Request for Information on the National Digital Twins R&D Strategic Plan

Trimble

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National Coordination Office for NITRD
National Science Foundation
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Subject: Federal Register Docket No. 2024-13379, Networking and Information Technology Research and Development Request for Information (RFI) on Digital Twins Research and Development

Dear Ms. Cornelius:

Trimble welcomes the opportunity to provide comments to the National Coordination Office for Networking and Information Technology Research and Development (NITRD) on the creation of a National Digital Twins Research and Development (R&D) Strategic Plan.

Trimble is transforming the way the world works by delivering solutions that enable our customers to thrive. Core technologies in positioning, modeling, connectivity and data analytics connect the digital and physical worlds to improve productivity, quality, safety, transparency and sustainability. From purpose-built products to enterprise lifecycle solutions, Trimble is transforming industries such as agriculture, construction, geospatial and transportation.

Trimble offers the following comments as the NITRD looks to shape this important research and development effort related to digital twins across all domains.

Artificial Intelligence (AI)

AI and digital twins: Possible focus areas: integration of digital twins with artificial intelligence (AI); leverage generative AI for digital twin modeling & simulation with the consideration of the potential impact on a digital twins' physical counterpart.

In the construction and transportation industries, AI's role in digital twins is already transforming how state infrastructure owners are approaching how they manage assets over their lifetime. AI is playing a key role in capturing and processing existing conditions and asset data for use by planning, design, survey, construction and contractor teams. Its role in asset management is even larger considering how much AI processing is lowering the costs for state owners to capture information on their infrastructure assets including the condition of those assets. State Departments of Transportation (DOTs) like Minnesota Department of Transportation (MnDOT), Texas Department of Transportation (TxDOT) and the California

Department of Transportation (Caltrans) are leveraging more mobile mapping (LiDAR and image data capture) statewide to improve asset data used across multiple departments. Mobile mapping integrates laser scanning with high-resolution imagery enabling the collection of large amounts of accurate, georeferenced spatial data which can be transformed into a digital twin of the physical world. By providing an accurate digital twin for design engineers, mobile mapping avoids delays and rework. It also enables construction crews to verify specification conformity and increases worker safety by removing the need to have workers near an active roadway project site for data capture.

Today owners in the European Union (EU) are focused on the use of generative AI, parametric modeling and simulations as part of their planning and design process, where they can rapidly optimize planning and design options, including costs. National Highways England is an example owner moving forward with this approach today. U.S. state owners are also interested in moving in this direction to optimize design and project costs.

In addition to the growing owner interest in AI use for digital twin modeling and simulations at the U.S. state owner level, it is also being widely adopted by the design engineering consultant community who serves the owners. The opportunity for return on investment (ROI) and value creation using AI with owners could for example allow them to rapidly iterate on both design options for a bridge and the 30 year maintenance and asset management options and costs that design option will have long term. With the majority of a state construction owner's costs tied to asset management and maintenance post project, this type of approach has tremendous promise at optimizing infrastructure operations long term.

Trimble also sees a growing interest with U.S. state owners in leveraging field data, including monitoring sensors in the field to better manage sustainability and climate change impacts to their infrastructure assets. Annual maintenance plans can be developed, optimized and monitored to make informed decisions for future work related to climate change impacts. AI processing of this type of data would allow owners to move from being reactive to environment challenges to taking a proactive approach, with modeling based on real world conditions.

Business Case Analysis

Possible focus areas: foundational research cost; evaluate value/return on investment; cost and time to implement.

Value and return on investment (ROI), cost and time to implement are key items to consider as part of the business case analysis. All U.S. state owners today want to better understand their technology and data investment ROI at a state level along with where they should be considering their next investments.

Increasing safety is also a key part of the business case analysis that U.S. state owners are looking at today. A key example is their interest in using mobile mapping and AI processing to capture roadway data with vehicle systems instead of asking people to capture data along the active roadway.

Total cost of ownership (how costs can be reduced) and enterprise value are key elements of the business analysis that U.S. state owners need to better understand when it comes to how they should invest in technology and data. Today investments are often siloed within a single department, leaving the enterprise-wide opportunity for its data and technology untapped.

Encourage Adoption of Data Management Best Practices

Possible focus areas: governance methods for data collection, curation, sharing and usage; shared public datasets and repositories; real-time data integration.

Perhaps the most foundational element when it comes to maximizing an owner's investment in technology and data is having data governance that drives both workflow and data flow at the enterprise level. This was so critical to infrastructure owners in the EU that the Norway Road Authority created a new organization to focus solely on data governance and data standards for the owner's enterprise operations.

Open API's and data interoperability are also foundational elements of maximizing ROI from technology and data investments. The use and re-use of data and AI across an enterprise can exponentially reduce costs and accelerate ROI. There are even opportunities today for owners to leverage AI to help them better understand and standardize their data at the enterprise level. The concept of "data lakes" that hold data from multiple sources, vendors and technologies is also an important part of the future landscape so construction owners can acquire larger sets of data across the above continuum and make even better decisions and outcomes.

Adoption is also tied directly to education as there is a need from every state owner in the U.S. to shift to educating our next generation of transportation professionals on the use of data across the enterprise for asset lifecycle management. Certain states, such as California, have even developed first of their kind programs focused on teaching students how data is used across a state construction owner organization to improve management of tax payer assets.

Establish a National Digital Twin R&D Ecosystems

Possible focus areas: collaborations across agencies to identify and address foundational research gaps and opportunities that spans areas such as biomedical sciences, environmental ecosystem, sustainability & climate change, smart and connected communities, scientific discovery, agriculture, military & mission planning, as well as common mathematical, statistical, and computational foundations.

There is a great opportunity for owner data collaboration at the national, state, local and utility level, even impacting other agencies that rely on transportation information such as emergency services. State owners like Colorado are passing data sharing and standards laws for agencies already, with their first policies helping the Colorado State Department of Transportation (CDOT), local government owners and utilities owners share data in a standard way for all projects statewide. Now imagine applying AI analysis to that shared data to help each level of owner improve on their asset operations.

Trimble's view of establishing a national digital twin R&D ecosystem is that it would increase the ROI potential of both owner data and AI processing, allowing any part of an owner's enterprise to engage with industry to explore the use of digital twins technologies and AI analysis.

Additionally, Trimble works very closely with the U.S. military and U.S. Army Corps of Engineers (USACE) as they have very similar needs when it comes to digital twins as the state DOT owners. They have some R&D projects in progress that would benefit state infrastructure owners in the future and state owners like Caltrans are educating USACE as well on their innovations. Trimble would like to see more of this type of innovation sharing available for all owners.

For the military, digital twins can address the complexity of multi-domain operational environments and associated operational constraints which can be identified earlier in systems design and impact decision-making for a more informed understanding of tradeoffs. Although the U.S. military needs to internally decide on requirements, industry can contribute software engineering expertise for the standardization of digital twins. As with construction, virtual representations of a system allow interoperability of data for design, development and maintenance or sustainment of a system's life cycle.

At Trimble, half of our work is also focused on building owners and project teams. State owners of infrastructure also own many buildings so Trimble works across a diversified group of technology owners, healthcare owners, bio-medical owners, manufacturing and oil and gas owners. They too are innovating today with digital twins and AI processing. There are benefits that all customers are missing because of a lack of a national standard approach to sharing innovation and information related to digital twins and asset lifecycle management.

International Collaboration on Digital Twins

Possible focus areas: global scale digital twins across foreign markets; global issues and digital twin development consensus standards; opportunities for international collaboration (e.g., European Union's Horizon 2020 program funding digital twin projects).

BuildingSMART International and IFC (Industry Foundation Classes) are key pieces of Trimble's international efforts surrounding digital twins. As a standardized, digital description of the built asset industry, IFC provides an open, international standard promoting vendor-neutral capabilities across different software platforms, hardware devices and interfaces allowing for collaboration and information sharing. Much of our experience today with digital twins and use of digital twins for asset lifecycle management comes from regions like the Nordics or Singapore who leverage open data standards.

Asset owners including all Trimble customers are concerned with the costs of technology as innovation accelerates. One way to offset the rising costs of technologies is to look at global standards for digital twins with open data standards. Today vendors like Trimble, Bentley, Autodesk and Environmental Systems Research Institute, Inc. (ESRI) can manage up to 20 different data formats depending on the projects and regions.

When looking at other industries that have adopted global standards, it is easy to see via the data results the explosion in innovation (as startups are able to take advantage of open

standards and global scale) as well as a reduction in costs due to lower operating costs and more competition. Trimble would ask why the construction and transportation industries have not considered what has already worked in other industries.

Long Term Research Investments

Possible focus areas: novel approaches for interactive data-driven modeling and simulation, both crosscutting and fit for purpose; research enabling the bidirectional flow between the virtual and the physical assets; creating test environments for digital twins ensuring sufficient resources and sustainable high-performance computing.

Trimble believes that a focus on the long term impacts of data-driven asset management and maintenance owners who are leveraging asset modeling, maintenance planning and capital planning along with AI analysis would help owners lower the total cost of ownership of all assets. Of particular interest to state owners is asset data updates and inventories and determining long term what is the best approach to best providing a full transportation system inventory of assets and updates on those assets that are not years old.

Regulatory

Regulatory science challenges associated with the use of digital twins.

There will be many regulatory challenges coming as industry members learn to better use data and technology like AI to create workflows and models that could incorporate more variables than ever considered in the past. Examples include whether there is a need to change how road design and materials are analyzed based on more real time weigh in motion data (dynamic vehicle weighing) from long haul trucking. Another example is how airport owners need a cost and time efficient way to capture runway conditions at night (their only downtime), which is a perfect fit for mobile mapping and AI analysis; however, regulations have not been updated to allow for this approach. The use of drones is also putting pressure on regulatory restrictions.

Trimble's view is that regulatory updates need to be made with an understanding of Moore's Law, that technology is advancing rapidly and regulatory changes are not keeping pace.

Promote Responsible Development & Use of Digital Twins

Possible focus areas: ethical use of digital twins; identifying ethical issues, mitigating and biases with respect to data ownership, intellectual property and privacy.

Responsible use of digital twins is tied to transparency. For example, owners in the EU are being transparent about their work as they work on digital twins, including the data they want to use and why they want to use it. They share this with the public and with their project partners, gaining the trust of both the industry and the public, especially as the benefits of using digital twins are tied to improvements in infrastructure for the public. This is another reason why open and interoperable data standards are critically important for digital twins.

Promote Development of Evaluation Tools, Methodologies and Consensus Standards for Digital Twin Development and Testing and Interoperability

Possible focus areas: community of practice, ontology and data exchange protocols; encryption standards; taxonomy; address challenges related to evaluation of data-driven digital twin components; continuous and multi-modal data sources; personalized applications derived from digital twins; transferability, generalizability and robustness of digital twins.

The development of evaluation tools and methodologies and building consensus standards is a large gap area today for state owners. While all state owners would like to move to digital twins, they will need a playbook or guide to help them understand this effort at an enterprise level.

There is also a large value opportunity for owners who are willing to share their data, with data being the new currency. Owners have an opportunity to increase the value of their data through the development of apps, sharing with industries, and in cases like local owners or utilities owners exchanging data currency to help each other's operations.

There is also a lack of a standard for the transportation and construction supply chain. When viewing other industries of similar size, they have all established standards and technologies for an electronic supply chain. One of the key items within a digital twin are the materials coming in through the supply chain, not just for project delivery, but over the lifetime the asset is being maintained. Without standards for supply chain, the efficiency gains from digital twins will be limited. Connecting the owner's entire supply chain (both field and office) with all data related to the built asset gives the owner a complete dynamic digital twin to the physical asset.

Design and Develop Systems and Architectures for Digital Twin Sustainability

Possible focus areas: sustainment as the operating systems and computational models on which they are based evolve and the data which they ingest are updated; intentional organizational effort and purpose-built modeling ecosystems energy-awareness; early consideration of computational requirements and effective workflows; develop approaches for the design, development, and deployment of digital twins; the ability to create interoperable digital twins with evolving technology and standards.

Based on the reality of Moore's Law, Trimble sees a key need for this approach as new AI models and input variables to AI models will constantly evolve. Owners of infrastructure will need to adopt new technologies, new data sources and even new data standards, such as the expanding visualization data standard Universal Scene Description (USD) from NVIDIA as one example. USD is an open-sourced 3D framework that allows for the interoperability of tools to create and exchange content.

To realize the scale and efficiency of digital twins as stated above, there is a need for a global approach to standards that all technology providers and consumers can support. A global, standardized and structured approach would again drive innovation and lower costs to sustain digital twins. Imagine having a global standard established for how all cars on all roads would use sensors and cameras to help owners capture ongoing conditions of those assets. AI

processing on top of that data would provide a wealth of information in real time that owners are missing today and expand to many other industries that want access to that type of data.

For digital twins, the need for supply chain information is growing. Trimble works with organizations such as ETIM International (https://www.etim-international.com/) to help owners, design engineers and contractors with supply chain standards that support both project and asset work. ETIM is the international classification standard for technical products which adds structure to the flow of information between B2B professionals within the value chain. Trimble also plays a key role in providing trade services (https://www.tradeservice.com/) product and supply chain data to our contractor customer base that enhances the value of a digital twin.

Realize Secure and Trustworthy Digital Twins

Possible focus areas: develop solutions to assure the security, cyber resilience, and trustworthiness of digital twins (taking into account all components of DTs such as their code base, data and data processing, operational environments, networking and connectivity with the physical counterpart); develop capabilities to utilize DTs to improve the security and cyber resilience of the physical counterpart, such as through threat analysis, attack modeling, risk analysis, security testing and similar analyses conducted on the digital twins.

The lack of cyber standards between state owners within the U.S. will create a dramatic increase in technology costs as technology providers work to try to align to 50 different standards. These state standards may or may not align to federal standards for cyber security, or local owner cyber security standards. A more scalable standard is needed not just for digital twins, but for transportation and infrastructure data in general. Trimble has presented on this topic already to state DOT owners.

Develop Rigorous Methods for Verification, Validation and Uncertainty Quantification (VVUQ) for Digital Twins

Possible focus areas: foundational and cross-cutting methods as well as domain specific; integration of VVUQ into all elements of the full digital twin ecosystem.

EU owners have built in VVUQ to their project, maintenance and asset management based workflows and data flows, which in turn generate and/or update their digital twins. While the industry will need VVUQ to help them manage digital twins over time, Trimble has seen that the impact of implementing VVUQ at the project level greatly improves the verification, validation and certainty for digital twins without post-project processing or analysis.

Cultivate Workforce and Training to Advance Digital Twin R&D

Possible focus areas: diverse talent recruitment; incentivize cross-disciplinary STEM research programs across educational institutions.

As mentioned previously, Trimble believes education plays a critical role in the adoption of digital twins. While Caltrans provides an example to highlight in this area, there is a definitive need for a more data-focused approach to workforce development and training. This approach has the potential to attract a younger workforce interested in data science, AI and app development, increasing the importance of state owners working closely with their local universities.

In conclusion, Trimble applauds this effort to provide guidance for government investments and further federal R&D coordination in digital twins related research through a National Digital Twins R&D Strategic Plan. Digital twins allow the owner the ability to have a complete dynamic virtual representation of the physical asset through the linkage of departments within an organization with the entire supply chain and all relevant data of the built asset. Trimble believes that leveraging digital technology across all parts of asset lifecycle management and sharing information among stakeholders results in infrastructure assets that are built faster, greener, more sustainable and operate more safely while providing equitable outcomes to all.

Trimble looks forward to working with NITRD to advance the technology and accelerate the use of and early adoption of digital twin models to shape a whole-of-government approach on R&D related to digital twins.

Thank you for your consideration.

Sincerely,

Stephen Kittle
Director - Proposals, Contracts & Grants Programs