for surveyors. A new green, focusable Class 1M laser pointer is safe for viewing with the naked eye, offers high-power visibility and makes it easy to see even at a distance. An improved camera system provides enhanced pointing and site documentation capabilities.

The Trimble SX12, users can quickly and easily operate with common survey workflows, including new versions of Trimble's industry-leading field and office software, including Trimble Access™ 2021 Field Software and Trimble Business Center version 5.40.

Use Case

When Precision Floats Your Boat

Mounting Trimble's mobile mapping system on a boat solved the problem of scanning inaccessible infrastructure

As one of only 19 major ports capable of receiving the world's largest container ships, Gemalink Port on the Cai Mep-Thi Vai River in Vietnam is an important transshipment center for global trade. With its strategic location, it provides the country an economic boost while cutting costs and reducing the time it takes exports to reach the US and Europe.

One year after the terminal's opening in January 2021, Portcoast Consultant Corporation, as a construction quality inspection consultant, conducted a full survey to update its as-built model. The Digital Twin serves many needs, from maintenance and BIM applications to verifying the length of the berths. Portcoast plans to conduct mapping updates every five years.

While Trimble SX12 scanning total stations were used to collect data on land, a different approach was needed to capture the infrastructure facing the river. To solve the problem, a Trimble MX50 mobile mapping system was mounted on a wooden boat and slowly driven at about 5 knots, with an approximate 15-foot distance between boat and scanned objects.

“We made sure the boat’s roof bars were strong enough to hold the roof rack (18 kg) and mapping sensor (23 kg),” said Dr. Hoang Hiep, vice general director at Portcoast. “And we adjusted the bracket position to orientate the roof rack horizontally as much as possible. That’s all there was to it.”

The MX50 is typically mounted on a car or truck and driven at highway speeds to capture data for asset management, mapping, and road maintenance projects. Portcoast found that the operations on the boat delivered the same 360-degree color imagery and precise point cloud and met the desired accuracy of less than 1 to 2 cm. The small waves on the river had negligible effect on operations; in just 15 minutes the riverbank and river-facing infrastructure were scanned. Trimble Business Center and Applanix POSPac® Mobile Mapping Suite were used to process the MX50 data.

Terrestrial data for the container terminal was collected with the Trimble SX12 over a seven-day period with 60 scan stations. Targets on land helped register the MX50 scans and seamlessly merge both data sets.

“We used the same coordinate system to combine the riverbank data with land data,” said Hiep. “The result is used as the input for Digital Twin design and BIM-GIS.”

voxelmaps

www.voxelmaps.com

Voxelmaps Insight Platform (VIP)

Next Generation Integrated Mobile Mapping System for Capturing and Generating Spatial Digital Twins.

The Voxelmaps Insight Platform consists of the SYMBO DUO mobile mapping system and the VIP Software as a Service (SaaS). The platform offers affordable and accessible methods to collect, process and utilize digital data to improve business processes.

The SYMBO DUO is a low-cost mobile mapping device that consists of state-of-the-art LiDAR, optical cameras, edge computing, and high accuracy GPS/IMU. It was initially designed to carry out large scale data collections but can be used across a variety of collection scenarios. The SYMBO device itself is relatively small, is mounted on a standard bike rack on top of the vehicle, and fits in a small case for easy transport between projects. The device also has 5G and edge processing capabilities, so users have the flexibility to perform processing at the time of collection and then the collected data can be uploaded to the VIP infrastructure for further processing.

Unique Features of The SYMBO DUO:

- LiDAR: 2 Velodyne Puck (16 channels, 905nm)
- Sampling rate: 1.2 million points per second (dual return mode)
- Cameras: 6 high resolution cameras at 58 total MP per frame, with 5 or 10 frames per second
- Edge computing: The NVIDIA Jetson AXG Xavier is a key component of the SYMBO DUO
- The system size/footprint is unmatched in the industry at less than 20 lbs/9 kgs
- Easy one person installation (<l hr) onto standard vehicle roof bike rack
- The system allows mounting at various angles via adjustable tilt to focus LiDAR/ imagery collection on key assets (e.g. Utility Poles/Joint Use attachments)

The Voxelmaps Insight Platform provides a fully automated pipeline to process LiDAR and imagery data to extract assets, features, and detailed information from data sets. The system is data agnostics, so it can consume data from satellites, manned aerial and unmanned platforms, other mobile sensors, or boots on the ground data collection.

The VIP SaaS consists of;

- Patented Multi-Resolution Voxel Occupancy Grid (MRVOG) database structure, which supports 4D Spatial Data Processing
- Machine Learning (ML) Layer for performing 3D Semantic Segmentation for automating the feature extraction process, and
- Visualization Layer consisting of 3 main Interfaces; Web, Desktop, and VR versions
- Infrastructure Layer – Voxelmaps' private cloud hosting environment

The Voxelmaps Insight Platform offers cost-effective and obtainable tools to collect and utilize digital data to improve business processes, identify potential problems and create new opportunities for organizations within many different industries.

About WGIC

The World Geospatial Industry Council (WGIC) is a registered Not-for-Profit trade association of commercial geospatial companies representing the geospatial ecosystem's entire value chain. WGIC enhances the geospatial industry's role and strengthens its contributions to the global economy and society. WGIC facilitates the exchange of knowledge within the geospatial industry and creates more significant business opportunities for the stakeholders through partnerships and collaborations in thematic areas of global significance.

For more information, please visit www.wgicouncil.org.

For collaborations and membership inquiries, please write to info@wgicouncil.org.

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