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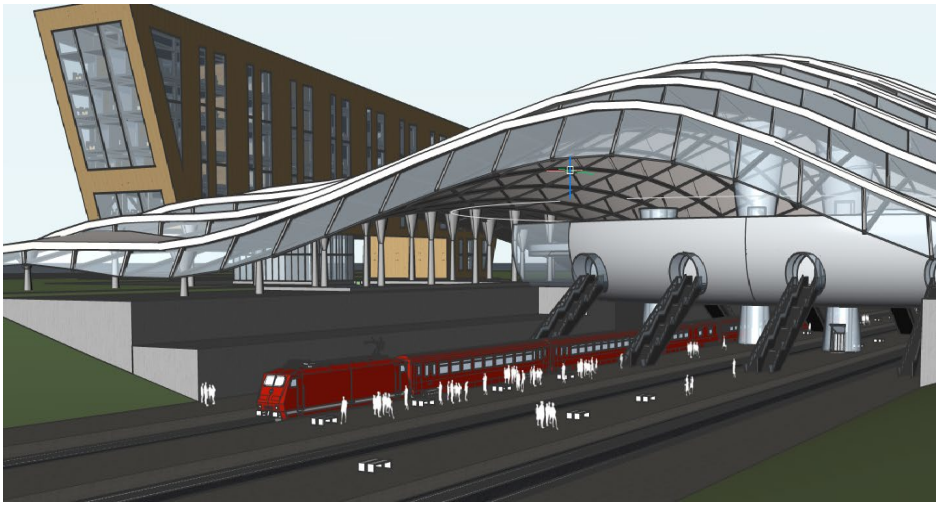

# Advanced Modeling Simplification

The Potential of Generating 2D/3D CAD, BIM, CAM, Reality Capture, and Geospatial/TIN Modeling Within a Single Software System.


## ABSTRACT

A single system, designed to handle all Advanced Modeling and design needs, has been a wish list item of government agencies for years. Having a single system, working with one file format, that can easily integrate and cross-reference data from other commercial systems would be an invaluable asset, but it hasn't truly existed until recently. The idea of a single software that can handle survey, civil, architectural, mechanical, manufacturing, digital twins, photogrammetry, GIS, and reality capture modeling in a single environment, within a single file, is game changing.



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# Introduction

**Advanced Modeling** for government agencies spans an array of requirements, needs, and desired outputs. It usually involves dozens of software systems to handle design and development of those models. To complicate things, government agencies are often faced with a frustrating mix of outdated custom-built government systems and the constantly changing "Software-As-A-Service" (SAAS) commercial modeling systems.

"Advanced Modeling"[1] is an umbrella term used by the US Army Corp of Engineers (USACE) CAD/BIM Technology Center to address the cross-platform needs of the design and construction industry that includes all aspects of the built world, using digital technologies. Advanced Modeling includes BIM, CIM, GIS, and CAD systems but it can also include digital twins, photogrammetry, reality capture, and CAM modeling processes.

These various processes, all of which are vital to the digital modeling world, traditionally require, at minimum, one specific software system for each function. It is common, particularly when using commercial design software, that each user may be working across a pre-purchased suite of products to provide functionality across all these disciplines. To further aggravate the issue, file/data types for these systems vary greatly and even systems from the same software developer aren't always interoperable.

Interoperability of modeling software systems is key to preventing miscommunication, re-work, and just plain "bad data". Bad data is responsible for an enormous amount of loss and inefficiency. A 2022 joint study by Autodesk/FMI[2] shows that 14% of all design/build work is "re-work" of bad data. That is more than a $31 Billion loss annually in the U.S. alone. A primary contributor is the loss of information and ensuing miscommunications that arise from cross-platform interoperability concerns. Implementation of a single design system that can harness its modeling capacity to address these various needs within a single software using a single, industry-standard file format can alleviate a substantial amount of this loss.

This whitepaper examines standard industry practices of leading commercial software developers, such as Autodesk®, ESRI®, Dassault®, and Bentley® and how they operate across multiple packages, proprietary file types, and disrupted workflows that can lead to bad data and inefficiencies. In contrast, we will be using BricsCAD® (by Bricsys®, a Hexagon company) design software as an example of an integrated, Advanced Modeling solution that allows for working these various design processes within a single package and a standard file type. Additionally, we will examine the interoperability between all these systems and the native processes for moving data between them, as may be required for contractual or communication needs.

1. *CAD/Bim Technology Center, (n.d.) "Contracting Requirements" Contract Requirements (dren.mil)*
2. *"HARNESSING THE DATA ADVANTAGE IN CONSTRUCTION ", 2022, Eric Thomas Manager, Construction Thought Leadership Autodesk Jay Bowman Managing Director of Research & Analytics FMI*

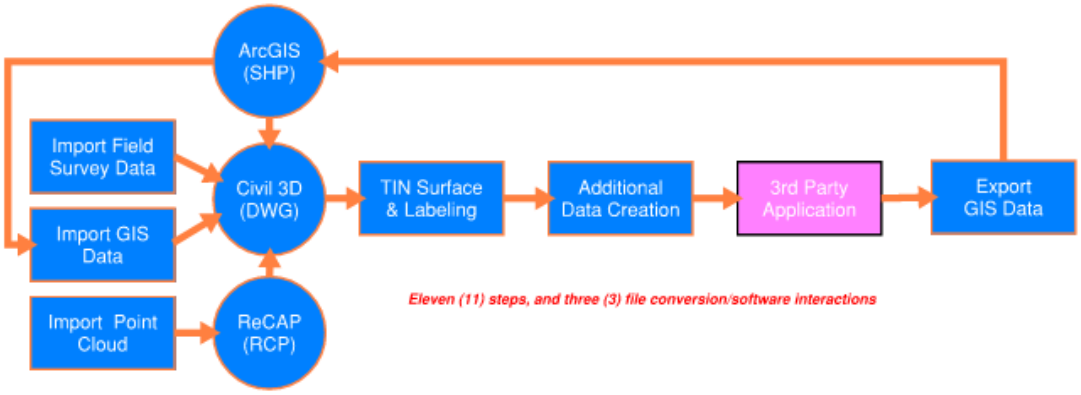

*Eric Thomas/Jay Bowman "Harnessing the Data Advantage in Construction", Table 7, page 19*

# Survey Modeling

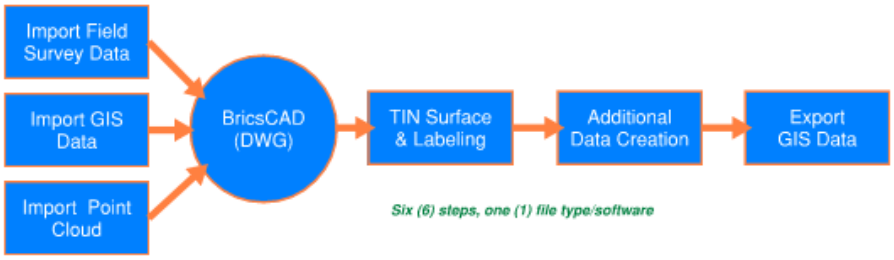
Survey TIN (3D) models are generated from three primary sources: survey point data imports, GIS data imports, and point cloud scan data. Survey data is normally imported into a design system from a text file containing point number, coordinates, and elevation data for all surveyed locations on a site. GIS data is commonly imported from data warehouses, like USGS, to import items such as utilities, roads, etc. and their associated metadata. Point clouds are the result of laser scans that can contain millions of 3D point locations defining all aspects of a site, with varying degrees of accuracy. Once this data is imported into the design system, it's used to generate a 3D model (TIN) of the surface conditions that can be contoured, labeled, legal data added, and used to develop proposed designs.

Workflows for survey TIN creation vary across software systems but invariably, most current processes require the use of multiple software packages and file conversions to achieve the end goal. As an example, using recommended Autodesk processes, since they are the most common, may require the use of three separate programs: Autodesk Civil 3D, Autodesk ReCAP®, and ArcGIS®. This means the use of three distinct files and separate file types (DWG, RCP, SHP) that need to be modified, edited, and converted for import into the primary design system. Additionally, data for surveys regularly needs to be bi-directional, meaning that you likely need to use third party add-ins to convert design data back out of the primary system for use in the source software systems.

Each time you need to export or convert a design file to another format/system you run the risk of lost information, data corruption, formatting changes, errors, compatibility issues, and an extended amount of work time lost to the transfer process. In a study[3] conducted by Adobe Systems: 47% of workers feel their daily workflows are too difficult to use effectively and 22% noted file integrations across multiple platforms as a primary work challenge. Each step eliminated from the survey data creation process increased efficiency and saved costs across every project worked.




Typical Autodesk Based Survey Workflow




Typical BricsCAD Based Survey Workflow

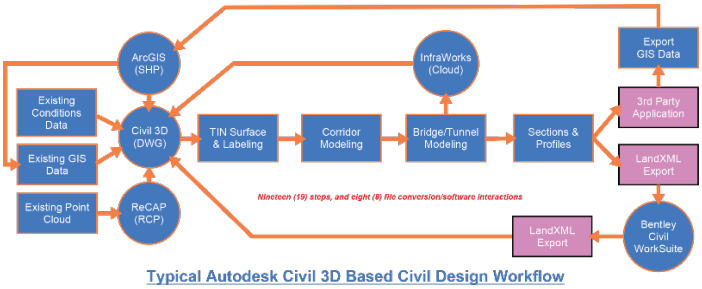
3. *Technology Science, "Adobe Survey: 10% Spend Over 4 Hours Weekly Struggle - Workplace Digital Chaos", Dec. 5, 2023:* *Adobe Survey: 10% Spend Over 4 Hours Weekly Struggle - Workplace Digital Chaos | Technology & Science News, Times Now (timesnownews.com)*

# Civil/Site Design

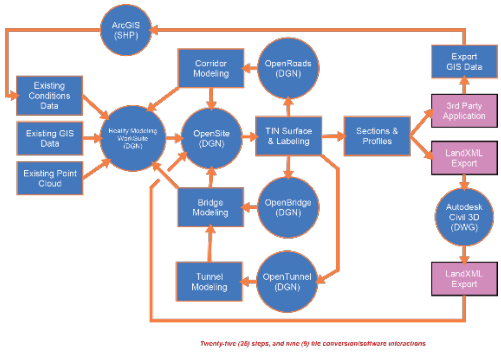
The design process for infrastructure projects can vary greatly from agency to agency, and it can incorporate many add-on and third-party applications alongside an organization's primary civil/site design software. Because civil/site work spans such a wide array of functions, such as grading, transportation, hydrology, GIS, land planning, and many others, it can be difficult to structure simple and reliable workflows to complete such design projects. With the passage of the $1.2 trillion Infrastructure Investment and Jobs Act (IIJA) in 2021, the demand for civil engineering designs has reached record levels and almost all those designs require digitalization of civil data at some level. The "silo" of design data in this space caused by multiple proprietary commercial and governmental design systems each using their own file types and data storage structures has become a major stumbling block to streamlining design processes to meet this increased demand.

The National Governors Association published a study[4] in late 2023 identifying key strategies that civil/infrastructure teams can use to address the issues of smaller workforce availability, coupled with more detailed technology requirements. A key component that NGA identified was the need for additional training, particularly in advanced technology, to help reduce the stress and mental exhaustion the increased demand is causing among a limited workforce. Industry focus on the use of AI, BIM, and other advanced modeling tools is a key component in most organizations planning to address the growing demands of the infrastructure space with a leaner staff. A study of engineering needs by Deloitte[5] from 2023 highlights the need for generative design, BIM, AI, and other advanced technologies in infrastructure to work together to seamlessly reduce carbon footprints and enable seamless project deliveries. The study states, "These technologies can also improve efficiency, increase delivery confidence, and hone resource allocation, ultimately lowering project expenses and risks." Implementing a simplified, or singular design system workflow for infrastructure projects can eliminate the complications of file conversions, siloed data, and extended workflows that slow design processes in this space.

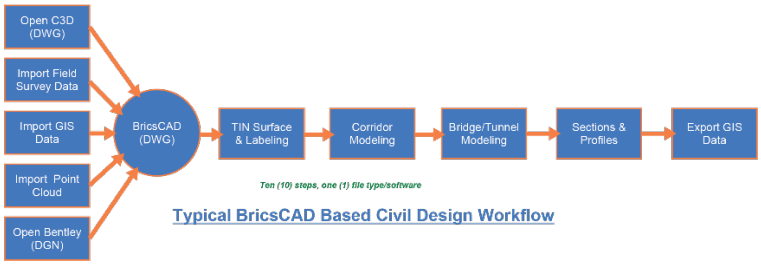
The key industry players in the civil/site space are Autodesk Civil 3D for private industry and Bentley Civil WorkSuite for public uses, particularly for DOT and transportation concerns. Both systems handle road, bridge, and site design very effectively, but they silo design data, requiring file conversion and/or export to translation formats to move data back and forth between each other and other necessary third-party tools, such as ArcGIS or Revit. The flowchart below shows both those industry leading workflows and contrasts them against a single system approach using BricsCAD.




Typical Autodesk Civil 3D Based Civil Design Workflow




Typical Bentley CivilWorksuite Based Civil Design Workflow

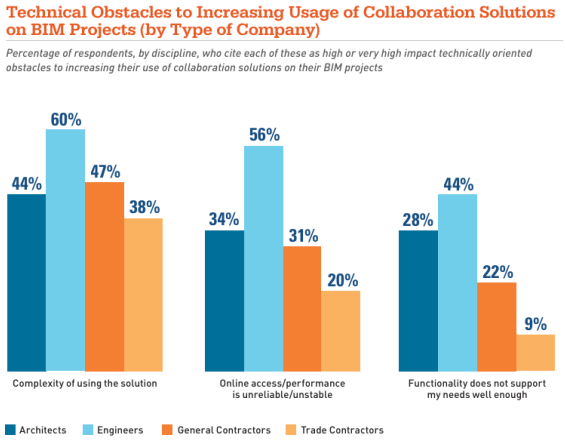



Typical BricsCAD Based Civil Design Workflow

4. *"Strategies To Address Engineering Workforce Challenges", Aug. 21, 2023, National Governor Association; https://www.nga.org/publications/strategies-to-address-engineering-workforce-challenges/*
5. *"2024 engineering and construction industry outlook", Deloitte, https://www2.deloitte.com/us/en/insights/industry/engineering-and-construction/engineering-and-construction-industry-outlook.html*

# Building Information Modeling (BIM) Design

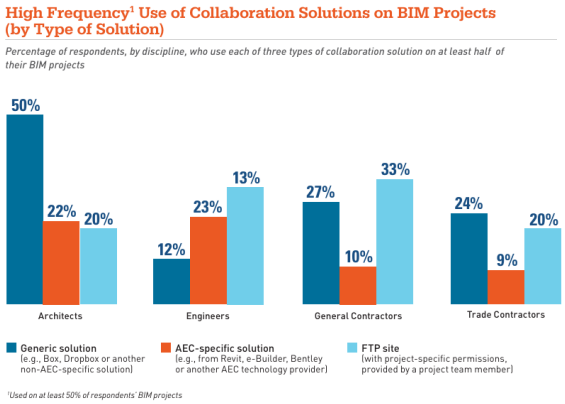
BIM technology use is an imperative within the federal space and a major component of Advanced Modeling. Many government agencies have developed and implemented detailed BIM plans, from the GSA's National 3D-4D BIM Program to the USACE CAD/BIM Technology Center, and NIBS National BIM Program (NBP). These programs demonstrate the accepted benefits, and even the necessity, of BIM on government projects. The positive impact of BIM in the A/E space is clear and its inclusion in design projects generates substantial time and cost savings. In a survey of BIM users conducted by Autodesk[6], 82% of users stated they'd seen a positive ROI from the use of BIM on their projects and 69% claimed BIM had reduced costs and material waste on their jobs. That shows the substantial benefit of BIM adoption, but the same study also showed that 59% of respondents felt their staff lacked the technical skill needed to work effectively in a BIM environment and almost 30% refused to bid BIM projects because of the technical difficulties associated with them.




*Leading the Future of Building, Dodge Data & Analytics, Stephen A. Jones. Donna Laquidara-Carr, Page 12*

The technical difficulties in BIM workflows are the largest roadblocks to full scale use of BIM solutions. A/E users struggle with both the complexity and reliability of BIM software systems, particularly when they must use multiple design systems to accomplish BIM tasks. Access to, and performance of, BIM across multiple software packages is deemed too unreliable for regular use on all design projects. Many of the major commercial players in the BIM marketplace, such as Autodesk, Vectorworks®, Tekla®, and Graphisoft® all use proprietary file types for their BIM systems. These BIM file types are often not even compatible with that developers' other design/CAD system files. As an example, Autodesk Revit, which is the most widely used BIM package on the market, uses .RVT files which aren't compatible with their base AutoCAD drafting system. To address compatibility issues in the BIM space, buildingSMART International maintains the ISO 16739 compliant Industry Foundation Classes (IFC) format as a centralized data format to ensure BIM information can be shared across multiple platforms. Unfortunately, most BIM software packages have only adopted IFC as an import/export function with limited display of IFC items from other modeling systems.

Implementation of a design system like BricsCAD, which offers a single system and single file type structure, is key to the elimination of "unreliable" data issues and gives the benefit of full IFC compliance. All BricsCAD files: 2D, civil, survey, BIM, etc., work with industry-standard DWG files, but the underlying BIM data modeling is completely IFC-compliant within DWG itself. This system is a fully certified buildingSMART IFC compliant partner member. Making use of a system like BricsCAD, which enables users to shift between 2D/Bim/Mechanical design processes within a single software session, using the same data and file, can have a dramatic impact on the adoption of BIM on more projects. Collaboration between BIM systems is vital to current processes, with large numbers of agencies/firms using at least one collaboration tool on more than 50% of their projects.




*Leading the Future of Building, Dodge Data & Analytics, Stephen A. Jones. Donna Laquidara-Carr, Page 18*

Removing the need for multiple collaboration steps and file conversions will provide substantial time and cost benefits to BIM projects. this will also remove a major obstacle to wider adoption and implementation of this vital design/build functionality across government agencies and projects.

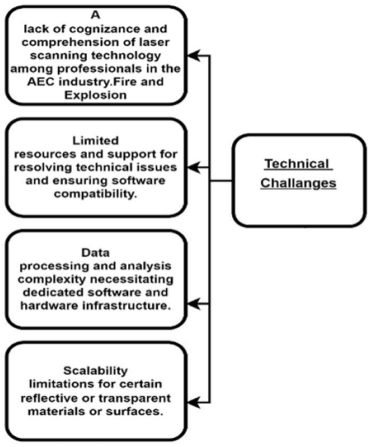
6. *"A Look Inside the Future of BIM", Mar. 10, 2023, Autodesk.com, A Look Inside the Future of BIM [infographic] - Digital Builder (autodesk.com)*

# Reality Capture & Digital Twins

Reality capture is the process of integrating high-accuracy laser scans of existing conditions and integrating them with photogrammetry to generate 3D models with photo realistic imagery overlaid on top of the scanned data for highly accurate digital models. Advances in technology, data storage, and compression have made the reality capture process much more accessible and affordable for projects of any size. These advances have been a key driver behind the growth of the Digital Twin concept that is becoming prevalent across all industries, from AEC, manufacturing, R&D, O&M, and social media interfaces. In May of 2024, the CHIPS for America Program announced a $285 million fund to help develop digital twins for the semi-conductor industry, while the Infrastructure and Jobs Act of 2021 has been seen as a key driver in both the reality capture and digital twin development spaces.

Key data for reality capture of an existing facility or process is developed from laser scans (point clouds) and photogrammetry (3D photos) that need to be combined and used to develop reliable and editable advanced models that can form the basis of design, development, and even operational management of complex systems throughout the government space. Collection of this data requires hardware such as high-resolution laser scanners, drones, 3D cameras, UAVs, and even LiDAR equipped planes. The cost of these hardware components has reduced dramatically in recent years making them more accessible to most agencies. In addition, the file sizes and speed of data transfer of modern point clouds have been greatly simplified, removing a substantial implementation barrier this space struggled with since its inception.

The largest remaining hurdle is the integration, editing, classification, and sharing of point cloud data/photogrammetry from the hardware to the advanced modeling system. There is currently no file standard for the reality capture industry, and individual hardware components will generate different output files. Most of those components can at least output XYZ coordinate text files so the scanned points can usually be brought into any CAD/BIM system equipped to handle point cloud data. The integration of photogrammetry and geolocation registration features, etc., are much more difficult to ensure compatibility. Another key feature that presents serious challenges is the ability to identify, configure, edit, and limit the number of points brought into the modeling system. Laser-based scanning can generate millions of points within a single project, which can quickly exhaust system resources within your modeling software. It's vital to be able to identify and classify points with what they represent in the real world (walls, pipes, conduits, etc.) so that only pertinent information needs to be imported/included in the model. These issues are commonly addressed by using different software systems to handle pre-processing, classification, and even editing of the point cloud data external to the modeling system. According to a 2023 study[7], most respondents saw these "technical challenges" as the leading obstruction to their implementation of 3D laser scanning on projects.




*"Complexities for adopting 3D laser scanners in the AEC industry: Structural equation modeling"; Figure 8, page 11*

Popular advanced modeling systems in this space, such as Autodesk, Trimble, and Leica, require the use of multiple software packages and file formats to fully process a point cloud to be usable by their modeling solutions. BricsCAD offers a single system that has full point cloud functionality integrated into it that allows not just for import of point data but the classification, editing, and manipulation of it within a single file. BricsCAD also integrates photogrammetric capabilities into its point cloud imports so that 3d photos can be displayed in situ, and even opened and exported from within the native DWG file.

Use of an advanced modeling system that will allow for the import of accurate scanned data from initial site conditions, through both existing building and as-built conditions for either structures or manufacturing processes within a single file, can have a tremendous impact on the viability of reality capture as a viable tool. Simplifying the digital twin concept by having all facility, process, and manufacturing sections of the twin developed, edited, and displayed in a single software package makes this technology much more accessible to government agencies.

7. *"Complexities for adopting 3D laser scanners in the AEC industry: Structural equation modeling"; Applications in Engineering, Volume 16, Dec. 2023, Ahsan Waqar, Idris Othman, Noha Saad, Abdul Hannan Qureshi, Marc Azab, Abdul Mateen Khan c*

# Smart Manufacturing

Manufacturing, and manufacturing-related facilities design, are traditionally an isolated subset of the design/build world. There is a heavily segregated interaction between the design of manufactured components, the manufacturing infrastructure required to make them, and the buildings/sites that house those components. This concept of "Smart Manufacturing" is a key component of the White House's "NATIONAL STRATEGY FOR ADVANCED MANUFACTURING" developed by the Office of Science and Technology Policy (OSTP) and is a key objective of its primary goal to "Develop and Implement Advanced Manufacturing Technologies" nationwide. This report highlights the need for Advanced Digital Modeling to enhance resiliency, reduce vulnerability of supply chains and mitigate the risk of disruption from outside factors.

Traditional modeling processes in this space are heavily dependent on software-specific file types and data which is notably intransient in terms of cross-platform data sharing and interactions. Systems such as Autodesk Inventor, Dassault SolidWorks®, Siemens Solid Edge, and other popular systems in the commercial space for this type of work use software-specific modeling tools and features. None of these lend themselves to an integrated, open model that can be distributed across multiple systems, agencies, and workflow processes to help move toward the government's noted goal of "smart manufacturing". Even within their own design environments, most of these systems require the use of secondary Product Data Management (PDM) systems to keep track of manufactured part assemblies, sub-assemblies, revisions, and associated metadata. Each secondary system required to manage and manipulate these models is a roadblock to increased efficiency and an additional failure point for data sharing and intelligent design. A study[8] by the National Center for Supercomputing Applications (NCSA) found ". . . **more than 140 different 3D file formats among 16 popular software packages**." That same study discusses the increasing complexity of file format conversions and the high potential for data and financial losses associated with each necessary conversion step.

Moving to a single design system that can handle all aspects of a smart manufacturing model, that will allow for PDM control within the same file, is a vital security step in the smart manufacturing process. A 3D modeling system that allows for the isolation of individual sub-assemblies, and the presentation of "exploded views" of manufactured components to visualize how each piece fits together, along with how they interact with real world spaces, is the ideal scenario. With a centralized design and modeling system like BricsCAD that incorporates all spatial, modeling, and process systems into a single software, government agencies can expect substantial ROI and eliminate many of the time-consuming inefficiencies that plague the sharing of advanced modeling information in the manufacturing and mechanical spaces.

A key factor for quality advanced modeling is in the interaction of designs within digital twin spaces. The ideal scenario is the development of a manufacturing facility, manufacturing process equipment, and the models of the manufactured components themselves that will all interact with each other in a realistic special twin. A single program, and a single file, that can implement all aspects of that manufacturing model, coupled with the associated metadata and PDM structures is warranted for all government agencies looking to implement and advance the Advanced Manufacturing goals of the White House and the OSTP.

*Smart manufacturing via digital design and manufacturing collects and distributes the information needed by production equipment to transform designs and raw materials into products, resulting in a highly connected industrial enterprise that can span a single company or across an entire supply chain. Smart manufacturing distributes relevant information to every level of the enterprise, from the factory floor to the C-suite, thus improving product quality and traceability while reducing cost.*

*National Strategy for Advanced Manufacturing, Oct. 2022, Objective 1.5. Lead the Future of Smart Manufacturing – page 10*

8. *"A Framework for Understanding File Format Conversions ", Peter Bajcsy, Rob Kooper, Luigi Marini, Kenton McHenry and Michal Ondrejcek*

# Conclusions

BricsCAD offers a unique design process that enables agencies and contractors to develop advanced models within a single file, using one integrated design process, to make best use of digital twinning concepts. BricsCAD integrates BIM and PDM data, alongside the ability to generate construction/assembly documentation from these models in one system. The major benefit we see with BricsCAD is the scalability and re-use of modeling skills across the entire spectrum of design, which substantially reduces project completion times while increasing the efficiency and intelligence of these models. The ability to develop models that include all aspects of design, from pre-construction sitework thru advanced component manufacturing models in the same system with repeatable modeling processes across all the aspects of advanced modeling has been an unreachable goal until now. There is substantial benefit to applying the same tools, processes, and techniques across all aspects of the modeling process. It broadens the base of workers available for each project because the same tools used on a building model will apply to a mechanical modeling process. A system like BricsCAD allows staff to focus on developing and mastering a single set of tools while still being able to generate highly compatible, industry-standard models in a common file type that can be easily shared/accessed by advanced analytics systems.

Additional benefits of BricsCAD lie in substantial cost savings and a highly familiar user interface that allows most modelers to make use of it with a minimal amount of training. BricsCAD also allows for quick system implementation due to it working natively with the world's most common design file type (DWG) so existing projects done in other software systems need no conversion - they can be simply opened and immediately worked on in BricsCAD. Those benefits aren't the focus of this paper but should be considered in the decision-making process. You can refer to https://zentekconsultants.net for more data on cost/UI, etc.

### 11 Benefits

1. Scalability
2. Maintainability
3. Productivity
4. Consistency
5. Improved code and design quality
6. Better knowledge sharing
7. Avoiding siloed knowledge
8. Closing the brand-product gap
9. Promoting the company's design philosophy and principles
10. Better brand and guideline adoption through shared ownership
11. Promoting equality

*11 Benefits of Design Systems for Designers, Developers, Product Owners, and Teams; https://builtin.com/articles/11-benefits-design-systems*

A unified design system allows for the sharing of data across multiple departments, agencies and with the public, using a single file containing the advanced models required so all stakeholders on a given project can easily access and even manipulate data as necessary. It provides consistent output, and the design tools used/mastered can be applied at all levels of work, making it a much more efficient and scalable process. All government agencies should be investigating systems such as BricsCAD to reduce costs, time to project completion, better information sharing, and the elimination of siloed data. Anyone interested in additional information, or a demonstration of BricsCAD functionality, can reach out to government@zentekconsultants.net.

# Reference Videos

- BricsCAD Survey
- BricsCAD for Infrastructure
- BricsCAD BIM
- BricsCAD Reality Capture
- BricsCAD Mechanical Design
- BricsCAD IFC & BCF Data
- BricsCAD Manufacturing