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

Bentley

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RFI Response: Digital Twins R&D Plan

Prepared for: NITRD, NCO, NSF

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1. BACKGROUND

Bentley Systems is pleased to offer this response to the Office of Science and Technology Policy ("OSTP") at the Networking and Information Technology Research and Development ("NITRD") National Coordination Office ("NCO"), National Science Foundation ("NSF"), regarding the proposed creation of a National Digital Twins R&D Strategic Plan. Bentley applauds the creation of this plan, and is looking forward to working with NITRD, NCO, and NSF on driving Digital Twin innovation and adoption.

Bentley Systems has been at the forefront of the digital transformation of civil infrastructure for 40 years, and has focused heavily on the creation, management, analysis, and visualization of Digital Twins. These Digital Twins not only encompass the planning and design phases, but transition through the entire asset lifecycle including operations and maintenance. Bentley's multi-discipline, whole life Digital Twins are already making measurable improvements in safety, cost efficiency, construction times, environmental impact, compliance, and reliability for infrastructure in the United States and around the world.

Bentley's solutions encompass the following:

Spatially Enabled Asset Information

View and use information from a graphical perspective for spatially located assets and related information. This asset-centric approach supports enhanced decision-making across different types of assets and information.

Enhanced Decision Support

Combine data from multiple sources with advanced analytics to enable engineers to make more informed decisions relating to maintenance and renewal of infrastructure.

Trusted Information, When and Where it is Needed

Manage information throughout the asset's lifecycle – ensuring the delivery of relevant, trusted information, in context – where and when it is needed.

Connected Data Environment

Leverage existing investments in information by establishing an open framework for collaboration and the management of asset information throughout the full lifecycle of infrastructure.

Reality Models Creation and Visualization

Combine existing point cloud and images to create realistic 3D representations of assets to deliver a baseline for asset condition, provide context to other datasets and support digital inspection.

About Bentley Systems

Bentley Systems (Nasdaq: BSY) is the *infrastructure engineering software* company. Bentley provides innovative software that advances the world's infrastructure – sustaining both the global economy and environment. Bentley's industry leading software solutions are used by engineering professionals, and organizations of every size, for the design, construction, and operations of roads and bridges, rail and transit, water and wastewater, public works and utilities, buildings and campuses, mining, and industrial facilities. Bentley's offerings include applications for modelling and simulation, project delivery, asset and network performance, and sub-surface mapping.

www.bentley.com

Bentley Differentiators

- **Global Reach** – Bentley Systems is a US based, publically traded company with 5,000 colleagues worldwide, offices in over 40 countries and users in over 100.

- **Proven Experience** – Bentley has both local and global experience implementing digital technologies on brownfield and greenfield projects. Bentley has helped deliver civil infrastructure projects in all 50 states and serves as the primary design authoring software for 42 state Departments of Transportation ("DOTs"), the New York Metropolitan Transit Authority ("MTA"), CSX Transportation ("CSX"), Amtrak, Canadian National, and many others.

2. DIGITAL TWIN TOPICS

2.1 Artificial Intelligence (AI)

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

Bentley believes Artificial Intelligence ("AI") and Digital Twins are natural partners. AI requires large swaths of data to learn from, and a Digital Twin can provide a rich variety of that required data. Bentley already incorporates AI into its Digital Twin products for a range of different applications. These applications span from concrete crack detection for bridges and dams to intelligent legacy Piping & Instrumentation Diagrams ("P&ID"), and roadway and asset assessment through the use of vehicle dashcams.

Impactful areas of focus could include how AI can better support Digital Twins in automating the assessment of existing infrastructure. Bentley remains deeply focused on helping engineers make better, faster, and safer decisions throughout the entire lifecycle of an asset. These AI capabilities function as a digital co-pilot to support engineers in all facets of their jobs by serving as a repository of information about the current state, history and potential future state of an asset or system. This type of supplemental assistance helps engineers more effectively use their data to make better decisions, leading to improved project delivery.

Additional research could be done to further determine how AI can help train and assist the existing and incoming workforce in transitioning or entering a Digital Twin experience by helping them navigate newly formed tasks, protocols, and procedures. This will help improve performance of job functions that may have changed or adapted from a paper and pdf-based workflow to one that utilizes Digital Twins.

Exploring how building automation into the design process to assist in performing mundane and repeatable tasks could benefit the industry at-large. Developments in task automation often seek to increase efficiency for the designer to achieve the most optimal results when it comes to safety, environmental, ethical, and financial considerations. This research will help the industry get to a point where the cost of Digital Twin implementation pays for itself and drives additional cost-savings for owner-operators.

2.2 *Business: Business Case Analysis*

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

Bentley has been collecting Return on Investment ("ROI") data from its customers' Digital Twin projects for years. Additional analysis could be done to consider user digital maturity, supply chain readiness, contractual relationships, existing IT infrastructure and required process changes to generate an overall roadmap of digital transformation. Digital Twins are a powerful tool, but full value can only be achieved if they are embedded into existing processes and utilized by trained individuals.

Additional research could be done regarding foundational information packs and datasets used to fast-track digital maturity including roadmaps and best practices for pragmatic digital transformation. This would assist in covering roles, accreditations, processes, and impact including security, data volumes, processing power, and compatibility with existing systems. This type of research could result in a better understanding of how to measure ROI during implementation. In the interim, research into extrapolating ROI from multiple siloed instances of existing Digital Twin efforts would help industry leaders more accurately project ROI.

Bentley believes research into short and long-term implementation and expansion of Digital Twins into various agencies and industries would benefit long term, educational, business case, and workforce goals.

2.3 *Data*

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.

As an organization helping deliver some of the world's largest civil infrastructure projects, Bentley has users with multi-terabyte sized datasets. These users are federating data from dozens of source systems to provide a "single pane of glass" view into a system. Research regarding open data formats, data validation, Master Data Management ("MDM"), data archiving, data longevity, data management and visualization at scale, and data security should be considered.

Additionally, uncertainty persists around data ownership and its utilization for AI and machine learning ("M/L"). In many instances, data ownership for the use of training AI systems remains unclear; for example, on a government-commissioned project designed by an architecture, engineering, and construction ("AEC") firm using digital design software. Simply put, the clarity surrounding data ownership remains an obstacle to full-scale innovation and adoption. Additional research on these types of data management best-practices, specifically related to improving AI-training data, are going to be paramount in driving Digital Twin innovation forward.

2.4 *Ecosystem*

Establish a National Digital Twin R&D Ecosystem: 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.

Through its deep roots in helping deliver government-funded projects, Bentley has continued to build upon its experience working closely with government agencies at the local, state, and federal level. This experience and knowledge are paramount to Bentley's ability to navigate the complexities of working with various levels of government, often on

the same project. Bentley knows well that this collaboration is a cornerstone of not only project delivery, but also driving adoption of technology at all levels of government.

Bentley believes that additional research into cross-functional and cross-agency information sharing will help drive the industry forward in a way that accounts for and benefits all levels of government and its citizens. Research into this ecosystem development would ideally include multiple simultaneous coordinated research streams to advance Digital Twin ROI collection and advancement.

Investigating cross functional and cross agency activity sharing in multiple industries would be of great value. Research into this ecosystem development to include multiple simultaneous coordinated research streams to advance digital twin ROI collection and advancement would help foster collaboration at-large.

2.5 *International*

Collaborations 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).

As a US based, global IT company, Bentley has visibility into cutting-edge digital transformation around the world. Bentley belongs to various international organizations such as buildingSMART and the European Rail Supply Industry Association ("UNIFE"). Researching global supply chain alignment, international standards for file formats, data exchange, and taxonomy would be of great benefit to the Digital Twin industry.

Additionally, as governments around the world continue to invest in building and enhancing existing infrastructure, research regarding technology use within those projects will be paramount in understanding the state of the industry. In cases where a country has a higher adoption rate of Digital Twins, understanding why and what barriers may exist in areas with lower levels of adoption will help organizations and governments more effectively drive adoption and modernization.

2.6 *Long Term*

Identify Long Term Research Investments: Possible focus areas: novel approaches for interactive data-driven modelling 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.

Bentley believes there is immense value in research that will help determine best practices for creation, publication, and maintenance of sample Digital Twins for specific industries that will support innovation and continued long term research opportunities. Research into how to align the rapidly changing world of IT advancements with the relatively static world of civil infrastructure, will help give long term sustainability to the Digital Twins based on today's technologies.

2.7 *Regulatory*

Regulatory Science Challenges associated with the use of Digital Twins.

Bentley has experience in multiple industries globally and is constantly monitoring regulatory developments and requirements. While Bentley does not see any immediate regulatory science concerns when it comes to the use of Digital Twins, ensuring standards, definitions, and requirements are set in close collaboration with industry will be essential to ensure innovation and adoption are encouraged and not stifled. Bentley continues to closely monitor the regulatory landscape as it relates to requirements in cybersecurity, AI, and government data.

2.8 *Responsible*

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.

Bentley believes profound care must be taken in determining when and where integrating AI into its Digital Twin technologies makes sense and where its use provides measurable value. Bentley takes seriously concerns about data quality, privacy, data leakage, and the strategic nature of civil infrastructure. Bentley remains steadfast in its view that implementing AI when it doesn't provide additional value could defeat its intrinsic value.

Additional research should be done on managing intellectual property ("IP") in shared Digital Twins, AI respecting data ownership, and AI usage on top of Digital Twins. Further research on access permissions to data derived and data resulted from AI run against sensitive or private data would help mitigate potential privacy issues in the future.

2.9 *Standards*

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.

Bentley participates in several standards committees and organizations worldwide. Bentley believes that these organizations provide immeasurable value to the greater industry through their approaches on collaboration, information sharing, and standard setting. This collaboration allows the industry to move together in its pursuit of advancement and innovation. Research areas such as standardizing definitions, management and usage of network definitions, and linear referencing systems on top of Digital Twins for civil infrastructure use-cases would be additive to the value of the committees themselves, allowing them to be more effective.

2.10 *Sustainability*

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 modelling 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.

Bentley has been generating open file formats to support Digital Twins for several years. Bentley understands well that longevity of data is critical and works tirelessly to ensure that legacy data can still be accessed in newer products. Bentley sees the immense value in potential exploration of longevity of data, data accessibility, and lossless data migration between Digital Twin technologies. Bentley sees the benefits of researching how to align the rapidly changing world of IT to better provide long term sustainability for Digital Twin products.

2.11 *Trustworthy*

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.

Bentley remains committed to security, cyber resilience, and trustworthiness of all its products and data as a standard level of practice. Bentley also takes an additional level of care, when required, by complying with applicable compliance frameworks, which may relate specifically to government data.

Research should encompass not just the resilience of the Digital Twin and its component elements but also the use of Digital Twins to ensure the resilience of the corresponding physical infrastructure. Multiple datasets should be used to cross-reference and validate data currency, completeness, reproducibility, and accuracy to support a self-policing Digital Twin that can raise alerts and alarms when it detects discrepancies or anomalies. Research can also be done to ensure appropriate levels of access and security to Digital Twins are easily obtained, maintained, and verified.

2.12 *VVUQ*

Develop Rigorous Methods for Verification, Validation, and Uncertainty Quantification 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.

Bentley has created methods for VVUQ on its own digital twins and can provide insight into lessons learned from methods in practice. Researching open source and more transparent VVUQ development through committee creation and practices would also be useful.

2.13 *Workforce*

Cultivate Workforce and Training to Advance Digital Twin Research and Development: Possible focus areas: diverse talent recruitment; incentivize cross-disciplinary STEM research programs across educational institutions.

Over the past decade, Bentley has invested heavily in STEM education spanning from k-12 to higher education. These investments have not only included various levels of education but have also been inclusive of different industries and disciplines of engineering and technology. While Bentley's products may help in addressing workforce shortages, its technologies are not meant to replace human beings. Bentley believes that Digital Twins play a paramount role in helping close existing workforce gaps, all while continuing to support expansion of the STEM workforce.

Bentley sees great value in researching the standardization of workforce and supply chain digital maturity assessment. Providing standard Digital Twin datasets to academic institutions and education organizations as well as the development of short and long-term implementation training strategies will be instrumental in future research and dissemination.

New skillset and role requirements for research, education, and execution of new changes will be required by the workforce to continue the further implementation of Digital Twins. Research into how best to attract the next generation of engineers into asset disciplines will be essential. Additionally, studying how to extract the expertise of experienced engineers to encapsulate within Digital Twins to ensure their knowledge is not lost will be extremely valuable for future generations of engineers.